New Zealand Standard

Automatic fire sprinkler systems

Superseding NZS 4541:2013

NZS 4541:2020



STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COMMITTEE REPRESENTATION

This standard was prepared by the P4541 Automatic Fire Sprinkler Systems Committee. The membership of the committee was approved by the New Zealand Standards Approval Board and appointed by the New Zealand Standards Executive under the Standards and Accreditation Act 2015.

The committee consisted of representatives of the following nominating organisations:

Association of Building Compliance
BRANZ
Engineering New Zealand
FM Global
Fire and Emergency New Zealand
Fire Protection Association of New Zealand
Independent Designer Group
Institution of Fire Engineers New Zealand Branch
Insurance Brokers Association of New Zealand Inc
Insurance Council of New Zealand
Local Government New Zealand
Ministry of Business, Innovation and Employment – Building Performance
New Zealand Council of Elders
New Zealand Fire Equipment Manufacturers' Association
Property Council New Zealand
Society of Fire Protection Engineers (New Zealand chapter)
Universities New Zealand

ACKNOWLEDGEMENT

Standards New Zealand gratefully acknowledges the contribution of time and expertise from all those involved in developing this standard.

COPYRIGHT

The copyright in this document is owned by the Crown and administered by the New Zealand Standards Executive. With the exception of Figures 11.1, B2, H1, and N2, Tables H1, J1, and J2, clauses F4 and F6, and Appendices A, D, E, and S, for which separate permissions apply, you may not reproduce any part of it without prior written permission of the New Zealand Standards Executive, unless your actions are permitted by the Copyright Act 1994.

Figures 11.1, B2, H1, and N2, Tables H1, J1, and J2, clauses F4 and F6, and Appendices A, D, E, and S are licensed under a Creative Commons Attribution 3.0 International Licence. This means you may use, adapt and redistribute the content of only these figures, tables, clauses, and appendices for commercial or non-commercial purposes, provided that you acknowledge that the copyright is owned by the Crown and administered by the New Zealand Standards Executive. For the licence terms please see http://creativecommons.org/licenses/by/3.0/nz/.

As indicated throughout, this document contains material used under licence. Where applicable, the following copyright applies:

© Factory Mutual Insurance Company. All rights reserved. Materials are reproduced by permission from Factory Mutual Insurance Company.

© FM Approvals LLC. All rights reserved. Materials are reproduced by permission from FM Approvals LLC.

© NFPA

© 2017 Standards Australia Limited

We will vigorously defend the copyright in this standard. Your unauthorised use may result in a fine of up to $10,000 for every infringing copy or imprisonment of less than 5 years, or a fine of up to $150,000 or imprisonment for less than 5 years. If the breach is serious, we may also seek additional damages from you as well as injunctive relief and/or an account of profits.

Published by Standards New Zealand, PO Box 1473, Wellington 6140.
Telephone: (03) 943 4259, Website: www.standards.govt.nz.

AMENDMENTS

No.	*Date of issue*	*Description*	*Entered by, and date*

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Terms and conditions / legal notice

Standards New Zealand: PDF NZS and AS/NZS Download Terms & Conditions

You are about to download material which is subject to strict conditions of use. Copyright in this material is owned by Standards New Zealand. Please read these terms and conditions carefully. By continuing with this download you, as the named user, are agreeing to be bound by all of these terms and conditions:

1. You are purchasing a single-user licence to store one or more non-revisable PDF files on your personal computer.
2. **You may print out and retain ONE printed copy of each downloaded PDF file.**
3. You acknowledge that Standards New Zealand retains title and ownership of the copyright in each PDF file and the corresponding permitted printed copy at all times.
4. Under this license use of both the PDF files and the single permitted printed copy of each PDF file you may make are restricted to you. Under no circumstances are you permitted to sell, transfer, or copy any of the PDF files, the one permitted printed copy of each PDF file, or any part of either of them.
5. You undertake that you will not modify, adapt, translate, reverse engineer, decompile, disassemble or create derivative works based on any of the downloaded PDF files, nor will you merge any of them with any other software or document, even for internal use within your organization.
6. Under no circumstances may any PDF file you are downloading be placed on a network of any sort without the express permission of Standards New Zealand. Requests for network licence quotations should be emailed to enquiries@standards.govt.nz
7. You acknowledge that you are solely responsible for the selection of the PDF files that you download and that any advice or recommendation given by Standards New Zealand or its employees or agents about any aspect of any of the PDF files is intended for guidance only and is followed or acted upon entirely at your own risk.
8. Standards New Zealand is not aware of any inherent risk of viruses in any of the PDF files at the time that it is downloaded. Standards New Zealand has exercised due diligence to ensure, so far as practicable, that such files do not contain such viruses.
9. No warranty of any form is given by Standards New Zealand or by any party associated with Standards New Zealand with regard to any of the PDF files, and you accept and acknowledge that Standards New Zealand will not be liable in any way to you or any to other person in respect of any loss or damage, however caused which may be suffered or incurred or which may arise directly or indirectly through any use of any of the PDF files.
10. Standards New Zealand will vigorously defend the copyright in all its publications. Every person who breaches Standards New Zealand's copyright may be liable, under section 131(5) (a) of the Copyright Act 1994, to a fine not exceeding $10,000 for every infringing copy to which the offence relates, but not exceeding $150,000 for the same transaction, or to imprisonment for a term not exceeding 5 years. Those in breach under section 131(5) (b) of the Copyright Act 1994 may be liable to a fine not exceeding $150,000 or to imprisonment for a term not exceeding 5 years. If there has been a flagrant breach of copyright, Standards New Zealand may also seek additional damages from the infringing party, in addition to obtaining injunctive relief and an account of profits.
11. Regardless of where you are when downloading these PDF files you accept and acknowledge that to the fullest extent possible you submit to New Zealand law with regard to this licence and to your use of each of the PDF files.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Terms and conditions / legal notice

Standards New Zealand: PDF NZS and AS/NZS Download Terms & Conditions

You are about to download material which is subject to strict conditions of use. Copyright in this material is owned by Standards New Zealand. Please read these terms and conditions carefully. By continuing with this download you, as the named user, are agreeing to be bound by all of these terms and conditions:

1. You are purchasing a single-user licence to store one or more non-revisable PDF files on your personal computer.
2. **You may print out and retain ONE printed copy of each downloaded PDF file.**
3. You acknowledge that Standards New Zealand retains title and ownership of the copyright in each PDF file and the corresponding permitted printed copy at all times.
4. Under this license use of both the PDF files and the single permitted printed copy of each PDF file you may make are restricted to you. Under no circumstances are you permitted to sell, transfer, or copy any of the PDF files, the one permitted printed copy of each PDF file, or any part of either of them.
5. You undertake that you will not modify, adapt, translate, reverse engineer, decompile, disassemble or create derivative works based on any of the downloaded PDF files, nor will you merge any of them with any other software or document, even for internal use within your organization.
6. Under no circumstances may any PDF file you are downloading be placed on a network of any sort without the express permission of Standards New Zealand. Requests for network licence quotations should be emailed to enquiries@standards.govt.nz
7. You acknowledge that you are solely responsible for the selection of the PDF files that you download and that any advice or recommendation given by Standards New Zealand or its employees or agents about any aspect of any of the PDF files is intended for guidance only and is followed or acted upon entirely at your own risk.
8. Standards New Zealand is not aware of any inherent risk of viruses in any of the PDF files at the time that it is downloaded. Standards New Zealand has exercised due diligence to ensure, so far as practicable, that such files do not contain such viruses.
9. No warranty of any form is given by Standards New Zealand or by any party associated with Standards New Zealand with regard to any of the PDF files, and you accept and acknowledge that Standards New Zealand will not be liable in any way to you or any to other person in respect of any loss or damage, however caused which may be suffered or incurred or which may arise directly or indirectly through any use of any of the PDF files.
10. Standards New Zealand will vigorously defend the copyright in all its publications. Every person who breaches Standards New Zealand's copyright may be liable, under section 131(5) (a) of the Copyright Act 1994, to a fine not exceeding $10,000 for every infringing copy to which the offence relates, but not exceeding $150,000 for the same transaction, or to imprisonment for a term not exceeding 5 years. Those in breach under section 131(5) (b) of the Copyright Act 1994 may be liable to a fine not exceeding $150,000 or to imprisonment for a term not exceeding 5 years. If there has been a flagrant breach of copyright, Standards New Zealand may also seek additional damages from the infringing party, in addition to obtaining injunctive relief and an account of profits.
11. Regardless of where you are when downloading these PDF files you accept and acknowledge that to the fullest extent possible you submit to New Zealand law with regard to this licence and to your use of each of the PDF files.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

New Zealand Standard

Automatic fire sprinkler systems

Superseding NZS 4541:2013

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

ISBN (Print) 978-1-77686-030-2
ISBN (PDF) 978-1-77686-031-9

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

CONTENTS

Committee representation ..... IFC
Acknowledgement ..... IFC
Copyright ..... IFC
Referenced documents xv
Latest revisions xix
Review of standards xix
Foreword xx

Section

1 GENERAL 1
1.1 Scope 1
1.2 Interpretation 1
1.3 Definitions 1
1.4 Abbreviations 7
1.5 Notations 10
1.6 Inspection testing and maintenance 12
1.7 Seismic resistance 12
1.8 Workmanship, competency, and qualifications 12
1.9 Typical arrangements 13
1.10 Welding compliance 13
1.11 Hydrostatic tests 13
1.12 Roles and responsibilities of SSC 14
1.13 Formal interpretations 15
1.14 Sprinkler system certificate of compliance methodology 15
1.15 Listing of contractors 17
1.16 Listing of equipment 18
1.17 Withdrawal of listing 18
1.18 Existing installations 19
1.19 Alternative design criteria 19
1.20 Sprinkler system decommissioning 19
2 BASIC RULES OF DESIGN 21
2.1 Installer to be listed 21
2.2 Minimum required discharge and design flow 21
2.3 Determination of fire hazard 21
2.4 Extent of sprinkler protection 30
2.5 Fire loads adjoining, linked, or adjacent to the sprinkler-protected building or sprinkler-protected firecell 30
2.6 External fire loads adjacent to the sprinkler-protected building or sprinkler-protected firecell 33
2.7 Requirements for external sprinklers and internal drenchers 36
2.8 Permitted exceptions from sprinklering 37
2.9 Provision of block plan 41

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

2.10 Provision of supply reference information 41
2.11 Multistorey buildings 45
2.12 Buildings constructed with expanded plastic cored insulated panels 45
2.13 Features likely to impair sprinkler efficacy 47
3 TYPES OF INSTALLATIONS 49
3.1 General 49
3.2 Conventional sprinkler installations 49
3.3 Deluge installations 59
3.4 Water mist installations 60
3.5 Methods to determine water delivery for gas filled sprinkler installations 60
4 SYSTEM COMPONENTS 63
4.1 General 63
4.2 Sprinklers 63
4.3 Pipework 70
4.4 Valves 107
4.5 Enhanced safety valve set 115
4.6 Pressure gauges 116
4.7 Alarm devices 117
4.8 Storage height limitation indicators 126
4.9 Aerosol warning signs 126
4.10 Labelling 127
5 LOCATION OF SPRINKLERS 129
5.1 General 129
5.2 Walls and partitions 129
5.3 Ceilings and roofs 130
5.4 Position of sprinklers 132
5.5 Vertical obstructions to sprinkler discharge 132
5.6 Columns 135
5.7 Open roof trusses 135
5.8 Clear space below sprinklers 135
5.9 Spacing and location of sidewall sprinklers 136
5.10 Locations or conditions requiring special consideration 137
5.11 Obstructions below sprinklers 143
5.12 Film and television production studios 149
5.13 Theatres and music halls 149
5.14 Fixtures and fittings 149
5.15 Skylight shafts 150
5.16 External sprinklers 150
5.17 Extended coverage ordinary hazard and extended coverage light hazard sprinklers - Special requirements 152

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6 WATER SUPPLY 155
6.1 General 155
6.2 Classes of water supply 155
6.3 Flow and pressure requirements 159
6.4 Town's main, boosted town's main, and supplemented town's main 159
6.5 Pumped supplies – Water sources 170
6.6 Water storage 173
6.7 Pumped supplies – Pump units 178
6.8 Elevated tanks 195
6.9 Pressure tanks 195
6.10 Fire sprinkler inlets 195
6.11 Proving of water supplies 202
6.12 Private site fire mains 204
7 EXTRA LIGHT HAZARD SYSTEM DESIGN DATA 205
7.1 Water supplies 205
7.2 Sprinkler type and spacing 206
7.3 Pipework 207
7.4 Storage areas and drying rooms 207
8 ORDINARY HAZARD SYSTEM DESIGN DATA 209
8.1 Design criteria, pipe sizing, and water supplies 209
8.2 Sprinkler type and spacing 214
8.3 Special requirements for vehicle stacker sprinkler systems 215
9 EXTRA HIGH HAZARD SYSTEM DESIGN DATA 221
9.1 Scope 221
9.2 Extra high hazard class terminology 222
9.3 General system design requirements 234
9.4 General installation requirements, EHH 239
9.5 Categorised commodities design requirements 283
10 FULLY HYDRAULICALLY CALCULATED DESIGN 301
10.1 General 301
10.2 Design requirements 302
10.3 Determination of area of operation 302
10.4 Determination of design flow and pressure 306
10.5 Method of calculation 306
10.6 Documentation 309

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

11 FIRE PROTECTION SYSTEM SHUTDOWN PRECAUTIONS 311
11.1 General 311
11.2 Risk assessment 311
11.3 Notification and authorisation 311
11.4 Isolation tags for sections of a sprinkler system 314
11.5 Hot work precautions 315
11.6 Methods of temporarily isolating system sections 316
11.7 Interruption to water supplies 316
12 ROUTINE TESTING, MAINTENANCE, AND INSPECTIONS 317
12.1 General 317
12.2 Routine tests and maintenance 318
12.3 Routine inspections 323
12.4 Twelve-yearly inspections 325
12.5 Testing of sprinklers 325
12.6 Water supply strainers 326
12.7 Testing of antifreeze solutions 326

Appendix

A Testing of dry and pre-action systems – Example form (Informative) 329
B Alternative method of protection of certain small community buildings for which a sprinkler system is not a legal requirement (Normative) 331
C Evaluation of contractors by a sprinkler system certifier (Normative) 335
D Certificate of listing of contractor (Normative) 337
E Sprinkler system certificate of compliance (Normative) 338
F Guidelines for evaluation of equipment for listing by a sprinkler system certifier (SSC) (Normative) 343
G Retrospective upgrades (Informative) 346
H Sprinkler system storage declaration (Informative) 348
J Material classifications (Informative) 352
K Sprinkler protection design requirements for buildings constructed with foamed plastic cored insulated panels (Normative) 369
L Recommendations for frost protection measures for fire sprinkler systems (Informative) 372
M Water mist fire protection (Informative) 374
N Test certificate for flushing underground piping (Informative) 378
O Orifice plates (Informative) 382
P Pipework design for seismic resilience – Flow charts (Informative) 385
Q Aerosol warning signs (Normative) 388
R Testing of territorial authority water mains (Normative) 390
S Information to be provided when ordering a pump unit (Informative) 392
T Contact details of agencies to be informed when a sprinkler installation is rendered inoperative (Informative) 393
U Maintenance provisions for non-standard sprinkler systems (Informative) 394

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 : 2020

COPYRIGHT © Standards New Zealand

V Guidance on the testing of sprinklers (Informative) 396
W Frost protection – Electrical requirements (Normative) 398
Index 399

Table

2.1 Representative schedule of occupancies and hazard classes 23
2.2(a) Limits on storage of conventional commodities in OH3 occupancies 25
2.2(b) Limits on incidental storage in OH1 and OH2 occupancies 25
2.2(c) Limits on incidental storage of special commodities in OH3 occupancies 26
2.3 Comparison of classification of flammable liquids designations as specified in NFPA 30 and Hazardous Substances (Classification) Regulations 28
2.4 Classification of external fire loads 34
2.5 Minimum separation distances 35
2.6 Block plan sprinkler information 41
2.7 Typical reference pressure schedule 44
2.8 Design data for protection of expanded plastic cored panels 46
3.1 Properties of antifreeze solutions 56
3.2 Gas-filled water delivery calculation design requirements 61
4.1 Acceptable types of sprinklers 66
4.2 Temperature classification of sprinklers – Rating and colour 67
4.3 Minimum distance from edge of heat sources to nearest sprinkler 68
4.4 Pipe and jointing options for underground pipework 70
4.5 Pipe and jointing options for above-ground pipework 71
4.6 Rates of flow required for flushing mains pipe diameters 73
4.7 Suitable supports 76
4.8 Zone values and shortest major fault distances D for New Zealand locations (north to south) 79
4.9 Component risk factor per building importance level 83
4.10 Mass of water-filled pipe 84
4.11 Maximum allowable lateral brace spacing (m) 85
4.12 Horizontal design loads for U-bolts 90
4.13 Maximum permitted rod length without sleeving for Θ = 30° to vertical 94
4.14 Maximum permitted rod length without sleeving for Θ = 45° to vertical 94
4.15 Maximum permitted rod length without sleeving for Θ = 60° to vertical 95
4.16 Maximum capacity of horizontal loads of typical pipework brace elements with l/r = 100 (ULS design) 96
4.17 Maximum capacity of horizontal loads of typical pipework brace elements with l/r = 200 (ULS design) 97
4.18 Maximum capacity of horizontal loads for various lengths of 25 NB medium wall pipe (ULS design) 98
4.19 Maximum capacity of horizontal loads for various lengths of 10 mm threaded rod (ULS design) 98

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

4.20 Maximum capacity of horizontal loads for various lengths of 12 mm threaded rod (ULS design) 98
4.21 Horizontal load capacity of typical connections (ULS Design) 99
5.1 Spacing arrangements 132
5.2 Sprinkler distances from obstructions 133
5.3 Maximum distance of residential sprinklers above bottom of ceiling obstruction (where not specified by manufacturer) 135
5.4 Obstructions to standard sidewall sprinkler discharge 136
5.5 Extra light hazard standard spray and extended coverage sprinklers distances from suspended or floor mounted obstructions 143
5.6 Sprinkler positioning above open grid or perforated ceilings and decks 145
5.7 Sprinkler protection requirements below open grid or perforated ceilings and grids 146
5.8 Sprinkler spacing rules for cloud skipping 147
5.9 External sprinkler spacing and location 151
5.10 ECOH and ECLH sprinkler distances from ceiling mounted obstructions 153
6.1 Duration of water supplies for EHH occupancies 169
6.2 Nominal fuel duration 190
6.3 Number of inlets 199
7.1 Minimum pipe sizes for pre-calculated extra light hazard sprinkler arrays 206
7.2 Friction losses for pipe diameters at 270 L/min 207
8.1 OH1, OH2, and OH3 sprinkler numbers for coverage areas 209
8.2 OH3S – Minimum design density of discharge for ceiling heights 209
8.3 Design criteria for storage of Category 1 to 4 commodities in OH4 occupancies storage height ≤ 3.7 m 210
8.4 Design criteria for storage of Category 5 and 6 commodities in OH4 occupancies storage height ≤ 3.7 m 211
8.5 Maximum number of sprinklers on tabular pipework 213
8.6 Loss of pressure per metre of pipe 214
8.7 Design criteria for vehicle stackers 217
9.1 Reference standards for special commodities 221
9.2 Design density and design area for process occupancies 236
9.3 Maximum area coverage per roof/ceiling sprinkler 237
9.4 Storage sprinklers under sloped ceilings 240
9.5 Spacing of ceiling-level storage sprinklers 241
9.6 Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of storage sprinklers (not extended coverage) 247
9.7 Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of extended coverage storage sprinklers 248
9.8 Installation guidelines to avoid obstructions to inner core distribution pattern of storage sprinklers 250
9.9 Hydraulic design for in-rack sprinkler systems 266
9.10 Hydraulic design for ceiling-level sprinkler systems supplemented with in-rack sprinklers 266

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

9.11 Number of sprinklers in the in-rack design 274
9.12 Minimum flow in the in-rack design 274
9.13 Summary of ceiling-level protection tables 284
9.14(a) Ceiling-level protection guidelines for Categories 1, 2, and 3 commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement 286
9.14(b) Ceiling-level protection guidelines for Category 4 and Category 5 cartoned unexpanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement 287
9.14(c) Ceiling-level protection guidelines for cartoned Category 6 expanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement 288
9.14(d) Ceiling-level protection guidelines for uncartoned Category 5 unexpanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement 289
9.14(e) Ceiling-level protection guidelines for uncartoned Category 6 expanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement 290
9.14(f) Ceiling-level protection guidelines for Categories 1, 2, and 3 commodities in open-frame rack storage arrangements 291
9.14(g) Ceiling-level protection guidelines for Category 4 and cartoned Category 5 unexpanded plastic commodities in open-frame rack storage arrangements 292
9.14(h) Ceiling-level protection guidelines for cartoned Category 6 expanded plastic commodities in open-frame rack storage arrangements 293
9.14(i) Ceiling-level protection guidelines for uncartoned Category 5 unexpanded plastic commodities in open-frame rack storage arrangements 294
9.14(j) Ceiling-level protection guidelines for uncartoned Category 6 expanded plastic commodities in open-frame rack storage arrangements 295
9.14(k) Ceiling-level sprinkler system designs for Categories 1 and 2 commodities protected by dry-pipe and similar sprinkler systems 298
9.14(l) Ceiling-level sprinkler system designs for Category 3 commodities protected by dry-pipe and similar sprinkler systems 299
10.1 Accuracy required for dimensions used in design requirements calculations 306
10.2 Values of R for steel and chlorinated PVC pipes 308
10.3 Hazen-Williams loss of pressure factors for flow direction changes in pipes 308
12.1 Routine tests and maintenance frequency tolerances 319
C1 Scope of listing 336
H1 Representative list of material categories 350
J1 Commodity and category examples – Alphabetical listing 352
J2 Commodity and category examples – Listed by category 360
O1 Pipes of 50 mm and 65 mm diameter and 500 L/min flow 383
O2 Pipes of 80 mm to 200 mm diameter and 5000 L/min flow 384

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Figure

1.1 Definition of range and distribution pipes 3
1.2 Typical fire sprinkler system 13
2.1(a) Link to unprotected building with eave height ≥ 600 mm 32
2.1(b) Link to unprotected building with eave height < 600 mm 32
2.2 Typical external sprinklers 37
2.3 Permitted exceptions from sprinklering of concealed spaces 40
2.4 Display of water supply reference information 43
3.1 Typical subsidiary floor valve arrangement 50
3.2 Typical tail-end antifreeze installation valves 58
4.1(a) Hazard factor, Z, for the North Island 81
4.1(b) Hazard factor, Z, for the South Island 82
4.2 Bracing in two orthogonal horizontal directions 83
4.3 Maximum lateral brace spacing 85
4.4 Location of pipework bracing 86
4.5(a) Examples of tributary lengths of pipe in the zone of influence for braces (east-west) 88
4.5(b) Examples of tributary lengths of pipe in the zone of influence for braces (north-south) 89
4.6 Elements of lateral braces for horizontal pipe 91
4.7 Elements of longitudinal braces for horizontal pipe 91
4.8 Elements of braces for vertical pipe 91
4.9 Option to brace horizontal pipe using two opposing diagonal elements 92
4.10 Four-way bracing on vertical pipe using two diagonal elements 93
4.11 Diagram of vertical force component F_v 93
4.12 Seismic separation assembly (SSA) 102
4.13 Droppers to non structural elements 104
4.14 Short droppers 105
4.15 Long droppers 106
4.16 Configuration of air supply for dry pipe systems in refrigerated areas 111
4.17 Enhanced safety valve set arrangement 116
4.18 Wet pipe control valve showing an acceptable arrangement for type 'X' signalling complying with 4.7.2.2.1 119
4.19 Wet pipe control valve showing an acceptable arrangement for type 'Y' signalling complying with 4.7.2.2.2 121
4.20 Typical dry pipe control valve arrangement 122
4.21 Arrangement for single sprinkler system 124
4.22 Arrangement for multiple sprinkler systems 125
4.23 Storage height limitation sign 126
5.1 Example of application of 5.2.4 129
5.2(a) Shadow area in corridor 130
5.2(b) Example of a shadow area 130

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

5.3 Positioning of sprinkler heads 131
5.4 Sprinkler distances from obstructions 133
5.5 Obstruction area to umbrella pattern of pendent and upright non-storage sprinklers (excluding extended-coverage sprinklers) 134
5.6 Position of residential sprinkler deflector when located above the bottom of a ceiling obstruction 134
5.7 Installation of horizontal sidewall sprinklers using soffits 137
5.8 Sprinkler positions for machines in tiers 139
5.9 Location of sprinklers in extraction ducts 142
5.10 Position of sprinkler head to avoid suspended or floor mounted obstruction to sprinkler discharge (extra light hazard standard spray and extended coverage sprinklers) 144
5.11 Open grid ceilings dimension definitions 146
5.12 Additional sprinklers installed below flat, continuous, solid obstructions between 0.8 m and 3.0 m wide 147
5.13 Additional sprinklers installed below non flat, non-continuous, or non-solid obstructions between 0.8 m and 3.0 m wide with flat, continuous, solid barrier provided 148
5.14 Additional sprinklers installed below non flat, non-continuous, or non-solid obstructions between 1.2 m and 3.0 m wide without a flat, continuous, solid barrier provided 148
5.15 Sprinkler positioning under eaves 152
5.16 Position of sprinkler head to avoid obstruction to sprinkler discharge (extended coverage upright and pendent spray sprinklers) 153
5.17 Minimum distance from obstruction (extended coverage upright and pendent spray sprinklers) 154
6.1 Water supply classes – Typical diagrammatic layouts 157
6.2 Diagrammatic key to water supply requirements 158
6.4 Permissible supply to hydrants from town's main sprinkler connections – Diagrammatic layout (Class C1 supply) 162
6.5 Illustrative example of hydrant allowance (see 6.4.1.7.2) 163
6.6 Typical arrangement for boosted town's main without pressure relief line 165
6.7 Typical arrangement for boosted town's main with pressure relief line 166
6.8 Typical arrangement for boosted town's main with pressure reducing valve system 167
6.9 Typical arrangement for supplemented town's main (using infill tank) 168
6.10 Typical arrangement for pump and tank supply 171
6.11 Typical arrangement for Class A2 water supply 172
6.12 Pump suction waterway fittings 182
6.13 Diesel engine water cooling unit 185
6.14 Diesel engine controller logic unit 189
6.15 FSI standard requirements 197
6.16 Details of box lock 198
6.17 Fire sprinkler inlet arrangement for multiple valve sets 201

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

8.1 Typical arrangement of open-frame vehicle stacker sprinklers 217
8.2 Typical arrangement of single column vehicle stacker sprinklers....218
8.3 Typical arrangement of single-row vehicle stacker sprinklers 218
8.4 Typical arrangement of pit vehicle stacker sprinklers....219
8.5 Typical arrangement of pit vehicle stacker sprinklers....219
9.1(a) Double-row racks – Without solid or slatted shelves 222
9.1(b) Double-row racks – With solid shelves 223
9.1(c) Double-row racks – With slatted shelves 223
9.2 Typical double-row (back-to-back) rack arrangement 225
9.3(a) Multiple-row rack – Flow-through racks....226
9.3(b) Multiple-row rack – Double deep rack, serviced by reach (forklifts) truck 227
9.4 Typical pallets....228
9.5 Portable racks 229
9.6(a) Rack storage – Automatic storage type rack....230
9.6(b) Rack storage – Flow-through pallet rack 231
9.6(c) Rack storage – Drive-in rack, two or more pallets deep – Forklift truck drives into rack to deposit or withdraw loads in the depth of the rack....231
9.6(d) Rack storage – Cantilever rack....232
9.7 Portable rack using wood pallet base and steel frame 233
9.8 Examples of adjacent areas with differing design criteria 238
9.9 Maximum increase in linear and area spacing to avoid obstructing sprinkler discharge....242
9.10 Location of sprinklers under non smooth ceilings....243
9.11 Quick response sprinklers installed under automatic smoke and heat vents....245
9.12 Quick response sprinklers installed under ceiling-level exhaust devices....246
9.13 Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of storage sprinklers (not extended coverage) 248
9.14 Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of extended coverage storage sprinklers 248
9.15 Obstruction to inner core discharge pattern of ceiling-level storage sprinklers....249
9.16 Upright storage sprinklers can tolerate individual objects up to 100 mm wide located directly below them at any vertical distance. 250
9.17 Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects up to 20 mm wide 251
9.18 Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 20 mm and up to 32 mm wide 251
9.19 Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 32 mm and up to 50 mm wide 252
9.20 Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 50 mm and up to 300 mm wide 252

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

9.21 Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 300 mm and up to 600 mm wide 254
9.22 Additional sprinklers installed below flat, continuous solid obstructions from over 0.6 m wide to 3.0 m wide 254
9.23 Additional sprinkler installed below non flat, non continuous, or non solid obstructions more than 0.6 m wide up to 3.0 m wide 255
9.24 Additional sprinkler installed below non flat, non continuous, or non solid obstructions over 0.6 m and up to 3.0 m wide without a flat, continuous, solid barrier provided 255
9.25 Additional sprinklers installed within storage racks to account for obstructions to the inner core distribution pattern of a sprinkler 256
9.26 Elevation view of in-rack sprinkler locations with roof level to previous editions of the standard 258
9.27(a) Plan view of IRS(EO) in-rack sprinkler arrangement for single-row racks 260
9.27(b) Plan view of IRS(EO) in-rack sprinkler arrangement for double-row racks 261
9.27(c) Plan view of IRS(EO) in-rack sprinkler arrangement for multiple-row racks 261
9.28(a) Plan view of IRS(E) in-rack sprinkler arrangement for single-row racks 262
9.28(b) Plan view of IRS(E) in-rack sprinkler arrangement in longitude flue only double-row racks 263
9.28(c) Plan view of IRS(E) in-rack sprinkler arrangement for double-row racks 263
9.28(d) Plan view of IRS(E) in-rack sprinkler arrangement for multiple-row racks 264
9.29(a) Fire Protection Scheme A within single-row racks 268
9.29(b) Fire Protection Scheme A within double-row racks 269
9.29(c) Fire Protection Scheme A within multiple-row racks 270
9.30(a) Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 0.9 m deep 271
9.30(b) Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 1.8 m deep 272
9.30(c) Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 1.8 m deep located against wall 272
9.30(d) Plan view of alternative in-rack sprinkler arrangement for double-row racks up to 2.7 m deep 272
9.30(e) Plan view of alternative in-rack sprinkler arrangement for double-row racks up to 3.7 m deep 273
9.30(f) Plan view of alternative in-rack sprinkler arrangement for multiple-row racks 273
9.31 Determining ceiling height in applicable protection table 275
9.32(a) Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in single-row racks, Option 3 277
9.32(b) Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in single-row racks, Option 2 278

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.32(c) Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in double-row racks, Option 2 279
9.32(d) Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in double-row racks, Option 2 280
9.32(e) Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in multiple-row racks, Option 2 281
9.32(f) Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in multiple-row racks, Option 2 282
10.1 Determination of mean area per sprinkler 303
10.2 Location and shape of hydraulically 'most remote' area of operation 304
11.1 Typical form for notifying that an installation is to be rendered inoperative 313
11.2 Typical form for isolation tag card 315
12.1 Density of propylene glycol in solution 327
12.2 Specific gravity of glycerine in solution (% by volume) 328
B1 Option for arrangement of control valves 332
B2 Building owner declaration form 334
E1 Compliance flow chart for new systems 339
E2 Compliance flow chart for biennial inspections 340
E3 Compliance flow chart for extensions or alterations to existing systems 341
E4 Compliance flow chart for systems installed to other standards 342
H1 Declaration of storage intentions 349
N1 Flow rates by pipe diameter 379
N2 Test certificate for flushing underground piping 381
P1 Design sprinkler system seismic resilience 385
P2 Determine seismic coefficient C 386
P3 Design of braces 387
Q1 Example of a graphic symbol to accompany warning signs prohibiting the storage of aerosols 389
R1 Water supply flow graph 391

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Referenced documents

Reference is made in this document to the following:

New Zealand standards

NZS 1170: - - - -	Structural design actions
Part 5:2004	Earthquake actions – New Zealand
NZS 3501:1976	Specification for copper tubes for water, gas, and sanitation
NZS 3604:2011	Timber-framed buildings
NZS 4219:2009	Seismic performance of engineering systems in buildings
NZS 4503:2005	Hand operated fire-fighting equipment
NZS 4510:2008	Fire hydrant systems for buildings
NZS 4512:2010	Fire detection and alarm systems in buildings
NZS 4515:2009	Fire sprinkler systems for life safety in sleeping occupancies (up to 2000 square metres)
NZS 4517:2010	Fire sprinkler systems for houses
NZS 4520:2010	Fire-resistant doorsets
NZS 4541:1972P	Automatic fire sprinkler systems (Withdrawn)
NZS 4541:1987	Automatic fire sprinkler systems (Withdrawn)
NZS 4541:1996	Automatic fire sprinkler systems (Withdrawn)
NZS 4541:2003	Automatic fire sprinkler systems (Superseded by NZS 4541:2007)
NZS 4541:2007	Automatic fire sprinkler systems (Superseded by NZS 4541:2013)
NZS 4541:2013	Automatic fire sprinkler systems (Superseded by NZS 4541:2020)
NZS 4781:1973	Code of practice for safety in welding and cutting
NZS 7643:1979	Code of practice for the installation of unplasticized PVC pipe systems
NZS 7702:1989	Specification for colours for identification, coding and special purposes (Withdrawn)
SNZ PAS 4505:2007	Firefighting waterway equipment

Joint Australian/New Zealand standards

AS/NZS 1170:- - - -	Structural design actions
Part 0:2002	General principles
Part 1:2002	Permanent, imposed and other actions
Part 2:2011	Wind actions
Part 3:2003	Snow and ice actions
AS/NZS 1477:2017	PVC pipes and fittings for pressure applications
AS/NZS 1530: - - - -	Methods for fire tests on building materials, components and structures
Part 3:1999	Simultaneous determination of ignitability, flame propagation, heat release and smoke release
AS/NZS 2032:2006	Installation of PVC pipe systems
AS/NZS 2033:2008	Installation of polyethylene pipe systems
AS/NZS 2566:- - - -	Buried flexible pipelines
Part 2:2002	Installation
AS/NZS 2642:- - - -	Polybutylene (PB) pipe systems
Part 1:2007	Polybutylene (PB) pipe extrusion compounds
Part 2:2008	Polybutylene (PB) pipe for hot and cold water applications

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Part 3:2008	Mechanical jointing fittings for use with polybutylene (PB) pipes for hot and cold water applications
AS/NZS 2980:2018	Qualification of welders for fusion welding of steels
AS/NZS 3000:2007	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 4129:2008	Fittings for polyethylene (PE) pipes for pressure applications
AS/NZS 4130:2018	Polyethylene (PE) pipes for pressure applications
AS/NZS 4441:2017	Oriented PVC (PVC-O) pipes for pressure applications
AS/NZS 4765:2017	Modified PVC (PVC-M) pipes for pressure applications
AS/NZS ISO 9000:2016	Quality management systems – Fundamentals and vocabulary
AS/NZS ISO 9001:2016	Quality management systems – Requirements
AS/NZS ISO/IEC 17020:2013	Conformity assessment – Requirements for the operation of various types of bodies performing inspection
AS/NZS ISO/IEC 17021:- - - -	Conformity assessment – Requirements for bodies providing audit and certification of management systems
Part 1:2015	Requirements

International

IEC 60947:- - - -	Low-voltage switchgear and controlgear
Part 4-1:2012	Contactors and motor-starters – Electromechanical contactors and motor-starters
IEC 60896:- - - -	Stationary lead-acid batteries
Part 11:2002	Vented types – General requirements and methods of tests
ISO 6182 - - - -	Fire protection – Automatic sprinkler systems
Part 1:2014	Requirements and test methods for sprinklers
Part 7:2004	Requirements and test methods for early suppression fast response (ESFR) sprinklers
ISO 9705:- - - -	Reaction to fire tests – Room corner test for wall and ceiling lining products
Part 1:2016	Test method for a small room configuration

Australian standards

AS 1074:1989	Steel tubes and tubulars for ordinary service (Reconfirmed 2018)
AS 1851:2012	Routine service of fire protection systems and equipment
AS 2845: - - - -	Water supply – Backflow prevention devices
Part 3:2010	Field testing and maintenance
AS 4029: - - -	Stationary batteries – Lead-acid
Part 1:1994	Vented type
AS 4118: - - - -	Fire sprinkler systems
Part 2.1:1995	Piping – General
AS 4587:1999	Water mist fire protection systems – System design, installation and commissioning
AS ISO 9906:2018	Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3

American standards

ASTM A53/A53M-18	Standard specification for pipe, steel, black and hot-dipped, zinc-coated, welded and seamless

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

ASTM A312/A312M-18a	Standard specification for seamless, welded, and heavily cold worked austenitic stainless steel pipes
ASTM A315/A315M-09	Standard specification for electric-resistance-welded steel pipe
ASTM A403/A403M-19	Standard specification for wrought austenitic stainless steel piping fittings
ASTM A795/A795M-13	Standard specification for black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe for fire protection use
ASTM D2261-13e1 (2017)	Standard test method for tearing strength of fabrics by the tongue (single rip) procedure (constant-rate-of-extension tensile testing machine)
ASTM E711-87 (2004)	Standard test method for gross calorific value of refuse-derived fuel by the bomb calorimeter (Withdrawn 2004)
ASTM F439-19	Standard specification for chlorinated poly (vinyl chloride) (CPVC) plastic pipe fittings, Schedule 80
ASTM F442/F442M-19	Standard specification for chlorinated poly(vinyl chloride) (CPVC) plastic pipe (SDR–PR)
NFPA 13-2019	Installation of sprinkler systems
NFPA 13D-2019	Installation of sprinkler systems in one- and two-family dwellings and manufactured homes
NFPA 13R-2019	Installation of sprinkler systems in low-rise residential occupancies
NFPA 15-2017	Water spray fixed systems for fire protection
NFPA 16-2019	Installation of foam-water sprinkler and foam-water spray systems
NFPA 20-2019	Installation of stationary pumps for fire protection
NFPA 24-2019	Installation of private fire service mains and their appurtenances
NFPA 25-2017	Inspection, testing, and maintenance of water-based fire protection systems
NFPA 30-2018	Flammable and combustible liquids code
NFPA 409-2016	Aircraft hangars
NFPA 750-2019	Water mist fire protection systems

British standards

BS 2971:1991	Specification for class II arc welding of carbon steel pipework for carrying fluids
BS 3600:1997	Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes (Withdrawn and replaced by BS EN 10220:2002)
BS 5514: - - - -	Reciprocating internal combustion engines: performance
Part 1:1996	Standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods (ISO 3046/1:1995) (Withdrawn and replaced by BS ISO 3046-1:2002)
BS EN 1982:2017	Copper and copper alloys. Ingots and castings
BS EN 10255:2004	Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions

Military

MIL-C-8068B:2000	Cloth, coated, nylon, rubber-coated fuel-resistant
MIL-T-6396E:2006	Tanks, aircraft propulsion fluid system, internal removable, non-self-sealing

Other publications

ACI 355.2R-01	Evaluating the performance of post-installed mechanical anchors in concrete and masonry (American Concrete Institute)
ETAG 001	Metal Anchors for Use in Concrete Annex E: Assessment of Metal Anchors under Seismic Action (European Technical Approval Guideline)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

FM Approvals Standard 4880:2015 – *Class 1 Fire Rating of Building Panels or Interior Finish Materials*

FM Global Property Loss Prevention Data Sheets:

- Data Sheet 1-57, *Plastics in construction*. 2018 Edition
- Data Sheet 1-59, *Fabric and membrane structures*. 2014 Edition
- Data Sheet 2-8, Earthquake protection for water-based fire protection systems. 2017 Edition
- Data Sheet 5-4, *Transformers*. 2017 Edition
- Data Sheet 7-11, *Belt conveyors*. 2017 Edition
- Data Sheet 7-29, Ignitable liquid storage in portable containers. 2018 Edition
- Data Sheet 7-31, *Storage of aerosol products*. 2019 Edition
- Data Sheet 7-32, *Ignitable liquids operations*. 2018 Edition
- Data Sheet 7-74, *Distilleries.* 2010 Edition
- Data Sheet 8-1, *Commodity classification.* 2015 Edition
- Data Sheet 8-3, *Rubber tire storage.* 2009 Edition
- Data Sheet 8-7, *Baled fiber storage.* 2017 Edition
- Data Sheet 8-9, Storage of class 1, 3, 3, 4 and plastic commodities. 2018 and 2019 Edition
- Data Sheet 8-18, *Storage of hanging garments*. 2015 Edition
- Data Sheet 8-21, *Roll paper storage.* 2019 Edition
- Data Sheet 8-22, *Storage of baled waste paper*. 2013 Edition
- Data Sheet 8-24, *Idle pallet storage*. 2015 Edition
- Data Sheet 8-29, *Refrigerated storage.* 2007 Edition
- Data Sheet 8-33, *Carousel storage and retrieval systems*. 2004 Edition

LPCB LPS 1181: - - - -	Series of fire growth tests for LPCB approval and listing of construction product systems
Part 1:2014	Requirements and tests for built-up cladding and sandwich panel systems for use as the external envelope of buildings
Part 2:2014	Requirements and tests for sandwich panels and built up systems for use as internal construction in buildings
LPCB LPS 1208:2014	LPCB fire resistance requirements for elements of construction used to provide compartmentation
UBC 26-3	Room fire test standard for interior of foam plastic systems
UL 199:2017	Standard for automatic sprinklers for fire-protection service
UL 300:2014	Standard for fire testing of fire extinguishing systems for protection of commercial cooking equipment
UL 1626:2018	Standard for residential sprinklers for fire-protection service

Fire Offices' Committee. *Rules for automatic sprinkler installations*, 29th ed. London: Fire Offices' Committee, 1968.

Fire and Emergency New Zealand. *Designer's guide. Firefighting operations on automatic sprinklers systems* (F5-06 GD). Draft 13 June 2018. Retrieved from https://fireandemergency.nz/assets/Documents/Business-and-Landlords/Building-and-designing-for-fire-safety/F5-06-GD-Firefighting-operations-on-automatic-sprinkler-systems-guide.pdf (17 July 2019).

New Zealand Society for Earthquake Engineering. *Seismic design of storage tanks*. Wellington: New Zealand Society for Earthquake Engineering, 2009.

New Zealand legislation

Building Act 2004 and New Zealand Building Code Handbook and compliance documents

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Building (Forms) Regulations 2004

Building (Specified Systems, Change the Use, and Earthquake-prone Buildings) Regulations 2005

Charitable Trusts Act 1957

Chartered Professional Engineers of New Zealand Act 2002

Electricity Act 1992

Electricity (Safety) Regulations 2010

Fire and Emergency New Zealand (Fire Safety, Evacuation Procedures, and Evacuation Schemes) Regulations 2018

Fire and Emergency New Zealand Act 2017

Fire Safety and Evacuation of Buildings Regulations 2006

Fire Service Act 1975

Hazardous Substances and New Organisms (HSNO) Act 1996

Hazardous Substances (Classification) Regulations 2001

Health and Safety at Work (Hazardous Substances Regulations) 2017

Incorporated Societies Act 1908

Resource Management Act (RMA) 1991

Standards and Accreditation Act 2015

Te Ture Whenua Maori Act 1993

Websites

www.legislation.govt.nz
fireandemergency.nz
www.mbie.govt.nz
www.standards.govt.nz

Latest revisions

The users of this standard should ensure that their copies of the above-mentioned New Zealand standards are the latest revisions. Amendments to referenced New Zealand and joint Australian/New Zealand standards can be found on www.standards.govt.nz.

Review of standards

Suggestions for improvement of this standard will be welcomed. They should be sent to the Manager, Standards New Zealand, PO Box 1473, Wellington 6140.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Foreword

This revised edition of NZS 4541 supersedes NZS 4541:2013. It provides rules for the design, installation, and maintenance of sprinkler systems so that systems reliably achieve their fire-control function. That function is twofold: firstly, the fire should be controlled within a specified area and secondly, control should beachieved before levels of toxic by-products of combustion become life-threatening.

Compliance with this standard will provide a reliable level of fixed fire protection for the preservation of life, property and the environment based on sound engineering principles, fire test data, and through the review of sprinkler performance through field experience.

Compliance with this standard provides protection against a single fire event. It may not include protection against explosions or multiple simultaneous fires.

It is intended that the supporting documents to the New Zealand Building Code (NZBC) and the Fire Safety and Evacuation of Buildings Regulations will reference this edition of the standard, NZS 4541:2020, as the means of compliance. This is subject to:

(a) Publication of an amendment to the supporting documents to the NZBC Clause C Protection from fire; and

(b) An amendment to the Fire Safety and Evacuation of Buildings Regulations.

Until then, NZS 4541:2013 remains current as the means of compliance. Once NZS 4541:2013 is no longer referenced in the supporting documents to the NZBC Clause C Protection from fire, and in the Fire Safety and Evacuation of Buildings Regulations, NZS 4541:2013 will be advertised for withdrawal by Standards New Zealand.

For this reason, there will be a transition period with both NZS 4541:2013 and NZS 4541:2020 in force. It is suggested that users apply the latest edition where circumstances allow, so that experience is gained in working with NZS 4541:2020 before NZS 4541:2013 is withdrawn. This approach could be adopted under the provisions of NZS 4541:2013, clause 117, if approved by a sprinkler system certifier.

If users require assistance over this interim period, the committee recommends that guidance should be sought from territorial authorities, Standards New Zealand, or the Fixed Fire Protection Formal Interpretation Committee.

Users of this edition of NZS 4541 should note that sprinkler systems certified under previous editions of NZS 4541 will not need to be upgraded as a result of the publication of NZS 4541:2020 and the proposed amendment to the Regulations. This is due to the 'grandfathering' clause in Appendix G, which specifically provides that such systems are deemed to comply with NZS 4541:2020 for the purposes of the Fire Safety and Evacuation of Buildings Regulations.

The basis of this standard is protection of complete 'firecells' or complete buildings or groups of buildings. The standard has no integrity if applied to partial protection of areas that are not physically fire separated from others.

This standard is an integrated set of rules. The validity and effectiveness of any one rule is likely to depend on adherence to other rules. It is not possible to ignore or vary sections of this standard, except where this is provided for in the standard. The importance of detail cannot be over-emphasised. Experience in New Zealand, and internationally, has shown repeatedly that sprinkler system failure is likely to be the result of inattention to small details. Users of the standard are encouraged to apply all parts of the document.

It is anticipated that this standard will form part of a full fire-risk assessment protocol. Further information on risk assessment can be found in SA/SNZ HB 436:2013 *Risk Management Guidelines: a companion to AS/SNZ ISO 31000:2009*.

This revised standard includes some significant changes from previous editions of the standard, for seismic design of water storage tanks, high piled storage design criteria, and maintenance provisions. Many other changes have been made throughout the standard.

With the exception of systems installed in accordance with Appendix B (in certain small community buildings), the levels of reliability required by this standard are intended to maintain the existing record of satisfactory performance of sprinkler systems in New Zealand. Since the first systems were installed in the late 1880s, approved sprinklers have achieved their fire control function in better than 99.5% of the fires in which they have operated. By contrast, most western countries achieve at best only 95% successful performance.

In reviewing public comments made, the committee has recommended to Standards New Zealand that a number of issues be reviewed during the next revision of the standard. Additional recommendations and

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

submissions on how the standard can be improved are welcomed and can be directed to the Manager, Standards New Zealand, PO Box 1473, Wellington 6140.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

1 General

1.1 Scope

This standard sets out the requirements for the design, performance, installation and maintenance ofautomatic fire sprinkler systems. These integrated rules cover the systems' requirements for the detection, notification, and suppression or control of fire in the built environment.

1.2 Interpretation

For the purposes of this standard, the word 'shall' refers to requirements that are essential for compliance with the standard, while the word 'should' refers to practices that are advised or recommended.

Clauses prefixed 'C' and printed in italic type are intended as comments on the corresponding clauses. They are not to be taken as the only or complete interpretation. The standard can be complied with if the comment is ignored.

The terms 'normative' and 'informative' have been used in this standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a standard while an 'informative' appendix is only for information and guidance. However, where an informative appendix specifies a prescribed test procedure, the word 'shall' used in it means that if users elect to conduct this test, it shall be undertaken exactly as set out in the appendix.

The foreword, commentary, notes, figures, and informative appendices are included to assist interpretation of the substantive clauses of this standard.

Notes to tables form part of the mandatory requirements of this standard whereas notes elsewhere are for information and guidance only.

In this standard values for various parameters have been expressed as conversions of values originally expressed in foot-pound-second units. In some cases, a hard conversion (rounded to the nearest whole number) has been used; in others a soft conversion has been applied. For example, the value 305 mm derives from a hard conversion of 12 inches, whereas 300 mm is the value obtained by a soft conversion. Asthe original values have inevitably been rounded to rational numbers, engineering judgement shall beapplied in interpreting this standard and allowing appropriate tolerances on values of particular parameters where approved by a sprinkler system certifier (SSC).Testing has shown that small increases in ceiling heights can have a detrimental impact on sprinkler performance. The maximum ceiling heights stated in Part 9 should not be the subject of any engineering judgement.

The full titles of documents cited in this standard are given in the referenced documents immediately preceding the foreword.

1.3 Definitions

For the purposes of this standard, the following definitions shall apply:

NOTE – Part 9 has specific definitions. For details of these, see 9.2.

AEROSOL — A product in pressurised containers of up to 1 litre capacity designed to be released as a spray with the potential to 'rocket' when exposed to fire.

AISLE — See 9.2.2 for definition.

APPROVED — Subject to reported examination and acceptance by an SSC as meeting the normative criteria of the standard including, where applicable, reliable field performance.

ASSUMED AREA OF OPERATION (or assumed maximum area of operation) — The maximum expected area of sprinkler operation in a controlled fire.

BACK-TO-BACK SHELF STORAGE — Two solid or perforated shelves up to 800 mm in depth each, not exceeding a total depth of 1600 mm, separated by a longitudinal vertical barrier such as plywood, particleboard, sheet metal, or equivalent, with a maximum 6 mm penetration, no longitudinal flue space, and a maximum storage height of 4.6 m.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

BIN-BOX STORAGE See 9.2.3 for definition.

BUILDING HEIGHT Building height is as defined in the New Zealand Building Code (NZBC).

BUNDLED CABLES Any group of data, signal or power cables in bundles, trays or cable marshalling areas with a total cross-sectional area of more than 750 mm^2 (which equates to a single 31 mm diameter cable, three 18 mm diameter cables, or ten 10 mm cables).

CEILING POCKET An architectural ceiling feature that consists of a bounded area of ceiling located at a higher elevation than the attached lower ceiling (see 5.3.4).

CERTIFICATION A statement of compliance of a sprinkler installation with this standard.

CLEARANCE See 9.2.4 for definition.

COMBINED MAIN A pipe manifold normally located within a valve enclosure (see 4.4.1.2), supplied directly by more than one approved water supply via check valves.

COMMODITY The combination of product, packaging material, container and material handling aids (such as a pallet) upon which commodity classification isbased (see 9.2.5).

COMPARTMENT A space completely enclosed by walls and a ceiling. Each wall in the compartment is permitted to have openings to an adjoining space if the openings have a minimum lintel depth of 200 mm from the ceiling and the total width of the openings in each wall does not exceed 2.4 m. A single opening of 900 mm or less in width without a lintel is permitted when there are no other openings to adjoining spaces.

CONTRACTOR An organisation or person that carries out one or more of the following:
(a) Project management;
(b) Design;
(c) Supply;
(d) Erection;
(e) Fabrication;
(f) Maintenance and testing of sprinkler systems; or
(g) Routine inspection.

DESIGN DENSITY (density of discharge) The depth of water discharged in a given period of time expressed as mm/min (which is equivalent to $L/min.m^2$).

DESIGN FLOW The minimum flow rate required to supply the assumed area of operation with the specified density of discharge or the minimum flow rate required to operate the design number of sprinklers at the specified minimum operating pressure.

DESIGN POINT/S The hydraulically remote assumed area/s of operation in a sprinkler system.

NOTE – Pipework downstream of the design point is pre-calculated and given in tables in the standard. Design points are designated by letter on layout drawings and are classified as 4 or 18 sprinkler point and so on, according to the class of hazard. There will normally be more than one design point in any single installation.

DESIGN PRESSURE The minimum pressure required immediately downstream of the alarm valve to induce the design flow for each area of the protected building.

DISTRIBUTION PIPES Pipes directly feeding range pipes (see Figure 1.1).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

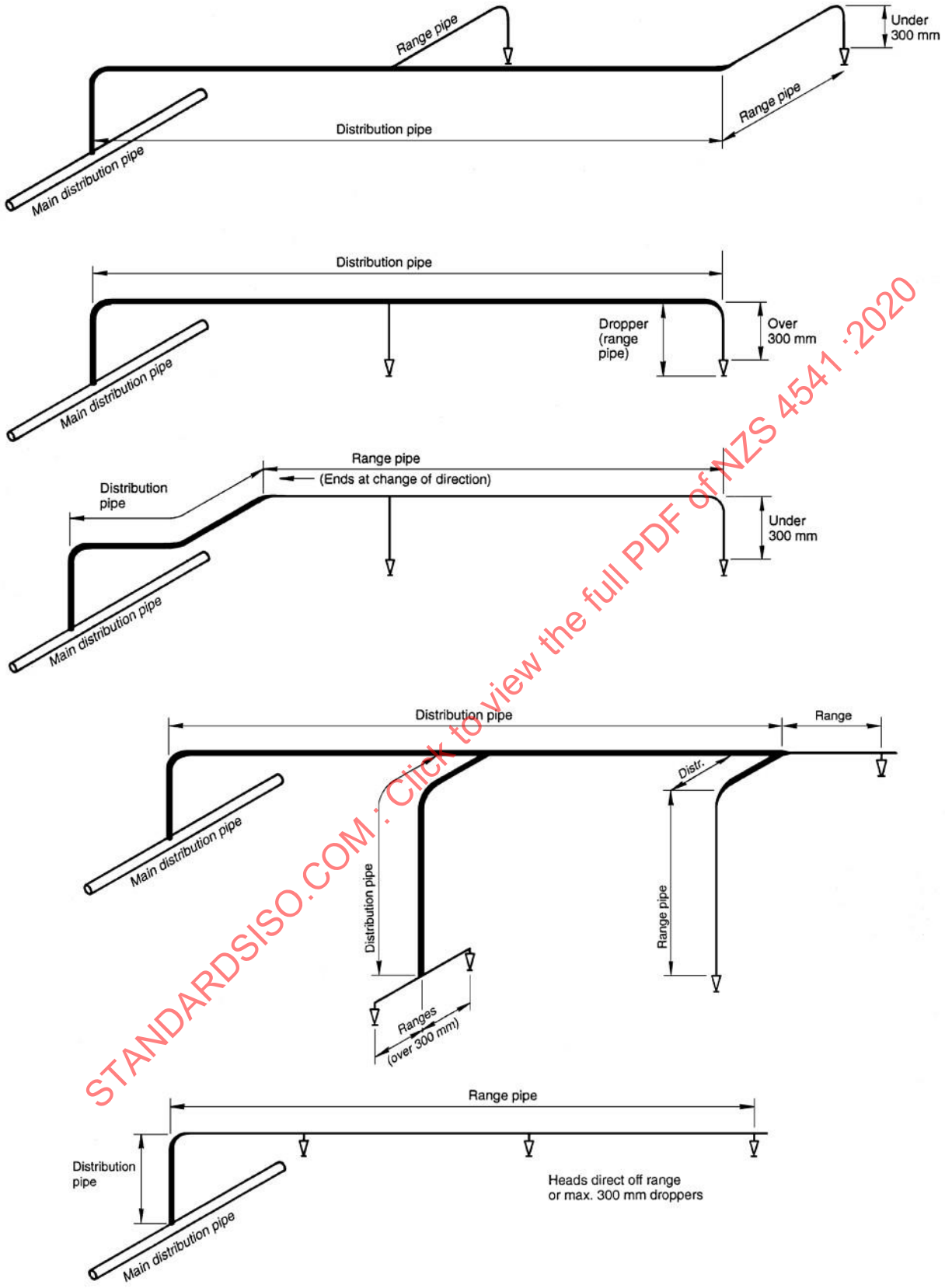


Figure 1.1 – Definition of range and distribution pipes

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

DOUBLE-ROW RACK (DRR)	See 9.2.6 for definition.
DRAFT CURTAIN	See 9.2.7 for definition.
DRIVE-THROUGH RACKS	A racking system incorporating sufficient space for only one drive-through aisle, the position of which is selected by moving individual racks sideways or a rack system of more than one pallet deep in which a forklift can drive into each pallet row to place or remove pallets.
ENCAPSULATION	See 9.2.8 for definition.
FACE SPRINKLER	See 9.2.9 for definition.
FALSE CEILING	See 9.2.10 for definition.
FAST RESPONSE SPRINKLER	A sprinkler with a thermal element with a response time index (RTI) of less than 50 $(m.s)^{1/2}$.
FIRE BRIGADE	The expected first emergency responder to a sprinkler alarm. NOTE – At the time of publication, this would usually be Fire and Emergency New Zealand.
FIRECELL	Any space, including a group of contiguous spaces on the same or different levels within a building, which is enclosed by any combination of fire separations, external walls, roofs, and floors.
FIRE DOOR	A doorset, single or multiple leaf, having a specific fire resistance rating and, in certain situations, a smoke control capability. Forms part of a fire separation and is arranged so that, in the event of a fire, if the door is not already closed it will close, and be held closed, automatically. Refer toNZS 4520.
FIRE RESISTANCE RATING (FRR)	The term used to classify fire resistance of primary and secondary elements as determined in the standard test for fire resistance, or in accordance with a specific calculation method verified by experimental data from standard fire resistance tests. It comprises three numbers giving the time in minutes for which each of the criteria, stability, integrity, and insulation are satisfied, and is presented always in that order, the values specified being minima.
FIRE-RESISTANT BARRIER	A physical barrier to minimise the spread of fire through unprotected concealed spaces. It shall extend the full height of the concealed space. It shall be constructed of materials, and in a manner that will provide equivalent protection to an FRR -/30/30. Other trades that pass through the barrier shall be sealed at their outer edges to maintain the integrity of the barrier.
FIRE SEPARATION	Any building element which separates firecells, or firecells and safe paths, and provides a specific FRR.
FIXINGS	The part of a pipe support system or brace that is used to attach to the building or structure.
FORM 12A	A proscribed form to be attached to the Building Warrant of Fitness in accordance with the Building (Forms) Regulations 2004
FLUE SPACES	See 9.2.11 for definition.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

GRIDDED PIPE-CONFIGURATION	Installation pipework wherein there are multiple waterways to each sprinkler.
HORIZONTAL BARRIERS (within and above racks)	See 9.2.12 for definition.
HORIZONTAL FLUE SPACE	See 9.2.13 for definition.
IGNITABLE LIQUIDS	See 9.2.14 for definition.
INNER CORE SPRINKLER DISCHARGE PATTERN	See 9.2.15 for definition.
IN-PROCESS NON-RACK STORAGE (aerosols)	See 9.2.16 for definition.
IN-RACK SPRINKLERS (IRS)	See 9.2.17 for definition.
INSPECTION	Visual examination of sprinkler system components to establish correct settings, physical condition, or fitness for purpose.
LISTED, LISTING	In reference to specific makes and models of equipment, materials, procedures, organisations, and facilities required or permitted by this standard, means that such has been determined by a sprinkler systemcertifier to meet relevant standards, and to be adequate for application wherepermitted or required by this standard subject to any conditions or limitations specified in the listing.
MAIN DISTRIBUTION PIPES	Main pipes feeding distribution pipework.
MOVABLE RACK	See 9.2.18 for definition.
MULTIPLE-ROW RACK (MRR)	See 9.2.19 for definition.
NETWORK UTILITY OPERATOR	The operator of the water supply system, irrespective of whether this is a local government agency or a private enterprise.
OPEN-FRAME RACK STORAGE	See 9.2.20 for definition.
OPEN-TOP CONTAINERS	See 9.2.21 for definition.
PALLETISED STORAGE	See 9.2.22 for definition.
PALLETS	See 9.2.23 for definition.
PIPE ATTACHMENT	The component of a pipe support system or brace that is attached to the sprinkler pipe.
PIPE HANGER	The component of a pipe support system that joins the pipe attachment to the structure/building attachment. In some cases the total of pipe attachment, pipe hanger, and/or the structure attachment may be listed asan assembly and referred to as a hanger.
PORTABLE RACK	See 9.2.24 for definition.
QUICK RESPONSE	A sprinkler with a high thermal sensitivity and listed as a Quick Response

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

SPRINKLER Sprinkler.

RACK DEPTH The width of the rack measured from aisle face to aisle face including any protruding storage. See Figures 9.1(a) to (c).

RACK STORAGE See 9.2.25 for definition.

RANGE PIPES Any pipes on which sprinklers are attached either directly or through short arm pipes which, except in the case of drops to individual sprinklers on extra light and ordinary hazard installations, do not exceed 300 mm in length. See Figure 1.1.

RESPONSE TIME INDEX (RTI) A measure of sprinkler sensitivity expressed as RTI = $tu0.5$, where t is the time constant of the heat-responsive element in units of seconds, and u is the gas velocity expressed in metres per second

ROOF/CEILING SPRINKLERS See 9.2.26 for definition.

ROUTINE INSPECTION (biennial survey) Visual inspection to identify if sprinkler systems have been altered, damaged, or compromised.

NOTE – This survey together with the inspection, test, and maintenance regime demonstrates sprinkler systems are functional and capable of performing to a standard not less than that to which originally designed. A further goal is to determine the sprinkler system is not compromised by occupancy changes or building or system alterations. Where a system upgrade or modification has resulted in a change of performance capability, the system should be appraised against the upgraded level of performance.

ROUTINE TESTS AND MAINTENANCE Actions including lubrication, cleaning, adjustment, and replacement of components at a predetermined frequency, to minimise the incidence of breakdown and ensure continuing system reliability.

SHELF STORAGE See 9.2.27 for definition.

SHELVING, SOLID OR SLATTED See 9.2.28 for definitions.

SINGLE-ROW RACK See 9.2.29 for definition.

SOLID-PILE STORAGE See 9.2.30 for definition.

SPECIAL RESPONSE SPRINKLER A sprinkler listed as having a thermal element with a response time index of more than 50 $(m.s)^{1/2}$, and less than 80 $(m.s)^{1/2}$.

SPRINKLER INSTALLATION That part of the system downstream from, and including, the main stop valve.

SPRINKLER SYSTEM A system including:

(a) The water supply pipes from the boundary of the protected premises to the sprinkler valves;
Any static water supply on the protected premises;
(c) Any pump providing water supply and its driving engine, motor, and control equipment;
(d) The control valves and all appurtenances thereto;
(e) The main stop valve anti-interference device;
(f) Any fire alarm signalling device;
(g) Compressors, air receivers, and related equipment forming part of a dry pipe system;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(h) All pipework, sprinklers, and appurtenances downstream of the control valves;
(i) Storage restriction signs;.
(j) Any fire rated wall, door, or partition required by this standard;

NOTE – In some cases this may not be a requirement for a sprinkler system to comply with the supporting documents to the NZBC Clause C Protection from fire.

(k) Backflow prevention devices between the boundary and the main stop valve.

SPRINKLER SYSTEM CERTIFIER (SSC) An organisation accredited by an internationally recognised accreditation body to AS/NZS ISO/IEC 17020 as a Type A inspection body as competent to fulfil the roles as defined in this standard.

STANDARD RESPONSE SPRINKLER A sprinkler listed as having a thermal element with an response time index of more than 80 $(m.s)^{1/2}$.

STORAGE HEIGHT See 9.2.32 for definition.

STORAGE SPRINKLER See 9.2.33 for definition.

TERMINAL PIPE-CONFIGURATION (or 'Christmas tree configuration') Installation pipework on which there is only one waterway to each sprinkler.

TEST Confirmation of correct function or performance of a component or system.

TIER See 9.2.34 for definition.

VERTICAL BARRIERS See 9.2.35 for definition.

WATER DELIVERY TIME See 9.2.36 for definition.

WATER SUPPLY The sources of water and includes the waterway and ancillary equipment up to but not including the sprinkler installation main stop valve.

1.4 Abbreviations

Abbreviations have the following meanings:

ACP Aluminium composite panels

ASD Allowable stress design

BCA Building consent authority

BLEVE Boiling liquid expanding vapour explosion

BPU Backflow prevention unit

BPV Back pressure valve

C/UP Conventional sprinkler

CMSA Control mode specific application

CP Chemically pure

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

CPEng	Chartered professional engineer
DPDT	Double pole double throw
DPST	Double pole single throw
DRR	Double-row rack
EC	Extended coverage
ECAD	Extended coverage area density
ECLH	Extended coverage light hazard
ECOH	Extended coverage ordinary hazard
EHH	Extra high hazard
EIFS	Exterior insulation and finish system
ELH	Extra light hazard
ELO	Extra large orifice
ESFR	Early suppression fast response
FBA	Fire brigade alarm
FENZ	Fire Emergency New Zealand
FRR	Fire resistance rating
FSI	Fire sprinkler inlet
kPa	Kilopascal
ID	Internal diameter
IL	Importance level
IMO	International Maritime Organisation
IQP	Independent qualified person
IRS	In-rack sprinkler
LED	Light-emitting diode
LPC	Loss Prevention Council
LPCB	Loss Prevention Certification Board
MJC	Multiple jet control
MRR	Multiple-row rack
NB	Nominal bore
NFPA	National Fire Protection Association (United States)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

NPSHR	Net positive suction head required
NZBC	New Zealand Building Code
OEM	Original equipment manufacturer
OH	Ordinary hazard
OH1	Ordinary hazard Group 1
OH2	Ordinary hazard Group 2
OH3	Ordinary hazard Group 3
OH3S	Ordinary hazard Group 3 Special
OH4	Ordinary hazard Group 4
PET	Polyethylene terephthalate
PRV	Pressure relief valve
PVC	Polyvinyl chloride
PVC-C	Chlorinated polyvinyl chloride
PVC-O	Oriented polyvinyl chloride
PVC-U	Unplasticised polyvinyl chloride
QR	Quick response
RPM	Revolutions per minute
RTI	Response time index
SIN	Sprinkler identification number
SMOGRA$_{RC}$	Smoke growth rate index
SMS	Suppression mode sprinkler
SOLAS	Safety of Life at Sea
SPDT	Single pole double throw
SPST	Single pole single throw
SSA	Seismic separation assembly
SSC	Sprinkler system certifier
SSP	Spray sprinkler pendent
SSU	Spray sprinkler upright
TA	Territorial authority
UL	Underwriters laboratories
ULS	Ultimate limit state

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

USP	United States Pharmacopoeia
WH	Horizontal sidewall
WP	Pendent sidewall
WW	Water works pattern stop valve

1.5 Notations

This standard uses the following notations:

A = area; assumed maximum area of operation; for determination of area of operation

A_g = gross area of the rod leg (includes threaded rod)

C = lateral force coefficient (see 4.3.12.2); for determination of earthquake load demand; or

= flow in the first range divided by the square root of the junction pressure at start of that range for the calculation of flow from identical ranges; or

= a constant for the type of pipe, that is:

cast iron (C = 100)

steel, galvanised after fabrication (C = 110)

steel, black or galvanised (C = 120)

steel, spun concrete lined (C = 130)

copper, PVC-M, PVC-U, and PE pipes (C = 140)

PVC-C C = 150); or

= a constant for pressure losses in all types of pipes (Hazen-Williams formula)

C_H = 3.0 for components above ground or 1.0 at or below ground floor level; for the determination of seismic acceleration expressed by the lateral force coefficient

C_p = performance factor = 0.85; for the determination of seismic acceleration expressed by the lateral force coefficient

d = mean bore diameter (mm); for pressure losses in all types of pipes (Hazen-Williams formula)

F = earthquake load demand (kN); for determination of earthquake load demand

F_u = tensile strength of the steel

F_{uls} = maximum horizontal seismic design load capacity of the U-bolt based on the assumption that F is resisted in shear by one leg of the U-bolt

F_v = net vertical force

h = difference in height between sprinklers, junctions, and datums (m); for static pressure head calculation

K = sprinkler discharge co-efficient; for the calculation of discharge from a sprinkler, also called K factor

l = length of brace; for slenderness ratio (l/r)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

L	= the long side; for determination of area of operation
L_p	= tributary length of pipe for that brace, determined from 4.3.13.2.5 (m); for determination of earthquake load demand
N_a	= number of sprinklers on those ranges within the rectangular portion of the area of operation
N_b	= number of ranges within the rectangular portion of the area of operation
P	= pressure in kPa; or = pressure gain or loss due to head (kPa); for static pressure head calculation; or = loss of pressure per metre of pipe (kPa/m); for pressure losses in all types of pipes (Hazen-Williams formula); or = loss of pressure per metre of pipe (kPa); or = pressure at entry to sprinkler orifice (kPa); for the calculation of discharge from a sprinkler
Pn	= junction pressure of the range under consideration; for the calculation of flow from identical ranges
P_O	= discrete values of pressure loss; for the determination of pressure loss produced by the orifice plate
P_X	= pressure loss; for the determination of pressure loss produced by the orifice plate
Q	= flow in L/min; or = flow rate of water through pipe length (L/min); for pressure losses in all types of pipes (Hazen-Williams formula); or = flow rate of water through pipe length (L/min); or = discharge from sprinkler (L/min); for the calculation of discharge from a sprinkler
Qo	= assumed rate of flow, for the determination of pressure loss produced by the orifice plate
Qr	= flow in the range under consideration; for the calculation of flow from identical ranges
Qx	= rate of flow, for the determination of pressure loss produced by the orifice plate
r	= least radius of gyration of brace element; for slenderness ratio (*l*/*r*); or = remainder sprinklers not within the rectangular portion
R	= the appropriate value from Table 10.2; for determination of pressure losses in each metre of steel or PVC-C pipe
R_{60}	= 60 second running average; for the determination of the smoke growth rate
R_c	= component risk factor is determined from Table 4.9 for the determination of seismic acceleration expressed by the lateral force coefficient
R_{inst}	= instantaneous rate of light-obscuring smoke
S	= mean spacing of sprinklers on the ranges under consideration
$SMOGRA_{RC}$	= smoke growth rate index
W	= weight of water-filled pipe in the zone of influence (kN) = 0.00981 W_p L_p; for determination of earthquake load demand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

W_p = mass per metre of the water-filled pipe (from Table 4.10) (kg/m); for determination of earthquake load demand

Z = zone factor (shall be determined from Table 4.8 or interpolated from Figure 4.1(a) or (b); for the determination of seismic acceleration expressed by the lateral force coefficient

θ = angle of brace from vertical; for the determination of net vertical force (F_v)

1.6 Inspection testing and maintenance

To ensure that sprinkler systems operate reliably, they shall be tested, inspected, and maintained in accordance with the requirements of Part 12 of this standard, and that any defects that are identified shall be rectified in a timely manner.

1.7 Seismic resistance

1.7.1 *General*

Sprinkler systems (as defined in 1.3) shall be designed, detailed, and installed so as to remain operational at the limit state derived from Table 8.1 of NZS 1170.5, or to a higher loading if specified.

NOTE –

(1) AS/NZS 1170.0 requires New Zealand design and detail to NZS 1170.5 for earthquakes. In this context, the term 'importance level' refers to the building structure, not the sprinkler system itself.

(2) Sprinkler systems are classified as parts category P.6 in Table 8.1 of NZS 1170.5, except if they are required for NZBC compliance for ongoing occupancy of IL4 buildings, in which case they are parts category P.5.

(3) In new buildings, the seismic design of the sprinkler system should be developed in conjunction with that of the building.

(4) The sprinkler system should not be damaged or impaired by the movement or failure of non-structural components or the movement of structural elements at the relevant serviceability limit state.

1.7.2 *Water supply tanks*

Every tank shall be designed to at least the same importance level (as defined by AS/NZS 1170.0) as the building or structure that the sprinkler system is to protect.

1.8 Workmanship, competency, and qualifications

1.8.1

Workmanship on all parts of a sprinkler system shall be consistent with best trade practice and no workmanship shall be permitted which will prevent the system from fulfilling its design function.

All work carried out under this standard shall be performed competently, or effectively supervised by, appropriately qualified personnel.

Qualification to the applicable industry training programme recognised by the New Zealand Qualifications Authority is the level necessary to satisfy the requirement to be qualified.

NOTE –

(1) The minimum qualification for installers or fitters is a NZ Certificate in Fixed Fire Protection Systems Level 3 or equivalent.

(2) The minimum qualification for testers is a NZ Certificate in Fire Protection Systems Technology Level 3 or equivalent.

(3) The minimum qualification for inspectors is a NZ Certificate in Fire Protection Systems Technology (Inspections) Level 4 or equivalent.

(4) The minimum qualification to plan, install, commission, maintain, and service fixed fire protection systems and associated equipment is a NZ Certificate in Fixed Fire Protection Systems Level 4 or equivalent.

(5) Personnel who have equivalent qualification or can demonstrate relevant experience and competency must submit them to the SSC for assessment with the current competencies.

1.8.2

Materials and components shall be appropriate for the ambient environmental conditions, the service conditions which apply, and the intended service life.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

1.8.3 *Qualification of welders*

All welds shall be completed by welders holding current certification in terms of AS/NZS 2980 for the type of welding employed

1.8.4

Where building insulation, including sound insulation is installed, it shall be installed in a manner that will not result in the fire sprinklers being compromised during a fire.

NOTE – Plastic type strapping is insufficient as it may sag during a fire and allow the batts to tent over the fire sprinklers.

1.9 Typical arrangements

Typical layouts for sprinkler systems, water supplies, and pipe arrays are provided in Figure 1.1 and Figure 1.2. For detailed requirements, see Part 4 – System components and Part 6 – Water supply.

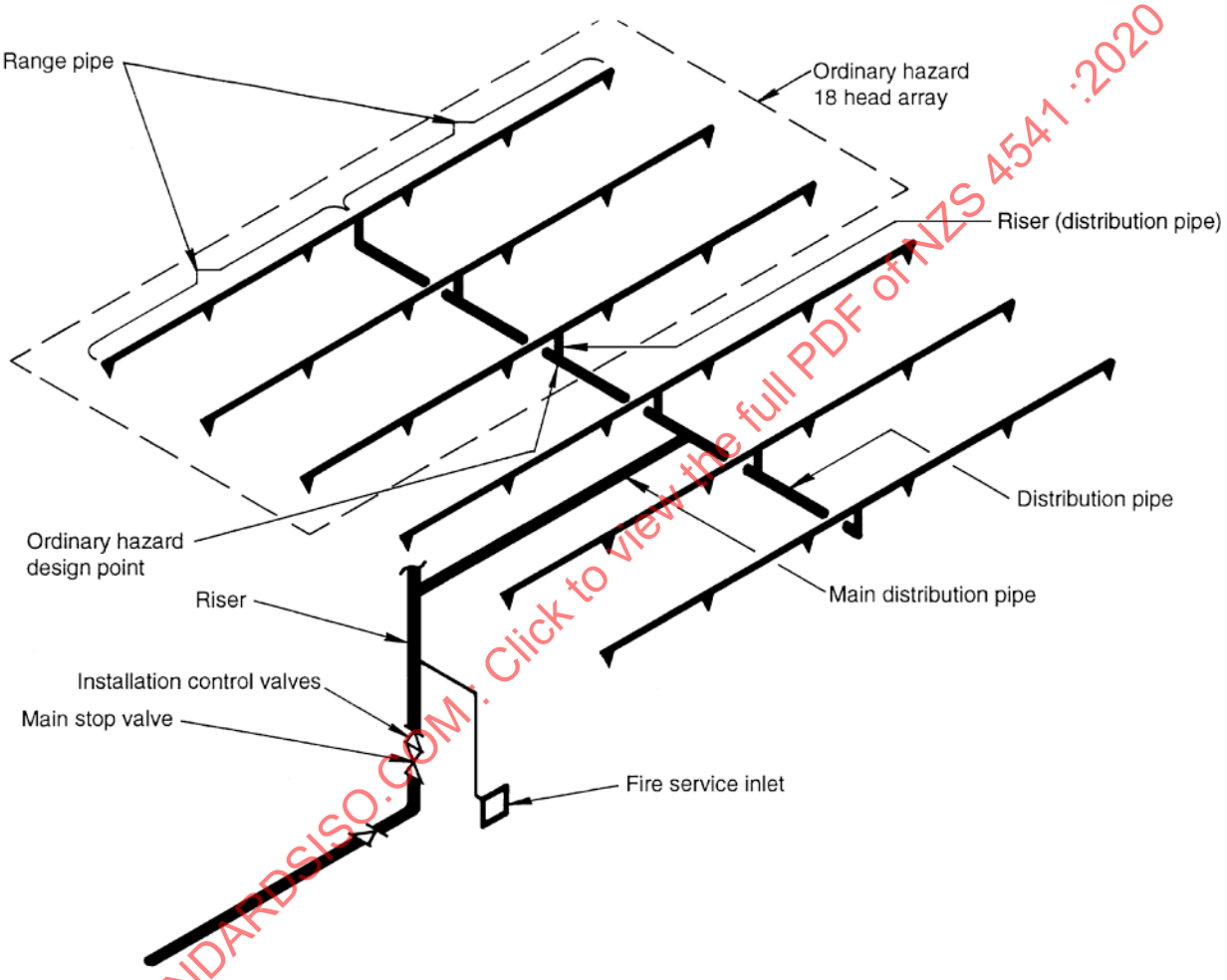


Figure 1.2 – Typical fire sprinkler system

1.10 Welding compliance

All welding on carbon steel pipes shall comply with the requirements of BS 2971 for Class 2 operating conditions except the qualification of welders for which 1.10.2 applies. The provision in BS 2971 to allow alternative joint preparation is permitted by this standard whether or not there is a specific agreement between the contracting parties, provided that for butt welded pipes there is adequate weld penetration.

1.11 Hydrostatic tests

1.11.1

Prior to completion, all sprinkler systems shall be hydrostatically tested at a minimum of 1400 kPa for a period of 2 hours. A successful test will result in no measurable pressure drop using the gauges specified in 4.6.

NOTE – To minimise the possibility of water damage from open pipe ends and the like, it may be advisable to carry out a low-pressure air test before the introduction of water into the system.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Copyright

In the unique case of a retrospective installation of a dry system into an operational freezer, this clause may be waived by the SSC where the hydrostatic test is deemed impractical.

1.11.2

Where portions of a sprinkler system are subjected to working pressures of greater than 1050 kPa, they shall be tested at a pressure of 350 kPa in excess of system working pressure.

1.11.3

Extensions and alterations not exceeding 20 heads do not require hydrostatic testing.

1.11.4

The test pressure shall be read from a gauge located at the low elevation point of the system, or portion being tested.

1.11.5

When deluge systems are being tested, the nozzles shall be replaced with plugs, or alternatively, the operating elements of open sprinklers shall be removed after the test is completed.

1.11.6

When the fire sprinkler inlet (FSI) has been fabricated from unrated components it shall be hydrostatically tested to a working pressure of 1600 kPa and a copy of the test certificate for this device shall be provided to an SSC with completion documentation provided in accordance with 1.14.2.

NOTE –

(1) This test is specified at a higher pressure than other sprinkler components following the field failure of a large square fabricated FSI.

(2) When the FSI is an assembly of pressure-rated components, this test is not required.

1.11.7

In addition to the standard hydrostatic test, each individual dry pipe and pre-action system, including the air supply compressor and air supply pipework up to each system valve, shall be subject to an air-pressure leakage test at 300 kPa for 24 hours. Any leakage greater than 10 kPa (when adjusted for any temperature differential) shall be corrected. See Appendix A for an example form.

NOTE –

(1) Any leakage greater than 10 kPa in any one system may be deemed to be unacceptable by the SSC (when adjusted for any temperature and barometric changes in the test period), unless it can be demonstrated to the SSC by calculation or field test that the compressor duty cycle (number of starts/hour) is within the compressor manufacturer's maximum recommendation, and the cumulative daily run time for the compressor is less than 2hours per day.

(2) In selecting an air compressor output and air receiver volume capacity, the cumulative leak rate of all systems supplied by the compressor needs to be known.

(3) Regenerative driers use considerable quantities of air over and above the system leak rate.

(4) Where air is drawn from an environment with a different temperature to the protected area under test, allow time for the air temperature in the pipes to equalise with the temperature of the environment.

1.12 Roles and responsibilities of SSC

An SSC shall be responsible for certification of the sprinkler system and making other determinations as provided for in the standard. That role shall include, but not be limited to:

(a) Approving design concepts;
(b) Reviewing installation inspection records against the requirements of the standard;
(c) Reviewing commissioning records against the requirements of the standard ;
(d) Reviewing testing, maintenance, and routine surveying records against the requirements of the standard;
(e) Listing of contractors;
(f) Listing of equipment;
(g) Approving equivalent variations in the design and/or components;
(h) Maintaining records; and
(i) Certification that the system complies with this standard.

An SSC shall employ an appropriately qualified chartered professional engineer (CPEng) for the purpose of such certification.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

An SSC may carry out the inspection required in (b), (c), or (d) themselves, or may gather evidence in the form of a report from an organisation accredited by an internationally recognised accreditation body to AS/NZS ISO/IEC 17020 as a Type A inspection body as competent to fulfil these roles.

Where the standard refers to an SSC it shall be the SSC responsible for the certification of the particular automatic fire sprinkler system under consideration.

NOTE –

(1) It is desirable that the CPEng be a professional member of Engineering New Zealand in the fire practice field.

(2) CPEng is defined in the Chartered Professional Engineers of New Zealand Act.

It is noted that site inspections are effectively a quality check of the installation, as inspectors cannot be on site for the full duration of the project. Installation contractors should take cognisance of the need to allow inspectors to view pipework, bracketing, and bracing before pipework is closed in.

1.13 Formal interpretations

1.13.1

Requests for interpretations, rulings, or clarifications received by Standards New Zealand directly shall be reviewed by a subcommittee of the Automatic Fire Sprinkler Systems Committee (P4541) which prepared this standard for the Standards Council established under the Standards Act.

NOTE – The Fixed Fire Protection Formal Interpretation Committee, which was constituted to deal with queries and interpretations of a number of fire protection standards, has jurisdiction to interpret the wording of the current published editions (NZS 4541:2003, NZS 4541:2007, NZS 4541:2013, and NZS 4541:2020) of the relevant standard only. Matters not mentioned in the standard are outside the scope of this committee and should be dealt with according to normal business practice.

Requests for formal interpretations should be sent to the Manager, Standards New Zealand, PO Box 1473, Wellington 6140; or fireinterpretations@standards.govt.nz. An administration fee is collected by Standards New Zealand for the processing of a request.

1.13.2

Formal interpretations shall be made when:

(a) An interpretation of a clause within this standard is required;
(b) There is ambiguity in this standard and clarification is required;
(c) Clarification of wording in this standard is required because it does not achieve the intent agreed to by the committee; or
(d) Fire testing or sprinkler system failures have been demonstrated and therefore the provisions of this standard are inadequate, and a recommendation on amending the standard is required and is submitted to Standards New Zealand for consideration.

1.14 Sprinkler system certificate of compliance methodology

1.14.1

To enable a SSC to certify an installation, the contractor shall submit the following information before the start of the sprinkler installation. The contractor shall provide all necessary drawings, calculations, and other descriptive information.

This shall include at least the following, where relevant:

(a) Separation from unsprinklered fire loads;
(b) The hazard classifications, densities, and area of operation proposed;
(c) A description of the nature and performance of the water supplies accompanied by a hydraulic graph of each, on which the design flows and pressures shall be marked together with the method and time of test, and for:
    (i) Town's main supplies: the name of the street and the diameter of the mains
    (ii) Pumped supplies: the make, model, impeller size, and rotational speed of the pump, and the power rating and method of drive of the motor
    (iii) Tanked supplies: the capacity, location, tank drawings showing nozzle connections, and filling method of tanks;
(d) Method of alarm;
(e) The assumed lowest ambient temperature the sprinkler system will be subjected to;
(f) Name by which protected premises will be known, if known, and full address;
(g) Whether there are unprotected fire loads within 10 m of the protected premises;
(h) The nature of any concealed spaces within the protected premises;
(i) The means by which separation from unprotected areas or fire loads will be achieved;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(j) Relevant constructional details of ceilings, roofs, floors, exterior walls, and walls separating sprinklered and non-sprinklered areas;
(k) The uses (occupancies) to which each part of the protected buildings will be put;
(l) Evidence of the owner's intentions for the storage of combustibles;
(m) The height of the highest sprinkler in each hazard classification area;
(n) If external sprinklers are used, the size of heads and the number designed to operate;
(o) The class of system water supply proposed;
(p) The type of system proposed;
(q) The type and location of the fire brigade receiving equipment or other alarm to which the system will be connected;
(r) The number, size, and location of alarm valves, and the area to be protected by each installation;
(s) Fire brigade approval of the fire sprinkler inlet location;
(t) A plan showing the following information:
  (i) Scale;
  (ii) North point;
  (iii) External sprinklers;
  (iv) Hazard classifications, densities, and assumed maximum areas of operation;
  (v) Height of highest sprinkler of each hazard classification area
  (vi) Area protected by each installation
  (vii) Location of fire sprinkler inlet and control valves
  (viii) Location of subsidiary stop valves
  (ix) Location of drain valves
  (x) Water supplies showing all valves between the source and alarm valve and, if a B2 system, the mains, interconnections, and valves
  (xi) The power supply route for electric motor-driven pumps including all switchgear. (If it is impracticable to supply this information at the design stage, it shall be provided as soon as possiblethereafter)
  (xii) The location of any fire alarm panel;
(u) A typical cross section showing the highest head(s), the height of the alarm valves and, where used, pump house, pump, tank and suction inlet;
(v) Details and location of alarm devices including pressure switches, isolation switches, and any flow switches;
(w) For special systems such as suppression mode sprinklers, dry pipe systems, and antifreeze systems, any further information that an SSC may require;
(x) A copy of the Fire Safety Design Report used to uplift the Building Consent for the installation of the system, including any specific issues required by the Building Consent;
(y) Any other pertinent information that the SSC should be aware of before accepting the design parameters;
(z) A copy of the Building Consent, including any special conditions relating to fire safety provisions; and
(aa) A statement as to whether the installation seismic resilience will be in accordance with NZS 1170.5 or this standard (4.3.12.1(a) or (b)). If in accordance with 4.3.12.1(b), the lateral force coefficient shall be provided.
(bb) Calculations shall be provided to demonstrate that the calculated seismic loads can be resisted by all components of the proposed seismic brace configuration. Alternatively, a Producer Statement (PS1) signed by a CPEng can be provided demonstrating the above.

1.14.2

Before final inspection, the contractor shall provide to an SSC:
(a) A notice of completion;
(b) As-built sprinkler and pipe layout plans with seismic resistance resilience provisions, including whether the design is to 4.3.12.1(a) or (b) showing the location, type and configuration of each brace, the location of flexible couplings and required seismic clearances;
(c) Hydraulic calculations including the information required by 10.6.2;
(d) A copy of the current data sheet for each type of residential, storage, or extended coverage (EC) head used;

NOTE – A contractor may agree an administrative procedure with an SSC whereby a data sheet reference may be used when the authority has the data sheet on file.

(e) Identification of any changes between the proposed design and the installed system including revised design proposal forms and block diagrams; and

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDS160.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

(f) Underground pipe pressure test according to AS/NZS 2566.2 or NFPA 24 and flushing certificates according to this standard;
(g) Confirmation of connection to fire brigade's receiving equipment;
(h) A copy of the pressure test certificate for the FSI assembly (see 1.11.6);
(i) An interface matrix showing how the sprinkler system interfaces between any other services in the building;

NOTE – This is not necessary if the only interface is an 'all -out' evacuation system.

(j) Any other relevant information; and
(k) A copy of the current data sheet for each listed seismic bracing component or assembly used.

NOTE – A contractor may agree an administrative procedure with an SSC whereby a data sheet reference may be used when the authority has the data sheet on file.

1.14.3

A copy of the certificate of compliance shall be displayed in a permanent holder at the control valves of each sprinkler system.

1.14.4

For systems installed to this standard, an SSC shall make available to listed contractors the information contained in 1.14.1, 1.14.2, and 1.14.3, subject to receipt of consent from the building owner, where practical.

1.14.5

Small alterations and extensions do not require documentation submissions to an SSC subject to the following limitations:
(a) Alterations to ELH, OH1, or OH2 systems of less than 20 sprinklers where the *K* factor of the sprinkler is not changed. In the event that the first fix pipework is unaffected by the works, the alteration may be up to 40 sprinklers;
(b) Alterations to OH3 systems of less than 10 sprinklers where the *K* factor of the sprinkler is not changed. In the event that the first fix pipework is unaffected by the works, the alteration may be up to 40 sprinklers;
(c) Extensions to OH3 systems of less than 14 sprinklers. The contractor shall complete hydraulic calculations to show that the design requirement is no worse than the existing demand. In the event that the extension is not at the hydraulically most remote point, the extension may be up to 20 sprinklers; and
(d) Any alteration or extension not subject to documentation submission to the SSC shall either be reviewed by a contractor with either the design or routine inspection endorsement of Appendix C. See also Figure E3.

1.15 Listing of contractors

1.15.1

All work on sprinkler systems (including testing, maintenance, and surveying) shall be undertaken under the supervision of listed contractors.

1.15.2

Only those contractors which an SSC has determined satisfy the criteria set out in Appendix C shall be listed.

1.15.3

The form of listing shall be by means of a certificate in the form determined by an SSC. An example certificate is shown in Appendix D.

The certificate shall include at least the following information:
(a) The legal name and physical address of the contractor;
(b) The names of key personnel with their scope and grade of listing. This information may be included in a schedule to the certificate;
(c) The scope of listing, giving the work for which the contractor is listed, in accordance with Appendix C, Table C1;
(d) Whether the listing is provisional or full;
(e) The date from which the listing takes effect;
(f) The date of listing expiry, or period of validity of the certificate;
(g) The name and authorising signature of an SSC senior manager or principal, plus date of signing;
(h) A unique certificate number; and
(i) The SSC's legal name.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

1.15.4

The listing shall have currency from date of issue for a period of 12 months for provisional listing or 24 months for full listing.

1.15.5

Contractors involved in routine inspections shall be accredited by an internationally recognised accreditation body to AS/NZS ISO/IEC 17020 as a Type A inspection body to inspect fire sprinkler systems for compliance with NZS 4541.

1.15.6

Provisional listing may be awarded to a contractor that complies with all requirements of the criteria and standards of competence. A provisionally listed organisation does not have to have completed a fire sprinkler system or have an ISO 9001 certified quality management system.

1.15.7

Full listing may be awarded to a contractor that complies with all requirements of the criteria and standards of competence to the satisfaction of the SSC and has current ISO 9001 certification for its quality management system.

1.15.8

The contractor's quality management system shall be certified to AS/NZS ISO 9001 by a certification body independently accredited to AS/NZS ISO/IEC 17021.1 by an internationally recognised accreditation body (for example, JAS-ANZ).

The scope of the AS/NZS ISO 9001 certification shall cover the activities and systems applicable to the contractor's listing.

1.16 Listing of equipment

1.16.1

Only equipment which an SSC considers satisfy the criteria, as set out in Appendix F, shall be listed.

1.16.2

The form of listing shall be by means of a duly completed certificate in the form set out in Appendix F.

1.16.3

In listing equipment, materials, procedures, organisations, or facilities, an SSC shall determine that any specific requirements of this standard have been met and that there is sound evidence to indicate reliabilityof performance.

1.16.4

Items of equipment having Underwriters' Laboratories (UL) listing, FM Approval, or Loss Prevention Council (LPC) approval or listing for equivalent service, shall on presentation of evidence of such approval or listing to an SSC, be listed pursuant to this standard unless an SSC considers that the approved or listed item is not suitable or is insufficiently reliable. Reasons for any decision not to list shall be provided by an SSC.

1.16.5

Listings shall be limited to the tenor and qualifications of an SSC listing document and shall cease to have effect from the date of any signed notice of withdrawal of listing issued by an SSC.

1.16.6

In submitting a device for listing, the manufacturer shall submit full drawings, the metallurgy of compounds, and an analysis of possible failure modes and likelihood.

1.17 Withdrawal of listing

An SSC shall withdraw any listing of a contractor or equipment if it is found on examination of the work or the equipment to be defective, or to have performed inadequately or in an unreliable manner. Any withdrawal of contractors or equipment shall take place in accordance with Appendix C5(a) or Appendix F2(b), and only if there is no evidence of corrective action being undertaken to remedy the deficiency.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

1.18 Existing installations

This standard does not require that systems approved to previous editions of NZS 4541 be upgraded. For the purposes of complying with legislation, such as the New Zealand Building Code and the Fire Safety and Evacuation of Buildings Regulations, existing sprinkler systems that are certified as complying with previous editions of NZS 4541 may, for the purposes of that legislation, be deemed to meet the requirements of NZS 4541:2020.

Existing sprinkler-protected buildings subject to alterations, additions, or a change of use may require the sprinkler system to be upgraded as described in Appendix G.

NOTE –

(1) If an existing building is being altered (including additions), the provisions of section 112 of the Building Act apply.

(2) If a building undergoes a change of use, the provisions of section 115 of the Building Act apply.

(3) For information on change of use, reference should be made to the Building (Specified Systems, Change the Use, and Earthquake-prone Buildings) Regulations. A change of use would potentially include a change in the types of goods being stored in the building, or the manner (particularly the height) in which they are stored, which would increase or change the design basis required for the system.

1.19 Alternative design criteria

1.19.1

The SSC may accept alternative design criteria as complying with this standard based on either full-scale fire testing or published in recognised standards and codes of practice.

NOTE: FM Global Property Loss Prevention Data Sheets, National Fire Protection Association Standards, Australian Standards, and International Standards Organization standards are considered to be recognised standards.

1.19.2

In restricted cases, this standard allows a less reliable level of protection for certain buildings primarily intended for use by community organisations where the installation of sprinkler systems is not required for compliance with the NZBC. See Appendix B.

1.20 Sprinkler system decommissioning

To ensure the safety of fire fighters, if a system is decommissioned, then visible evidence of the existence of a sprinkler system shall be removed, including, but not limited to:

(a) Signage;
(b) Water motor alarms;
(c) Fire brigade inlet connections; and
(d) Exposed sprinklers.

If the decommissioned sprinkler pipework is painted red, then either the pipework shall be removed, or it shall be over coated in an alternative colour.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

2 Basic rules of design

2.1 Installer to be listed

All work on sprinkler systems shall be undertaken under the supervision of listed contractors.

2.2 Minimum required discharge and design flow

2.2.1

Every sprinkler system shall be designed to deliver a minimum flow (the 'design flow') to each area of the protected building.

2.2.2

Water supplies shall be sized to permit the design flow to be maintained for a period specified by this standard.

2.2.3

To establish the minimum required discharge, the fire hazard (or intended fire hazard), of each area of the protected building shall be determined in accordance with this standard and shall be specifically approved. Thereafter, the minimum required discharge and the assumed area of operation shall be determined by reference to Parts 7, 8, or 9 as appropriate.

NOTE – The expression 'fire hazard' in this context is not intended to have the same meaning given to this expression in the NZBC.

2.3 Determination of fire hazard

2.3.1 *Classes of occupancy*

Three broad classes of fire hazard are hereby established:

(a) Extra light hazard (ELH): Non-industrial occupancies where the amount and fire load of the contents is low;

(b) Ordinary hazard (OH): Commercial and industrial occupancies involving the handling, processing, and storage of mainly ordinary combustible materials unlikely to develop intensely burning fires in the initial stages. This occupancy class is further divided, for the purposes of determining assumed area of operation, into five subgroups – viz:
   (i) Group 1 (OH1)
   (ii) Group 2 (OH2)
   (iii) Group 3 (OH3)
   (iv) Group 3 Special (OH3S)
   (v) Group 4 (OH4); and

   NOTE – The term 'storage' includes the warehousing or the temporary depositing of goods or materials while undergoing process.

(c) Extra high hazard (EHH): Commercial and industrial occupancies having high fire loads:
   (i) Where the materials handled or processed are mainly of an extra-hazardous nature likely to develop rapid and intensely burning fire (EHH – process risk)
   (ii) Involving high piling of goods beyond the limits specified in Table 2.2(a).

2.3.2 *Classification of occupancies*

2.3.2.1

Every area of the protected building or firecell (that is, each 'occupancy' within the protected building or firecell) shall be assigned to one of the above classes or respective subgroups according to the following three factors of fire hazard in the area concerned:

(a) The fire load;
(b) The rate of fire spread and development; and
(c) The extent of potential fire spread.

If adjacent areas that are not separated by a full-height wall have different hazard classifications (or in adjacent areas of EHH occupancy have different design requirements) then in some cases (as specified in 9.3.6) the hazard classification/design requirements of the area with the highest fire hazard shall be extended into the area of lower fire hazard for a distance of at least 4.6 m.

2.3.2.2

Table 2.1 is a representative schedule of occupancies to which is assigned a particular hazard classification that is based on the above three factors of fire hazard. (For ease of reference, the schedule is divided into

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

eight generic groups.) However, within a single generic occupancy – such as 'school' – there may be areas or sub-occupancies (such as auditoriums or technology blocks) that are appropriately classified differently.

Therefore, for the three factors of fire hazard referred to in 2.3.2.1, the fire hazard of a particular area of the protected building is typically or most closely that of one of the occupancies in the schedule, and the hazard classification of that area shall be that specified in Table 2.1.

In other cases, the classification shall be that of an occupancy in the schedule which, for each of the three factors of fire hazard, most closely approximates the fire hazard of the area being classified.

NOTE – Table 2.1 is informative and not an authoritative list of occupancies.

2.3.2.3

Classification of an area as OH occupancy is subject to storage of combustible materials and in some cases, the roof height, not exceeding limitations specified in 2.3.2.7, otherwise the classification shall be EHH requiring the density appropriate to the storage pattern.

For design purposes, the owner of the building or a CPEng or registered architect acting with the authority of the owner, shall make a signed declaration on the owner's intentions for the form of storage and maximum height above the floor, by commodity, using the form specified in Appendix H.

Where a building is occupied by tenants other than the owner, the tenants of the building or a CPEng or registered architect acting with the authority of the tenant, shall make a signed declaration in agreement with the owner for the intentions for the form of storage and maximum height above the floor, by commodity, using the form specified in Appendix H.

2.3.2.4

Apart from storage present in small storage areas and drying rooms, protected in the manner set down in 7.4, any occupancy which would otherwise be ELH shall, if used for storage of combustibles, be OH3 (or EHH if the storage limits of Table 2.2(a) are exceeded).

2.3.2.5

Fully enclosed rooms that have an area not greater than the surrounding hazard classification design area; are located in a sprinklered firecell that is protected to either ELH, OH1, OH2, or OH3; and have fire loads presenting a higher hazard classification than that of the firecell, may be protected as follows without changing the hazard classification of the building:

(a) The room shall be separated from other rooms by a minimum –/15/– minute fire rated construction. Any doors are not required to be fire rated;
(b) Any openings in the room shall not exceed 2.4 m in width. If the length of any opening is greater than 900 mm, the opening shall be fitted with a lintel of at least 200 mm depth; and
(c) The sprinkler protection within the room shall be designed to either OH3, OH4, or EHH, as appropriate to the hazard classification of the contents, with the number of operating sprinklers limited as follows:
    (i) If the openings are not fitted with self-closing or automatic doors, the design basis for the sprinkler shall be the total number of heads in the room, plus two sprinklers in the adjoining room
    (ii) If the openings are fitted with self-closing or automatic doors, the design basis for the sprinkler shall be the total number of heads in the room.

2.3.2.6 *Criteria for storage fixtures in OH4 hazard classification*

To qualify for the area concerned to be classified as OH4 (pertaining to some retail shops per Table 2.1), storage in fixtures that exceed the limits in Table 2.2(a) shall be within all of the following criteria (otherwise the area is classified EHH):

(a) Aisle width at least 1.2 m;
(b) Nominal width of single-width racking or shelving not greater than 1200 mm;
(c) Centre of transverse flues not greater than 3 m;
(d) Any full pallet loads are located only on the uppermost level of storage fixtures;
(e) Height of each full pallet not greater than 1.8 m;
(f) The lowest 2.4 m of the racking or shelving system is used only for retail display or picking of goods; and
(g) Combustible or flammable liquids shall be stored in accordance with 2.3.5.2.

NOTE – This signals intent to permit storage that would otherwise be protected to OH3 to be protected to OH4 without the need to modify the storage system.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 2.1 – Representative schedule of occupancies and hazard classes

	Hazard class
Educational	
Art galleries	ELH
Libraries (excluding stack rooms)	ELH
Schools	ELH
Metalwork rooms	OH2
Woodwork rooms	OH3
Universities	ELH
Teaching laboratories (using flammable liquids)	OH3
Residential	
Boarding houses	ELH
Hospitals	ELH
Hotels (residential portion)	ELH
Motels (residential portion)	ELH
Prisons	ELH
Residential clubs	ELH
Youth hostels	ELH
Public assembly	
Airport public areas (excluding kiosks)	ELH
Amusement arcades	OH3
Bars, cafeterias, dining rooms, meeting rooms, and restaurants	OH1
Beauty salons and hairdressers	OH1
Churches seating areas	OH1
Cinemas, auditoriums, theatres	OH3
Casinos	OH3
Exhibition halls (ceilings less than 18 m)	OH3S
Exhibition halls (ceilings greater than 18 m)	EHH Process
Grandstands	OH3
Gymnasiums (excluding equipment storage)	OH1
Museums (unless otherwise approved)	OH3
Night clubs	OH3
Recreation ground and racecourse pavilions	OH1
Swimming and bathing buildings	ELH

	Hazard class
Energy supply	
Briquette and smokeless fuels	OH3
Coal-fired plants	EHH Process
Electricity generation and distribution	Refer NFPA
LPG storage	EHH Process
Commercial and mercantile	
Commercial laundries	OH3
Retail shops and malls	OH3*
Offices, meeting rooms, staff amenity and cafeteria areas	ELH
Processing and production	
Aircraft engine testing	EHH Process
Agricultural produce:	
• high moisture content (for example, fruit and vegetables)	OH1
• low moisture content (for example, grain, straw, and tobacco)	OH3
Animal and animal products:	
• cutting, boning, and packing	OH2
• other processing	OH3
Beverages (non-alcoholic) – processing	OH2
Breweries – processing	OH2
Boat building sheds	OH3S
Celluloid manufacturers and celluloid goods' manufacturers	EHH Process
Combustible compounds and chemicals (excluding manufacture or extensive use of flammable liquids)	OH3
Dairy produce (casein, milk powder, butter, and cheese)	OH3
Distilleries	EHH Process
Electrical/electronic manufacturing and assembly (predominantly plastic components)	EHH Process

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

Table 2.1 – Representative schedule of occupancies and hazard classes (continued)

	Hazard class		Hazard class
Fish:		Bus and tram barns	OH3S
• cutting and packing	OH2	Car parking	OH2
• other processing and products	OH3	Car stackers	See part 5
Firelighter manufacturers	EHH Process	Cinematographic and TV	
Fireworks and explosives	EHH Process	production studios	OH3S
Flammable liquids:		Commercial battery charging rooms	
• laboratories	OH3	(not stored higher than 2.4 m)	OH3
• processing	OH3S	Heavy vehicle repair workshops	EHH Process
• storage	EHH	Loading canopies	OH3S
• spraying	EHH Process	Motor vehicle repair garages	OH3
Floor cloth and linoleum manufacturers	EHH Process	Plant rooms (building services)	OH2
Inert materials and compounds	OH1	**Shipping and storage**	
Leather, skins, and furs	OH3	Aerosol containers with more than 25%	
Metal working and engineering		flammable product	EHH S C**
workshops	OH2	**Baled fibres and waste paper storage**	EHH S C**
Paper and paper products	OH3	Carpet storage	EHH S C**
Plastic goods manufacturing and		Container stuffing and unstuffing sheds	
process works (where plastic is one of		(storage, as defined in 2.3.2.7)	OH3S
the basic materials in the operation)	EHH Process	Distilled spirits storage	EHH S C**
Resin and turpentine manufacturers	EHH Process	General storage	
Rubber	EHH Process	(storage, as defined in 2.3.2.7)	OH3
Tar distillers	EHH Process	Hanging garments storage	EHH S C**
Textile fibre and products	OH3	Idle pallet storage	EHH
Wood and wood products	OH3	Library stack rooms	OH3
Miscellaneous		Theatrical scenery store	EHH Process
Aircraft hangars	EHH Process	Roll paper storage	EHH S C**
Boat houses	OH3	Tyre storage	EHH S C**

* The classification for areas of retail shops with storage fixtures that exceed the normal limits for OH3 shall be treated as either OH4 or EHH. Where the limits specified in 2.3.2.6 for OH4 are exceeded, the occupancy shall be treated as EHH in accordance with Part 9.

** EHH special commodity – see 9.1.2 and 9.3.4.

2.3.2.7 *OH1 to OH3 storage limits*

Where combustible commodities of various categories (as determined in 2.3.3) are stacked or stored beyond the heights specified in Tables 2.2(a) to (c), the occupancy category of that area shall change from OH1 to OH3 to either OH4 (provided the configuration of storage is within the criteria specified in 2.3.2.6) or otherwise to EHH. However, if the combustible storage concerned comprises 'incidental storage', the occupancy class shall remain as OH.

These height maxima depend on the fire hazard category of the goods or materials being stored (including, the fire hazard category of any packaging materials associated with such goods) and the manner of stacking. See also 2.3.2.4.

The width of any shelving or racks shall not exceed 1.2 m or 2.0 m, respectively.

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

'Incidental storage' refers to small discrete arrays of storage in areas that are not otherwise used for storage, provided that the dimensions do not exceed those specified in Tables 2.2(b) and (c), and that each such section of storage is separated from any other storage by a clear width of at least 2 m.

Height of storage shall be measured from the floor to the top of the stored materials (including packaging) under consideration.

Table 2.2(a) – Limits on storage of conventional commodities in OH3 occupancies

Commodity category	Maximum storage height (m)
1	3.5
2	3.0
3	2.4
4	2.2
5	2.0
6	1.2

Table 2.2(b) – Limits on incidental storage in OH1 and OH2 occupancies

Commodity category	Maximum storage height (m)	Maximum storage area (m^2)
1	3.0	20
2		
3	2.2	
4		
5	2.0	
6	1.2	
This table is intended to cater for isolated storage within OH1 and OH2 occupancies. If there is significant storage in such occupancies, they should be protected in accordance with OH3 design criteria.		

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 2.2(c) – Limits on incidental storage of special commodities in OH3 occupancies

Special commodities	Maximum storage height (m)	Maximum storage area (m^2)
Rubber tyres	1.2	20
Rolled paper – lightweight – stored on-end	0.9	
Rolled paper – lightweight – stored on-side	1.3	
Rolled paper – heavy or medium weight, stored on-end, unbanded or banded	1.3	
Rolled paper – heavy or medium weight, stored on-side	2.0	
Baled cotton, jute, hemp, sisal, flax, synthetic fibre, or wool	4.0	
Waste paper	3.0	
Hanging garments	1.5	
Rack and tube carpet storage	1.5	

In Tables 2.2(b) and (c), if the nature of the combustible storage in a particular storage array means that the fire spread is likely to be principally in one direction, then the maximum permitted area of incidental storage in the array concerned may be doubled.

2.3.3 *Classification of storage*

2.3.3.1 *General*

The intensity of fires in stored materials and the difficulty of control or suppression by sprinkler head discharge depends on the method of storage, the hazardous nature of the materials ('commodities') being stored (which may be modified by the nature of the packaging) and the height of the storage. Therefore, as apreliminary step to determining both storage height limits for OH occupancy classifications (see Tables 2.2(a)to (c)) and the design of the sprinkler system, all commodities shall be assigned to a 'category' of storage.

Such classification requires considered judgement and is subject to the approval of an SSC.

Appendix J provides an indicative list of commodities and related categories. However, as noted, the actual classification in each case shall take into account the combined effect of the burning characteristics and permeability of the stored commodity (which may vary by manufacturer or model), the properties of any packaging and storage containers, and the configuration of the storage arrangements. For example:

(a) Metal parts in cardboard cartons would be properly classified as Category 1, but, if the parts are stored within plastic boxes, the classification changes to Category 5 or Category 6 due to the greater combustibility of the plastic boxes and the inability of the sprinkler discharge to pre-wet the packaging due to the plastic boxes;

(b) If plastic products in cardboard cartons that would normally be classified Category 5 or Category 6 (depending on the type of plastic) are in open-topped metal boxes, the classification would change to Category 3 because the metal containers both limit the amount of air available for burning and reduce the area of exposed vertical and horizontal plastic surfaces.

2.3.3.2 *Method*

2.3.3.2.1 Mixed category goods

A variety of commodities of different categories may be stored within one area (for example, in a warehouse) or in a storage array. It is not permitted to 'average out' the categories of the commodities being stored either across the warehouse or within a storage array to determine the hazard classification. Instead, the hazard classification and sprinkler system design shall be based upon the highest hazard commodity present in either the warehouse or the array and the total height of all storage.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

However, if commodities are segregated into separate areas or storage arrays according to category, and there is a method of control, acceptable to the SSC, to maintain such segregation at all times, each area or array can be classified separately based on storage height and commodity category. This is also subject to compliance with any relevant restrictions on aisle widths and limitations of areas (such as those on incidental storage in Tables 2.2(b) and (c) and in 2.3.2.6 for OH4).

NOTE –

(1) Maintaining segregation of commodities of different categories can prove very difficult in a practical sense as it can be expected that acceptable methods of control may require extensive use of a combination of signage, written procedures, training, auditing, and other procedures. Such controls reduce the flexible use of space and hence itmay prove more efficient to base sprinkler design on the unrestricted storage of the highest category commodity.

(2) The concept of segregation is also an aspect of protection to 'Scheme A' in certain EHH storage occupancies (see 9.4.2.7.3).

2.3.3.2.2 Use of plastic pallets for storage of commodities

Unless listed pallets are used to support stored commodities, the classification of the commodity shall be increased by one level. The additional weight of the plastic pallet shall not be factored into the plastic weight of the commodity itself. The classification shall be increased as follows:

Category 1, Category 2, Category 3, and Category 4 shall be increased to Category 2, Category 3, Category 4, and Category 5, respectively. A change in classification shall not be needed when the commodity itself is considered a plastic.

2.3.3.2.3 Free-flowing materials

Solid piled storage of plastic or paper bags and sacks of greater than 0.025 m^3 capacity containing free- flowing inert commodities such as minerals; seeds; powdered detergents; and salt in powdered, granular, flake, pellet or similar forms on wood pallets can be classified as non-combustible commodities. A fire will burn through the bags causing the material to flow or spill out, filling up the flue spaces and reducing the fire intensity. This same effect does not occur in racks. Protect inert goods in this form stored in racks as Category 1 commodities. This does not apply to plastics.

2.3.3.2.4 Expanded plastic commodities

Foamed or cellular (expanded) plastics are those in which the density is reduced by the presence of numerous small cells throughout their mass. The fire risk associated with these materials is considered significantly higher than 'unexpanded' goods of the same materials.

2.3.3.2.5 High hazard – Storage occupancies – Category 1

Category 1 commodities are equivalent to non-combustible products stored on wood pallets, within ordinary corrugated cardboard cartons.

2.3.3.2.6 High hazard – Storage occupancies – Category 2

Category 2 commodities are equivalent to Category 1 products stored in wood crates and boxes, within multiple thickness cardboard cartons, or similarly combustible packaging materials on wood pallets.

2.3.3.2.7 High hazard – Storage occupancies – Category 3

Category 3 commodities are equivalent to ordinary combustible products, such as packaged or unpackaged wood, paper or natural fibre cloth, or products made from these materials on wood pallets. Category 3 commodities also generally include Category 1 and Category 2 goods or paper goods containing no more than 5% plastics, either by weight or volume.

NOTE – Category 3 commodities would also include those plastic products classified as 'Group C Plastics' in NFPA 13 and FM Global Data Sheet 8-1. Examples include rigid or lightly plasticised PVC products (for example, pipe and pipe fittings), melamine, fluoroplastics, and urea formaldehyde.

2.3.3.2.8 High hazard – Storage occupancies – Category 4

Category 4 goods are equivalent to Categories 1, 2, and 3 goods containing in them, or in their packaging, no more than 25% by volume of expanded (foamed) plastic or 15% by weight of unexpanded plastics in cardboard cartons.

2.3.3.2.9 High hazard – Storage occupancies – Category 5

Category 5 products are equivalent to uncartoned or cartoned unexpanded plastics or cartoned expanded plastics.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTE – Some plastics have a heat of combustion and a burning rate similar to those of ordinary combustibles and can be treated and protected as a Category 3 commodity. Generally, these materials would be classified as 'Group C'.

2.3.3.2.10 High hazard – Storage occupancies – Category 6

Category 6 plastic commodities are equivalent to expanded and exposed plastics.

NOTE – Further guidance may be available in FM Global Data Sheet 8-1 and in NFPA 13.

2.3.3.2.11 Aerosol containers

Some aerosols contain a proportion of flammable products other than the propellant. If exposed to fire, aerosols with more than 25% flammable product can cause intense burning and may rocket with a flaming trail of contents. The combustibility of the propellant has little impact on fire behaviour.

Except for Level 1 aerosols, aerosols are to be treated as a special commodity. See 9.1.2.

Storage of aerosols containing 25% or less flammable liquid (Level 1 aerosols) are subject to the rules for OH and EHH.

2.3.4 *Process risks*

2.3.4.1

Those occupancies with processes, process materials, or types of storage (notwithstanding the amount and arrangement of stored combustibles) that will produce rapid and intense burning fires requiring higher densities than those for OH, shall be protected as EHH 'process' risks.

2.3.4.2

The density and assumed maximum area of operation shall be as specified in 9.3.5. For occupancies or processes not included in Table 9.1 but which present a process risk, the density and area of operation shall be approved by an SSC having regard to the three factors of fire hazard specified in 2.3.2.1 and relating these to the occupancies or processes included in Table 9.1.

2.3.5 *Other combustible and ignitable liquid hazards*

2.3.5.1

An SSC may require special provisions for the protection of flammable liquids. See Table. 2.3.

This standard does not provide design criteria for the protection of combustible liquids. Guidance may be sought from authoritative documents such as NFPA30 or FM Global Data Sheet 7-29.

The holistic design for a combustible and ignitable liquid storage occupancy will include the need to consider drainage and run-off water.

NOTE – There are differences between flammable liquid classification definitions in the Hazardous Substances (Classification) Regulations and NFPA 30. NFPA 30 protection criteria shall be based upon NFPA flammable liquid classifications. See Table 2.3 for guidance.

Table 2.3 – Comparison of classification of flammable liquids designations as specified in NFPA 30 and Hazardous Substances (Classification) Regulations

NFPA 30 designation			HSNO classification		
Liquid classification	Flashpoint (°C)	Boiling point (°C)	Liquid classification	Flashpoint (°C)	Boiling point (°C)
IA	< 22.8	< 37.8	3.1A	< 23	≤ 35
IB	< 22.8	≥ 37.8	3.1B	< 23	> 35
IC	22.8 ≤ FP < 37.8	NA	3.1C	23 ≤ FP ≤ 60	NA
II	37.8 ≤ FP < 60	NA	3.1C	23 ≤ FP ≤ 60	NA
IIIA	60 ≤ FP < 93	NA	3.1D	60 < FP ≤ 93	NA
IIIB	≥ 93	NA	NA	NA	NA

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

2.3.5.2 *Flammable liquids in retail areas and other OH occupancies*

2.3.5.2.1

Flammable liquids in retail glass, plastic, and metal containers may be stored and displayed in OH3 retail areas protected by a minimum of an OH3 or OH4 sprinkler system, subject to the following limitations:

(a) The maximum allowable storage height is 2.4 m;
(b) Classes 3.1A and 3.1B flammable liquids in containers of greater than 1 litre capacity shall not be stored in retail areas designed to OH3 or OH4;
(c) Classes 3.1C and 3.1D flammable liquids in containers of greater than 10 litres capacity shall not be stored in retail areas designed to OH3 or OH4;
(d) Adjacent storage areas (see 9.3.5.2.2) of flammable liquids in retail areas shall be separated by a horizontal distance of at least 15 m or be in an adjacent firecell.

For the purposes of this clause, a firecell is defined as providing an FRR of at least –/60/60.

2.3.5.2.2

The maximum volumes of flammable liquids allowed to be stored in OH3 retail occupancies protected to a minimum of OH3 occupancy are as follows:

(a) The maximum volume of Classes 3.1A and 3.1B flammable liquids in any one storage area is 100 litres;
(b) The maximum aggregate volume of other classes of flammable liquids in any one storage area is 1000 litres.

Storage or display of Classes 3.1A, 3.1B, or 3.1C flammable liquids is not permitted in basements.

If the required storage criteria exceed the limits specified in these clauses, alternative design criteria may be found in Part 9, or NFPA 30.

2.3.5.2.3

In commercial occupancies, consideration should be given to storing flammable and ignitable liquids in dangerous goods lockers.

2.3.5.3 *Transformers, hydraulic oil packs and lubricating systems*

Equipment within or adjacent to the protected building and which contains flammable liquids, including transformers, lubricating oil and hydraulic systems, and heat-transfer fluid systems may require the use of water spray systems where the quantity of flammable liquid which could become involved in the fire would present a greater fire load than the remainder of the occupancy. Such systems shall form part of the sprinkler systems and be designed to provide densities specified in NFPA 15.

2.3.5.4 *Liquid petroleum gas*

Fixed liquid petroleum gas (LPG) storage vessels, or quantities of more than 100 kg in portable cylinders, may require water spray systems where the risk of BLEVE (boiling liquid expanding vapour explosion) would expose the protected building and occupants (see Table 9.1).

NOTE – Typically, one or two LPG cylinders will only require standard sprinklers for coverage or exposure protection.

2.3.6 *Materials with a high spread of flame or exposed, extruded or expanded plastic materials on walls, ceilings, and undersides of roofs*

2.3.6.1

The combustible properties of the surface materials and finishes of walls, ceilings, and the underside of roofs shall be such that fire involving these materials cannot spread across the surface more rapidly than can be controlled by the sprinkler system. If such materials or surface finishes are present, they shall be either replaced or their combustion characteristics modified through the application of coatings or other means, so that the surfaces will comply with the requirements of the supporting documents to the NZBC Clause C Protection from fire.

NOTE – Materials that do not comply with the requirements of the supporting documents to the NZBC Clause C Protection from fire include, but are not limited to, unencapsulated polyurethane and painted-exposed expanded polystyrene.

2.3.6.2

Surface treatments on walls, ceilings, and under roof surfaces that have not been tested and certified as having lower ignitability/combustibility properties by FM Global, the Loss Prevention Certification Board (LPCB), or other accredited laboratories, or do not meet the requirements of the supporting documents to the NZBC Clause C Protection from fire, cannot be protected by automatic sprinkler systems.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Due to the nature of these products and their application, there is no suitable sprinkler protection currently available and advice should be sought from a suitably qualified fire engineer for an engineered solution for the protection of these buildings.

NOTE –

(1) The results of small-scale fire testing such as defined in AS/NZS 1530.3 cannot be used in isolation as evidence of compliance with this clause.

(2) Materials which have passed the FM Global parallel panel test or corner test and listed as Class 1 for the particular purpose, or ISO 9705-1 and achieved no greater than a group number 3 classification are deemed to be acceptable for listing purposes.

2.4 Extent of sprinkler protection

2.4.1

Any building which is required to be sprinkler-protected in accordance with this standard shall be sprinklered throughout except where the omission of sprinklers is specifically permitted by the standard.

2.4.2

Any firecell of any building which is required to be sprinkler-protected in accordance with this standard shall be sprinklered throughout except where the omission of sprinklers is specifically permitted by this standard. Otherwise the sprinkler system shall be deemed not to comply with this standard.

When a building includes unprotected firecells, a sign with 25 mm contrasting lettering shall be located at the fire brigade inlet, stating:

'Building Not Fully Sprinkler Protected' and clearly outlining the scope of protection. The exact wording of the sign shall be approved by the fire brigade.

2.5 Fire loads adjoining, linked, or adjacent to the sprinkler-protected building or sprinkler-protected firecell

2.5.1 *General*

2.5.1.1

To prevent the spread of fire and the operation of sprinklers inside a sprinkler-protected building or sprinkler-protected firecell as a result of a fire in some other building, firecell, or structure, the sprinkler-protected building or sprinkler-protected firecell shall be effectively separated in the manner required by this standard.

2.5.1.2

Separation requirements shall not apply in the case of any building under the same ownership or control as the sprinkler-protected building if that other building is a sprinkler-protected building. If the protected building sprinkler system does not comply with this standard, separation requirements shall be subject to theapproval of an SSC.

2.5.1.3

Separation may, in general, be achieved:

(a) In a sprinkler-protected firecell, by means of fire separations, external walls, roofs, and floors whereby fires in an unsprinklered firecell cannot be transmitted into the sprinkler-protected firecell irrespective of the presence of sprinklers;
(b) In a sprinkler-protected building, by means of one, or a combination of:
(c) separation distance,
(d) external walls having an FRR, or
(e) other external walls of the sprinkler-protected building to which are fitted external sprinklers.

NOTE – See 2.5.2, 2.5.3, and 2.5.4 for fire rating requirements.

2.5.2 *Adjoining buildings*

2.5.2.1

For the purpose of this clause, 'adjoining' means to touch or be within 1 m of the sprinkler-protected building. The exception is that a designated historic dwelling building shall not be deemed to adjoin provided that it does not touch the sprinkler-protected building and the gap between the buildings is totally open to the sky.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

2.5.2.2

The sprinkler-protected building shall be separated from every adjoining building by a wall having an FRR of 120/120/120 and which extends through the roof covering for a distance of at least 450 mm and in which any openings are protected by a fire door, having an FRR of –/120/60. In the case of a building requiring a Class A water supply, fire separations shall be of concrete or masonry construction.

NOTE –

(1) Insurance interests may require a higher level of separation than nominated in this standard.

(2) Where possible, all fire doors should be fitted with draught seals.

2.5.3 *Linked buildings*

2.5.3.1

For the purpose of this clause, 'linked' means physically connected over a distance greater than 1 m, by a passageway enclosed by two side walls and a roof, or by a conveyor (excluding a screw conveyor).

2.5.3.2

Either (a) – (c) or (d) shall apply:

(a) A link shall not be used for storage;

(b) A link shall not contain unprotected concealed spaces that communicate with the sprinkler-protected building; and

(c) The roof of an enclosed link shall be at least 600 mm below the eaves of the adjacent unprotected building or the most remote sprinkler in the link shall be at the notional edge of the unprotected building (see Figures 2.1(a) and (b)); or

(d) A specific engineering design as approved by an SSC shall be applied.

NOTE – The intention of this clause is to prevent propagation of combustible or hot gases through the link into the protected building.

2.5.3.3

Either (a) – (c) or (d) shall apply:

(a) The link shall be sprinkler protected for a minimum of 10 m from the notional edge of the sprinkler-protected building, or the entire length, whichever is the lesser, with a discharge density commensurate with the commodity being transported through the link and the means of conveyance (for example, a forklift or conveyor) (see Figures 2.1(a) and (b)); and

(b) Conveyors shall be interlocked to shut down on activation of the sprinkler system; and

(c) Openings from the link into the sprinkler-protected building may be required, at the discretion of an SSC, to be assessed for the potential of fire spread into the protected building; or

(d) Openings from the link to the protected building shall be fitted with fire doors having an FRR not less than –/60/30.

NOTE – The provisions of (c) are to cater for unprotectable openings such as may be required for conveyors and the like. The dimensions of such openings should be minimised, as reasonably practicable.

2.5.3.4

If the construction of the exposed wall of the sprinkler-protected building is at least FRR (60)/60/60 (from the exposed side) extending at least 10 m from the link, then external sprinkler protection is not required.

The pressure and flow requirements of the sprinkler system shall meet the concurrent demand of the link and the sprinkler demand immediately adjacent to the link.

2.5.3.5

If the exterior surface of the exposed wall of the sprinkler-protected building is a non-combustible cladding extending at least 10 m from the link, then the criteria of 2.5.3.3 shall be met and external sprinklers shall be installed on the exterior of the sprinkler-protected building above, and extending 5 m beyond, the link in accordance with 5.16.

The pressure and flow requirements of the sprinkler system shall meet the link demand and the most onerous of either the external drencher demand or the internal sprinkler demand immediately adjacent to the link.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

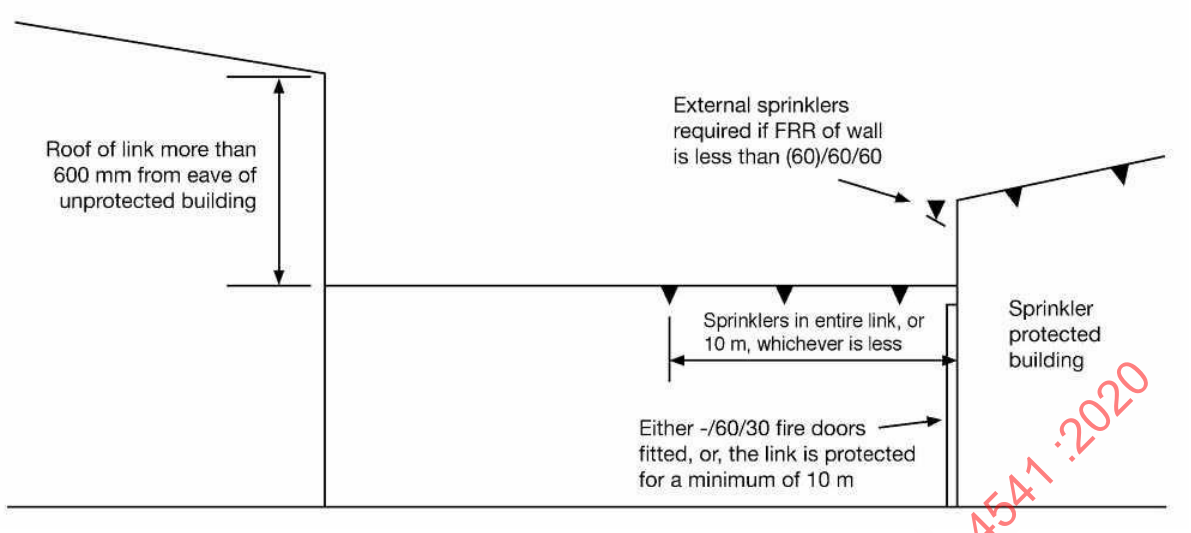


Figure 2.1(a) – Link to unprotected building with eave height ≥ 600 mm

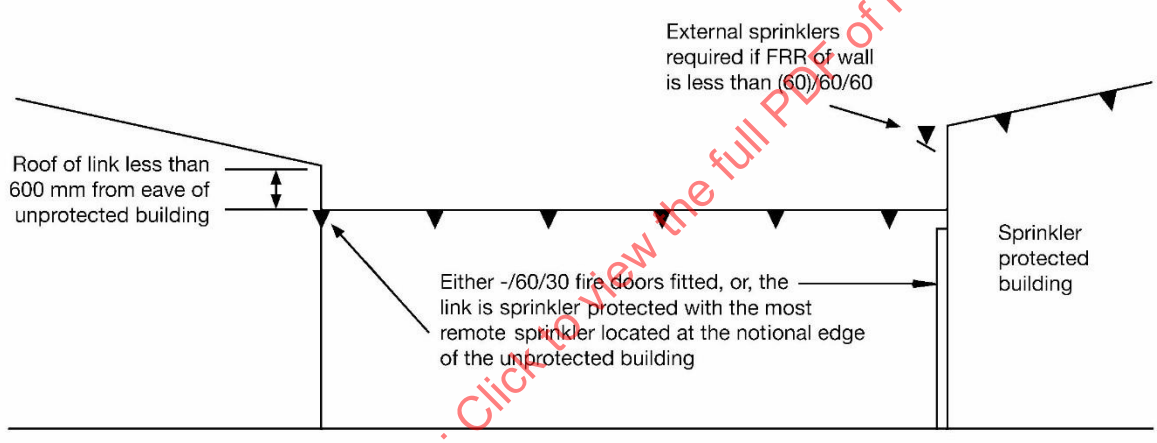


Figure 2.1(b) – Link to unprotected building with eave height < 600 mm

2.5.3.6

If the exterior surface of the exposed wall of the sprinkler-protected building is a combustible cladding within 10 m of the link, then that portion of the link within 1 m of the exposed wall of the sprinkler-protected building shall be considered as an adjoining building, and that section of the link between 1 m and 10 m of the exposed wall of the sprinkler-protected building shall be considered as an adjacent building.

The pressure and flow requirements of the sprinkler system shall meet the link demand and the most onerous of either the external drencher demand or the internal sprinkler demand immediately adjacent to the link.

2.5.4 *Adjacent buildings*

2.5.4.1

For the purpose of this clause, 'adjacent' means within 10 m of the sprinkler-protected building but not adjoining (see 2.5.2) or linked to it (see 2.5.3).

2.5.4.2

The sprinkler-protected building shall be separated from adjacent buildings by external sprinklers complying with sections 2.7 and 5.16 unless one of the following criteria is satisfied:

(a) The adjacent building is deemed by an SSC, in accordance with 2.5.4.3, not to present an exposure hazard;

(b) The external walls of the sprinkler-protected building, within the range of the following described arcs, are non-combustible and have a minimum FRR of –/30/30. Any glazing within these arcs shall be either protected by external sprinklers or have FRR of –/30/30:

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

(i) Horizontal arcs of 10 m radius from the extremities of the plan area of the adjacent building
(ii) Vertical arcs of 15 m radius from the highest openings or from the point on the roof of the adjacent building if the roof is not of a construction having an FRR of (30)/30/–
(iii) Horizontal arcs of 10 m radius from the top of any wall on the face of the adjacent building;

(c) The adjacent building is a domestic residence, domestic garage, or outbuilding and is more than 3 m distant.

2.5.4.3

An SSC may deem an adjacent building not to present an exposure hazard in any of the following circumstances:

(a) The adjacent building is less than 150 m^3 and the face of the sprinkler-protected building within 10 m is clad in non-combustible materials and has no openings through which fire could enter;
(b) Both the sprinkler-protected building and the adjacent building have been constructed in accordance with either the NZBC or NZS 1900 Part 5;

NOTE –

(1) Buildings on the same title may present an exposure hazard even though they comply with NZS 1900 Part 5.

(2) 'Constructed in accordance with NZS 1900 Part 5' should not be interpreted to automatically include any building for which a dispensation from the detailed requirements of that standard has been granted by the territorial authority (TA).

(c) The adjacent building is itself protected by an approved sprinkler system. An SSC, before granting relief under this subclause, may require proof of approval of the system in the adjacent building and may, in the event that such approval lapses, withdraw approval of the protected building until such time as external protection is provided.

NOTE – It is recommended that the attention of the owner of the protected building be drawn to this provision.

2.6 External fire loads adjacent to the sprinkler-protected building or sprinkler-protected firecell

2.6.1 *General*

2.6.1.1

In 2.6, 'external fire load' means any combustible equipment, material, or structure (other than an adjacent building as defined in 2.5) that is:

(a) External to a protected building or protected firecell;
(b) Permanent or of a type that is regularly transient;
(c) Not located within, or is part of, a structure that is sprinkler-protected in accordance with this standard; and
(d) Of sufficient fuel load and in such proximity to the building or firecell that if ignited it is capable of igniting the protected building or firecell, or causing operation of sprinklers within the protected building or firecell, given the construction (including the external wall) of the protected building or firecell.

All such external fire loads shall be separated from the protected building or protected firecell in the manner required by this standard, or if of a type not specifically referred to, in another manner approved by an SSC based on specific fire engineering design.

Provisions for separation shall take into account the potential for collapse (as a result of burning) of the external fire load against or on top of the protected building or firecell. Where this could occur, the separation arrangements shall be subject to specific approval by an SSC.

NOTE –

(1) Without limiting the generality of the above definition, external fire loads may be in the form of waste, waste containers, stored goods or idle pallets, relocatable enclosures, plant equipment, and other items specified inTable 2.4. Depending on its nature, nearby vegetation may be an external fire load.

(2) The following shall NOT be deemed external fire loads and are, therefore, exempt from consideration:
(a) Uncovered carparks;
(b) Domestic barbecues;
(c) Domestic gas heating appliances;
(d) Heat-pump units;
(e) LPG bottles with a total quantity less than 20 kg; and
(f) Outdoor furniture

(3) Requirements for external fire loads in the form of 'adjacent buildings' are set out in 2.5.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(4) Notwithstanding note (2), consideration should be given to prevent the spread of fire to combustible cladding from any potential fire source. Significant fires occurred at the Lacrosse Building (2014) and the Neo 200 Building (2019) where fire spread from such exempted sources to combustible cladding.

2.6.1.2

Subject to the specific provisions of this standard, the following are acceptable methods of achieving separation:

(a) A blank concrete or masonry wall; either as an exterior wall on the protected building or firecell, or as a free-standing wall between the external fire load and the exposed face of the protected building or firecell;

(b) A combination of non-combustible cladding on the exterior wall of the protected building or firecell and separation distance based on the characteristics of the external fire load (see Table 2.4 for classification of external fire loads, 2.6.3 for classification of external walls, and 2.6.4 for separation distance minima based on these two classifications);

(c) Other forms of construction on the exterior wall of the protected building or firecell, in combination with external sprinklers (see 2.7 for requirements); or

(d) Another solution deemed satisfactory by an SSC.

2.6.2 *Classification of external fire loads*

External fire loads shall be classified as Type 1, 2, or 3, in accordance with Table 2.4 according to their combustibility and quantity.

If the amount or volume of the commodity exceeds that shown in Table 2.4 and the external wall of the building is not masonry or concrete without penetrations of any kind, the requirements of 2.6.4.2 apply.

For other types of external fire loads the classification shall be made on the basis of specific fire engineering design and approved by an SSC.

Table 2.4 – Classification of external fire loads

Type 1	• Steel shipping container(s) that are kept closed and locked; and are either empty or contain ordinary combustible items • Waste bin(s) with a capacity of 1100 litres or less, with no hydraulic presses used for the purposes of compacting rubbish • Dry transformers or oil-filled transformers which meet the approval of an SSC • Diesel generators with a day tank capacity of 1000 litres or less
Type 2	• Waste bin(s) with a capacity of between 1101 litres and 8000 litres, with no hydraulic presses used for the purposes of compacting rubbish • Idle wood pallets, of a quantity not exceeding 50 pallets • Diesel generators with a day tank capacity of between 1001 and 2500 litres
Type 3	• Waste bin(s) with a capacity of between 8001 and 19 000 litres or less, with no hydraulic presses used for the purposes of compacting rubbish • Idle wood pallets, of a quantity between 51 and 200 pallets • Idle plastic pallets, of a quantity not exceeding 50 pallets • Transformers filled with mineral oil having a capacity of 1900 litres or less • Diesel generators with a day tank capacity of between 2501 litres and 5000 litres

NOTE –

(1) Where it can be demonstrated to the satisfaction of an SSC that an oil-filled transformer is constructed and maintained to a standard which demonstrates a negligible likelihood of either ignition or sustained combustion(such as FM Global Data Sheet 5-4), then the transformer may be treated as a dry transformer.

(2) Where the burning characteristics of particular types of plastic pallet can be demonstrated to an SSC as being comparable to that of wood pallets, they may be deemed to be wooden for the purposes of this table.

(3) Where the exposure is of a type not listed in the table, it shall be evaluated using the table as a guide to fire loads.

2.6.3 *Classification of external walls*

For the purposes of 2.6, external walls are classified according to (a) to (d) below. Where any uncertainty exists on the relevant classification, the most onerous definition shall be applied:

(a) Blank full height masonry or concrete wall (that is, without penetrations of any kind);

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

(b) Fire resistive or sprinkler protected:
  (i) Any external cladding system having an FRR of –/30/30 including all doors and windows
  (ii) Any fully clad external wall with either glazing or doors on any openings protected by a wall drenching sprinkler system complying with 2.7 and 5.17, or
  (iii) Any wall where the external fire load, to the satisfaction of the SSC, is adequately protected by part of the sprinkler system, or by the discharge of a water spray system;
(c) Non-combustible, unrated:
  (i) An, external wall of non-combustible construction (for example, with sheet metal cladding), provided that any unrated doors are constructed of steel or solid wood, and any unrated windows are of tempered or wired glass, or
  (ii) Any blank, external wall of non-combustible construction which does not meet the requirements of fire resistive or sprinkler protected;
(d) Combustible:
  (i) Any external wall system containing combustible components, including timber, plastic panels, exterior insulation and finish systems (EIFS), Aluminium Composite Panels (ACP), or similar,
  (ii) Any wall system which does not meet the requirements of fire resistive or sprinkler protected, or non-combustible, unrated,
  (iii) Any wall with penetrations or openings which do not comply with 2.6.3(b) or (c), or
  (iv) Any air intake or exhaust used for the purposes of heating, cooling, or ventilating the building.

If there is uncertainty about the correct classification, the wall shall be deemed to be 'combustible'.

2.6.4 *Minimum separation distances*

2.6.4.1

Separation distances between the sprinkler-protected building and external fire loads shall take into account the nature of the fire load, as defined in 2.6.2, and the building construction, as defined in 2.6.3. Separation distances shall comply with the minimum separation distances as specified by Table 2.5 and shall be measured as arcs in both the vertical and horizontal plane between the fire load and the building.

For the purposes of determining the minimum separation distance, the following shall be applied:
(a) Where a building has eaves or other projections, the minimum required separation distance shall be taken from the edge of the building eave or projection;
(b) For oil-filled transformers, unless the ground slopes away from the building, the transformer shall be bunded and measurement shall be taken from the edge of the bund;
(c) The measurement in the horizontal plane shall be taken from the closest point between the external fire load and the closest points of the sprinkler-protected building; and
(d) The measurement in the vertical plane shall be taken from the highest point of the external fire load, and shall be an arc with a dimension 150% of that of the minimum separation distance in Table 2.5.

Table 2.5 – Minimum separation distances

	Blank masonry or concrete wall	Fire resistive or sprinkler protected	Non-combustible, unrated	Combustible
Type 1	Nil	600 mm	2.0 m	3.0 m
Type 2	Nil	600 mm	3.0 m	6.0 m
Type 3	Nil	1.5 m	4.6 m	9.0 m

2.6.4.2

If there are multiple types of external fire loads or if the quantity of combustible material for one type exceeds that shown in Table 2.4, in addition to maintaining the separation distances from the building that are specified in Table 2.5:
(a) Different types of external fire loads shall also be separated from each other; and
(b) Similar types shall be subdivided and separated, so that the amount in any one quantity does not exceed the limits in Table 2.4.

In either case, the minimum separation distance between such external fire loads shall be at least half of the applicable separation distance shown in Table 2.5 according to types of fire load and wall construction.

This requirement does not apply if the external wall is blank masonry or concrete.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

2.7 Requirements for external sprinklers and internal drenchers

2.7.1 *Extent of external sprinkler protection*

Where external sprinkler protection is required by 2.5 or 2.6, external sprinklers shall be arranged to wet those doors, windows, and non-masonry portions (with an FRR of less than –/30/30) of the external walls of the sprinkler-protected building within the arcs described and shall comply with 5.17. See also Figure 2.2. This clause does not reconcile with Table 2.4.

2.7.2 *Design number*

The design number of external sprinklers is that number of sprinklers which an SSC deems may operate simultaneously.

2.7.2.1

In determining the design number, the following procedures shall generally be applied:

(a) For each exposure (that is, adjacent building or accumulation of combustibles) identify the probable maximum area of fire spread. For example, if the exposure is an uncompartmented warehouse, the maximum area would be the entire area of the warehouse;
(b) Describe arcs in the manner described in 2.5.4.2(b) and (c); and
(c) The sum of the sprinklers within those arcs is the design number.

2.7.3 *Water supply performance requirements*

2.7.3.1

The water supply requirement for the external sprinklers shall be the flow and pressure required at the control valves to adequately supply the hydraulically worst-placed design number of external sprinklers operating simultaneously.

2.7.3.2 *Performance*

Sprinkler systems that incorporate exposure protection shall be fully hydraulically designed, so that the flow from any external sprinkler shall be not less than 75 L/min when the required maximum number of external sprinklers are operating.

Where the area to be protected by an individual sprinkler is less than 2.5 m wide, the flow rate may be reduced proportionally subject to a minimum end head pressure of 70 kPa.

The required number of sprinklers assumed to be in simultaneous operation shall be the number of sprinklers opposed to each exposure hazard, but not exceeding 18 sprinklers in total (see 2.6.1.1 and 2.6.1.2). Hydraulic calculation methods shall conform to the requirements of Part 10, as appropriate.

Sprinklers that are specifically listed for this purpose shall comply with the performance criteria given in the listing.

2.7.3.3 *Water supply*

If the maximum calculated demand of the exposure protection is in excess of that required for the internal sprinklers alone, the water supply shall be increased to cover the excess.

2.7.4 *Internal drenchers*

Where internal drenchers are installed as part of a fire engineering design, their design flow shall be determined by simultaneously operating the number of drenchers and sprinkler heads bounded by the sprinkler system area of operation as if it were positioned adjacent to the wall(s) with internal drenchers.

NOTE –

(1) This standard is not intended to provide guidance on the installation and design of internal drencher systems. This clause has been included in the standard to ensure that sprinkler system operation is not compromised by the addition of internal drenchers, typically used to enhance the fire rating performance of elements of building construction, which exceed the requirement of the sprinkler standard.

(2) Notwithstanding note 1, when internal drenchers are specified, the designer should take into account when the drenchers are required to operate, that the sprinkler system may be impaired. The designer should carry out a risk assessment to determine the level of redundancy required for the drencher system.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

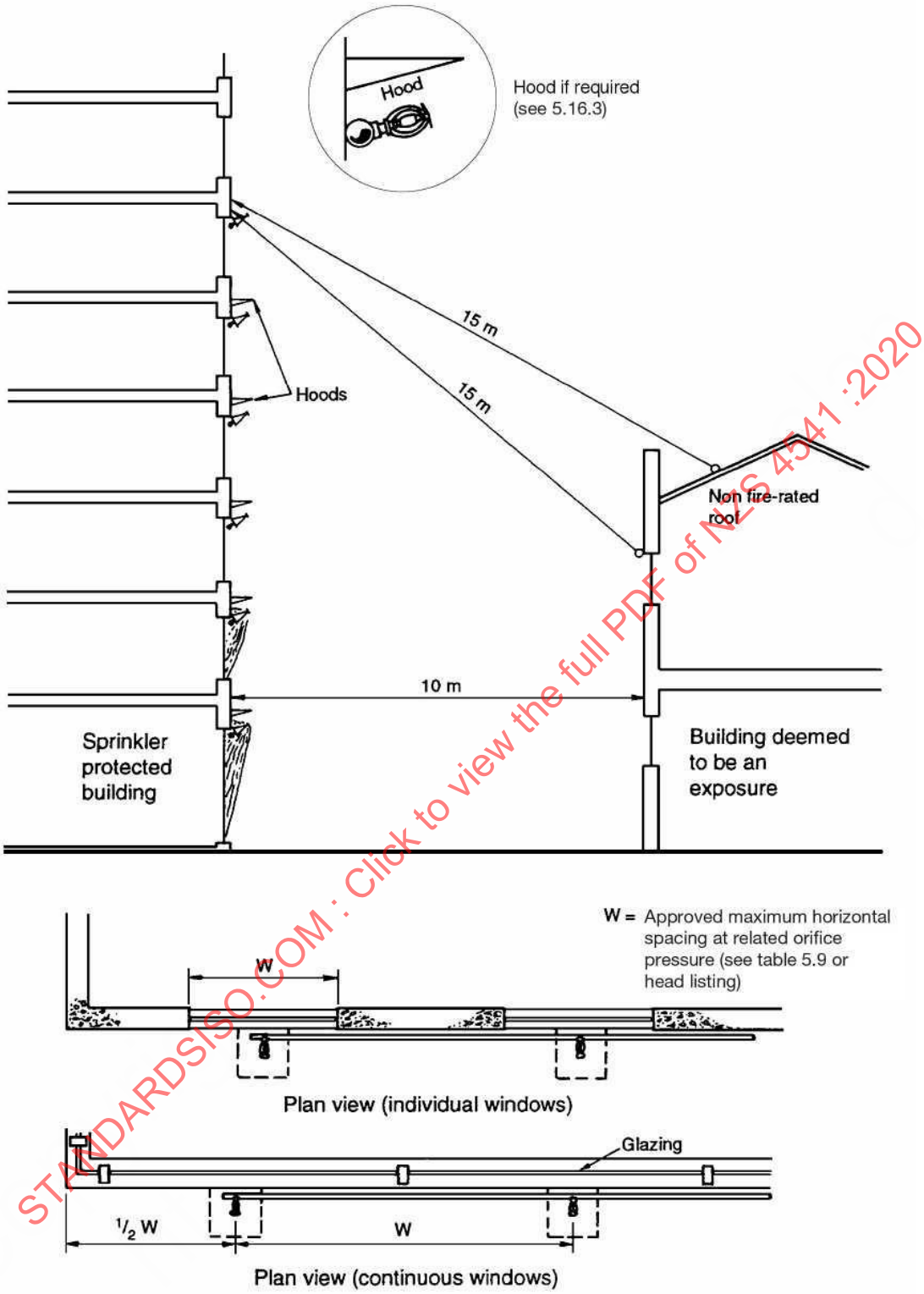


Figure 2.2 – Typical external sprinklers

2.8 Permitted exceptions from sprinklering

2.8.1 *Permitted areas exempt from sprinkler protection*

The following are permitted exceptions to the requirements of 2.4 that a sprinkler-protected building or sprinkler-protected firecell be sprinklered throughout (see also Figure 2.3 and see 2.12 for plastic panel construction):

(a) Concealed spaces between ceilings and roofs (including those at the apexes and sides of buildings) where the following criteria are met:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(i) The space is subdivided by fire resistant barriers at not more than 225 m^2 and no dimension exceeding 20 m, AND
(ii) The distance from the underside of the roof sheathing to the top of the ceiling lining does not exceed 0.8 m;

NOTE – Spaces containing bundled cables should be sprinkler protected.

(b) Concealed spaces between ceilings and floors above where the following criteria are met:
(i) The space is subdivided by fire resistant barriers at not more than 225 m^2 and no dimension exceeding 20 m, AND EITHER
(ii) The distance from the underside of the floor to the top of the ceiling lining does not exceed 0.8 m, OR
(iii) The space has all its bounding surfaces wholly formed of non-combustible materials and contains no combustibles other than individual electric cables;

NOTE – Spaces containing bundled cables should be sprinkler protected.

(c) Concealed spaces between the ground and the floor immediately above where either of the following criteria is met:
(i) The floor is of concrete and any openings are protected by fire resistant barriers and the space is not used for storage, OR
(ii) The floor is other than concrete and of tight construction and the space is not accessible for storage purposes or entrance of unauthorised persons, contains no equipment which could be a source of ignition, and is protected from the accumulation of debris. In such cases, flammable liquids are not permitted to be stored on the floor above;

NOTE – Spaces containing bundled cables should be sprinkler protected.

(d) Concealed spaces between a floor and the floor immediately above when all the following criteria are met:
(i) The space contains no combustibles other than plumbing pipes (or similar)
(ii) The space does not contain any sources of ignition other than single electrical cables (bundled cables are unacceptable)
(iii) There are no switch boards, or similar, backing on to the space unless a fire separation of at least FRR of -/30/30 is provided between switchboard and space
(iv) The maximum volume of the space is 2 m^3
(v) The distance may only exceed 800 mm in one dimension (excluding height)
(vi) The space is fire separated at each floor by fire separations having an FRR of -/30/30, AND
(vii) The walls of the space shall maintain the fire separations to the FRR as required by the fire design;

(e) Concealed spaces between structural floors and functional floors raised above them when all the following criteria are met:
(i) The space does not contain any sources of ignition or combustion (excluding non-bundled electrical power or lighting wiring)
(ii) The floor is of tight construction and the space is not accessible for storage purposes or entrance of unauthorised persons
(iii) The space is subdivided by fire resistant barriers at not more than 225 m^2 and no dimension exceeding 20 m
(iv) The distance from the underside of the functional floor to the top of the structural floor does not exceed 0.8 m
(v) The space is not used as an air-conditioning or ventilation plenum
(vi) The space is not constructed of, nor contains exposed foamed plastics, AND

NOTE –

(1) While some minor quantities of combustible material such as power, lighting, or data or communication cable may be present in such a concealed floor space, it should not be construed as requiring sprinkler protection. There is no defined limit to the quantities of such wiring that may be present before sprinkler protection is required. If bundles of non-fire-resistant cables are present, the space should be treated as having combustible content and should be protected accordingly.
(2) Spaces containing bundled cables should be sprinkler protected.

(vii) Notwithstanding (i) to (vi) above, it shall not be necessary to install sprinklers in the void between the structural floor and functional floor provided the height of the void does not exceed 150 mm, if the void is filled with sand or a preventative measure as approved by an SSC;

(f) Concealed spaces not listed above that are fully enclosed non-accessible voids, bounded entirely by non-combustible construction, and containing no sources of ignition or combustion;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(g) With respect to special cases where localised combustibles exist in a concealed space as defined in 2.8.1(b) to (d), which would otherwise not require the space to be protected, such combustibles may be protected with localised sprinklers;

NOTE – This clause is intended to allow localised protection of areas with small fire loads, such as electric motors contained within an air handling plant and the like.

(h) Staircases forming a vertical safe path enclosed by fire separations having an FRR of –/60/60 in which:
  (i) The stair is either bare concrete or steel and there is no carpet, vinyl, rubber tread (with the exception of nosing strips on the edge of each step), or other floor coverings, AND
  (ii) There is no lining or fitting within the stair enclosure which will ignite, other than light fittings, doors or bannister rail, AND
  (iii) No material is stored either permanently or temporarily, AND
  (iv) There is a sprinkler at the head of the stair, over every floor landing, and beneath any flight which intersects with a floor and forms a semi-enclosed space in which material could be stored without blocking the stair;

(i) Inside non-combustible silos or bins for the storage of grain which are within buildings forming a part of a corn mill, distillery, maltings, or oil mill premises;

(j) Those ovens (including powder-coated ovens), hovels, and kilns which are in potteries; earthenware, brick, tile and glass works, manufacturing facilities; bakeries; and similar occupancies;

(k) Over salt baths and metal melt pans where the application of water would endanger persons. Pipework and sprinklers may be located over such places if a suitable canopy is fitted;

(l) Shower areas that do not exceed 5 m^2 in area, that have walls and ceilings of non-combustible or limited combustibility materials with a 15-minute thermal barrier rating, including the walls and ceiling behind any shower lining;

NOTE – For the purpose of this clause, 10 mm gypsum board is deemed to have a 15-minute thermal barrier.

(m) Within revolving door enclosures;

(n) Within wind lobbies, where the bounding surfaces are of non-combustible or limited combustible surfaces, and storage is unlikely;

(o) Within enclosures for retractable doors, where;
  (i) A written declaration is made by the building owner that no storage is permitted within the enclosures, AND
  (ii) Clear signage using 25 mm letters in contrasting colours shall be fitted to the exterior of the doors to such enclosures stating that storage is prohibited within the enclosures;

(p) Under retractable seating areas. Clear signage using 25 mm contrasting colours shall be located at the entry points under such seating, to outline that storage in these areas is strictly prohibited; and

(q) The undersides of screens or shields erected over the wet end of paper-making machines.

2.8.2 *Contiguous protected and unprotected concealed spaces*

Where 2.8.1 permits concealed spaces to be unprotected, and these are located adjacent to concealed spaces that are required to be protected, either:

(a) The whole concealed space shall be protected; or

(b) The areas shall be separated from each other with a fire separation having an FRR of –/30/30.

C2.8

It is noted that sprinklers are designed to control and not necessary to extinguish a fire. It may be difficult to achieve ideal coverage in congested concealed spaces, which requires a level of pragmatic engineering judgement. For example, if ducts extend to the floor slab, they should be treated as obstructions. However, protection would not be normally provided under ducts or cable trays in congested areas.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

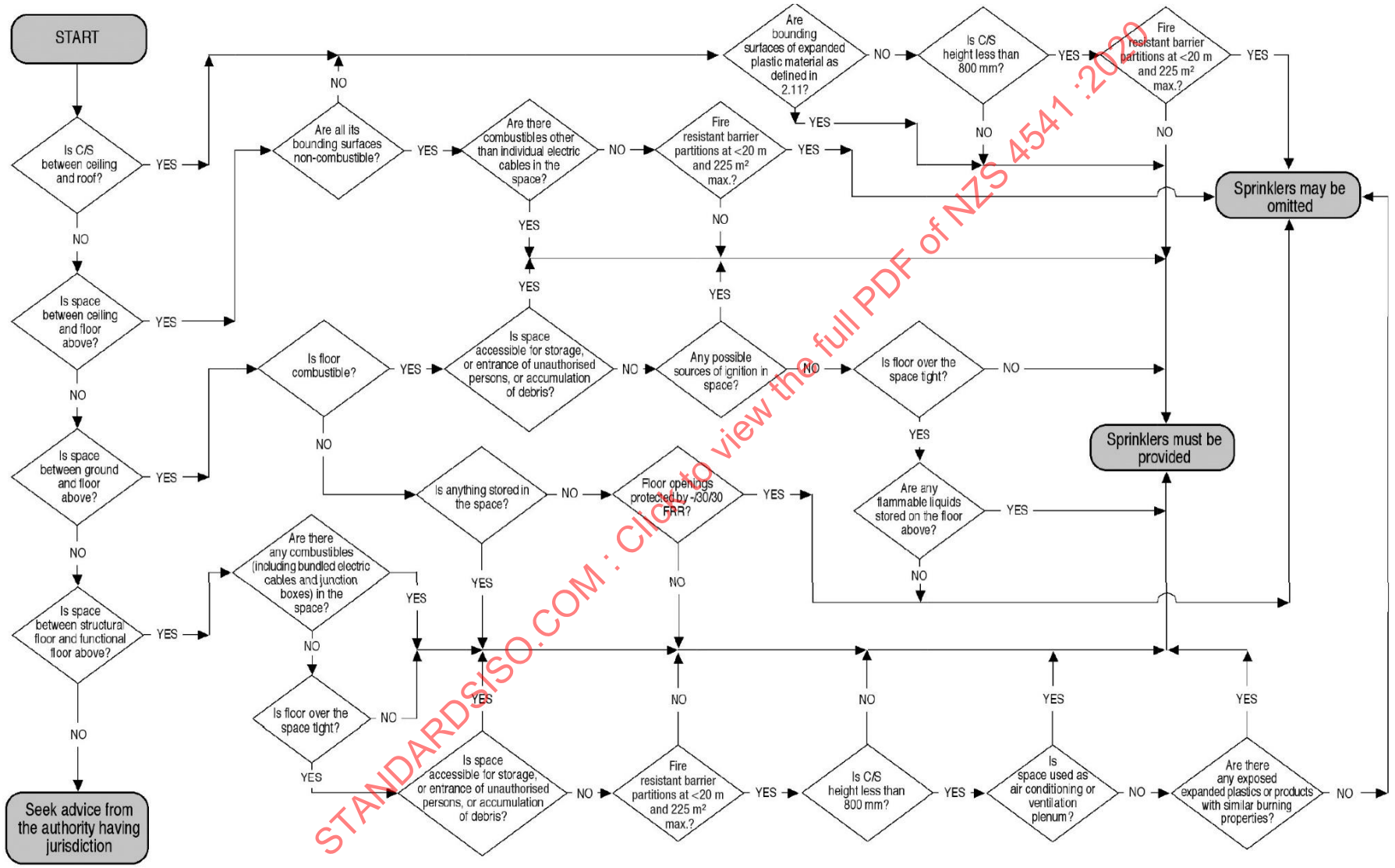


Figure 2.3 – Permitted exceptions from sprinklering of concealed spaces

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

2.9 Provision of block plan

A block plan of the buildings, including the adjacent buildings, protected by the sprinkler system shall be located in a position immediately adjacent to the control valves. This plan shall be oriented according to the viewing position and shall provide the following information:

(a) Location of the control valves and FSI;
(b) A diagram of the water reticulation network with connections to the street main or site fire main;
(c) A north point;
(d) Any external sprinklers;
(e) Show all sprinkler-protected and unprotected buildings within a 10 metre radius of the respective system;
(f) The design pressure and flow for each protected area or hazard classification;
(g) The hazard classification of each protected area and the design details, be it density and assumed area of operation or number of sprinklers, *K* factor and operating pressure;
(h) Fire separations, fire doors and self-closing doors required by this standard;
(i) The area protected by each installation;
(j) Location of any drain valves;
(k) Scale;
(l) Location of tail-end valve sets and other subsidiary stop valves;
(m) Location of any industrial, domestic or other approved take offs and their associated isolation valves; and
(n) The block plan shall generally identify the types of sprinklers used in the installation, to allow the correct types of sprinklers to be used for service work or for installations. The form of this information is shown in Table 2.6;
(o) Where the water supply tank is an infill tank, the infill rate shall be shown;
(p) Where a deluge system is installed on a spray dryer and its ancillary equipment, the system demand (both with and without the simultaneous demand) shall be shown.

Table 2.6 – Block plan sprinkler information

Location	Head manufacturer	Model	SIN number	*K* factor	Maximum area per head(*)	Minimum orifice pressure(*)
* These columns relate to the specific installation and are not to be the generic capabilities of the sprinkler head in question.						

(q) The block plan shall be updated as necessary following any extensions or alterations to the system;
(r) When the valve controlling the sprinkler system water supplies is located underground in a toby box or valve pit, the diagram of the water supplies in (b) shall include sufficient dimensions to allow the street valve to be located if the valve is obscured during road resealing or similar events;
(s) The version of the standard the sprinkler system was installed to (for example, NZS 4541:2013);
(t) Where the water supply is a Class B2, the details of the site fire main, including all fire hydrants and stop valves, shall be incorporated into the block plan as per 6.12.4.1;
(u) Shutdown instructions including where pumps are provided; and
(v) Details of all interconnected equipment or devices, such as fan, conveyor, lift, air-conditioning shutdowns, or any other devices, such as door interlocks and alarms.

2.10 Provision of supply reference information

2.10.1

To facilitate routine checking 'supply reference information' for each supply shall be displayed in an indelible form at the control valves, generally in the manner shown in Figure 2.4.

2.10.2

In the case of a new system, the reference pressures shall be established at the time of final inspection of the sprinkler system and agreed with an SSC. In the case of an existing system, they shall be established in the course of a routine inspection (see 12.3) and shall be agreed with an SSC.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

2.10.3

The reference pressures shall be as follows:

(a) The design pressure for each area of the protected building;
(b) The pressure shown on the installation gauge when each water supply is discharging separately through the fully open installation test valve;
(c) The pressure shown on the installation gauge when the design flow is passed through the alarm valves from each water supply;
(d) The pump pressure with the pump test return valve fully open;
(e) Pressure control valve set pressures (such as relief or reducing valves) and reference to diesel engine speed control when used; and
(f) Pressure switch set pressure.

Reference pressures shall be tabulated for all gauges, listing the range of expected gauge pressures, and what action is required if the measured pressure falls outside acceptable levels.

This information shall be provided in the form of gauge schedules, which shall be located as follows:
(g) Valve room – all sprinkler control valve gauge information;
(h) Pump room – all pump room gauge information; and
(i) Tail-end valve sets – all tail-end valve set gauge information.

Where such locations are co-located, the gauge schedules may be combined in a single document.

An indicative reference pressure schedule is shown in Table 2.7.

2.10.4

A water supply reference graph on $Q^{1.85}$ abscissa graph paper shall be mounted adjacent to the block plan with the following information plotted on it:
(a) Each agreed design pressure at design flow;
(b) Each water supply characteristic curve as measured at the time of final inspection of the system by an SSC;
(c) The installation drain friction loss curve; and
(d) If the system is a boosted town's main, the unboosted town's main curve shall also be plotted.

See example in Figure 2.4.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

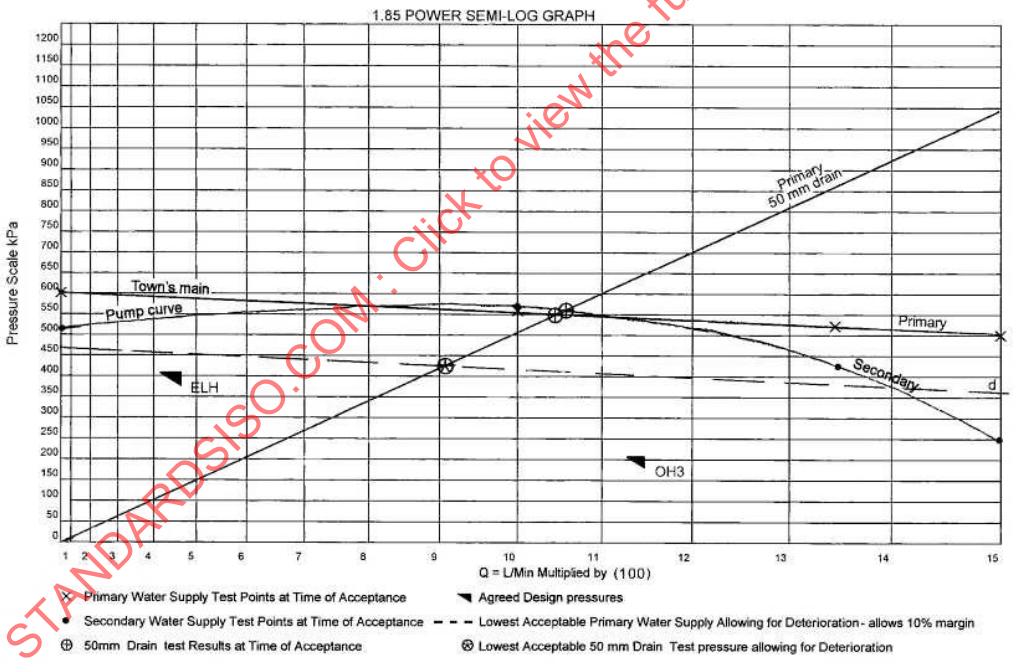
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

System..... Approval Date.....

HYDRAULIC REFERENCE PRESSURE MEASURED AND ACCEPTED ON APPROVAL DATE

Supply	Flow (L/min)	Installation gauge pressure (kPa)	Supply gauge pressure (kPa)	Suction or other gauge pressure (kPa)
Primary	0	600	610	-
	1000	560	570	-
	1350	520	540	-
	1500	500	510	-
	Drain fully open	550	560	
Secondary	0	510	510	70
	1000	565	565	60
	1350	430	430	60
	1500	250	250	60
	Drain fully open	560	560	50



Note - To Establish the Drain Valve Test Curve

(a) Mark the point of intersection on the graphed water supply curve of the installation pressure when the water supply is discharging through the fully open drain valve.

(b) Draw a line from zero through the point of intersection. THIS IS THE DRAIN TEST CURVE.

(c) The intercept of the drain test line with the lowest acceptable water supply curve is the critical pressure, this should be reported immediately if a drain test shows less than this pressure.

(d) If there is a second supply repeat the procedure of (a) with the second supply discharging. The intersect point should be on or close to the test curve of (b).

Figure 2.4 – Display of water supply reference information

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 2.7 – Typical reference pressure schedule

Agreed hydraulic requirements

For the most demanding	Design flow (L/min)	Design pressure (kPa)
ELH area of operation	375	675
OH 3 area of operation	1120	410
EHH area of operation	2050	675

Reference pressures

Item	Normal pressure	Comments
Standing pressure	1200 kPa	Report if varies 50 kPa
Defect pressure	1000 kPa	Report if varies 50 kPa
Fire pressure	850 kPa	Report if varies 50 kPa
Town's main static pressure	550 kPa	Report if less than 460 kPa
Town's main 50 mm test	550 kPa	Report if less than 430 kPa
Pressure control valve	1200 kPa	Report if varies 50 kPa
Primary pump start	600 kPa	Tank + Diesel 1
Primary pump test return pressure	1100 kPa	Report if less than 1050 kPa
Primary pump speed control	1200 kPa	Report if varies 50 kPa
Secondary pump start	700 kPa	Town main + Diesel 2
Secondary test by pass pressure	1000 kPa	Report if less than 950 kPa
Secondary pump speed control	1200 kPa	Report if varies 50 kPa
Site main jockey pump start	800 kPa	Report if varies 50 kPa
Site main jockey pump stop	900 kPa	Report if varies 50 kPa
Tail-end pre-action system Gas standing pressure	125 kPa	Report if varies 5 kPa
Tail-end pre-action system Gas defect pressure	115 kPa	Report if varies 5 kPa
Tail-end pre-action system Gas trip/release pressure	105 kPa	Report if varies 5 kPa
Tail-end pre-action system Maximum gas supply pressure	140 kPa	Report if varies 5 kPa
Tail-end pre-action system Trip test water pressure	900 kPa	Report if varies 50 kPa
Tail-end pre-action system Pneumatic detection standing pressure	175 kPa	Report if varies 5 kPa
Tail-end pre-action system Pneumatic detection defect pressure	160 kPa	Report if varies 5 kPa
Tail-end pre-action system Pneumatic detection trip/release pressure	140 kPa	Report if varies 5 kPa

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

2.11 Multistorey buildings

2.11.1

Multistorey buildings, having more than six floors, shall be fitted with flow switches to indicate the floor on which the sprinkler system has operated. The indication shall be provided on a fire indication panel complying with NZS 4512 in a location approved by the fire brigade. Multistorey buildings of fewer floors mayalso have flow switches.

Plant rooms and other similar normally unoccupied spaces, at the top of a building, where the floor area is less than 10% of the floor below, may be fed from the floor below, without requiring a separate flow switch.

NOTE – The number of floors includes the ground floor and any basements or levels below ground.

2.11.2

All such valves shall be supervised against interference and shall comply with the requirements of 4.4.2.4 and 4.4.2.5.

2.11.3

Multistorey buildings may be fitted with an enhanced safety valve set complying with 4.5.

2.11.4

In buildings of such height that the requirements of 4.1.2 and 4.7.2.1 mean that the fire brigade alarm (FBA) and control valves cannot, as a consequence of static head, be located at street level, alarm valves maybe located in an approved position at upper levels of the building.

2.12 Buildings constructed with expanded plastic cored insulated panels

2.12.1 *General*

Adequate protection for insulated sandwich panels that have foam plastic cores includes both automatic sprinklers and the proper securement of the panel facings. Specification of panel facing securement is outside the scope of this standard but must be evaluated to ensure the metal facings remain intact and will not delaminate in a fire.

Further design requirements for buildings constructed with foam plastic cored insulated panels are inAppendix K.

2.12.2 *Laboratory-approved panels*

Laboratory-approved panels must be tested and approved by an accredited laboratory in accordance with ISO 13784; ISO 9705-1; FM Approvals Standard 4880; LPCB LPS 1181 Part 1 or Part 2; or LPCB LPS 1208.

The installation method, supporting construction, and fire exposure (internal or exterior) in the test used as the basis for approval must reflect the intended panel application.

Assemblies which achieve all of the following criteria when tested in accordance with ISO 9705-1 by an accredited laboratory, shall ***not*** be required to comply with Table 2.8 below.

(a) They do ***not*** support a self-propagating fire which extends to the outer extremities of the test area within the 20-minute test as evidenced by flaming or material damage when the lining is removed (including melting or charring of core materials);
(b) They do ***not*** reach flashover (total heat release of 1000 kW) when exposed to 100 kW for 600 seconds followed by exposure to 300 kW for 600 seconds;
(c) They have a smoke growth rate index ($SMOGRA_{RC}$) ***not more than*** 100; and
(d) They sustain the applied load, if any, for the duration of the test period.

NOTE – See Appendix K for a definition of $SMOGRA_{RC}$.

2.12.3 *Non-laboratory-approved panels*

The requirements in Table 2.8 apply to foamed plastic (polyurethane, polyisocyanurate, or polystyrene) cored insulated panels that have *not* been tested and approved by an accredited laboratory in accordance with ISO 13784; ISO 9705-1; FM Approvals Standard 4880; LPCB LPS 1181 Part 1 or Part 2; or LPCB LPS 1208.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 2.8 – Design data for protection of expanded plastic cored panels

EPS thickness	Available sprinkler protection[a]		Perimeter ceiling sprinklers needed
	Density (mm/min) over 186 m²	Type	
≤ 100 mm (16 kg/m³) or ≤ 50 mm (32 kg/m³)	≥ 15	Wet	No
≤ 100 mm (16 kg/m³) or ≤ 50 mm (32 kg/m³)	< 15	Wet	Yes
> 100 mm, ≤ 250 mm (16 kg/m³)	≥ 18[b]	Wet	No
> 100 mm, ≤ 250 mm (16 kg/m³)	< 18	Wet	Yes
≤ 250 mm (16 kg/m³)	≥ 8	Dry	Yes

[a] Minimum duration is 60 minutes. In all cases, the sprinkler design and duration also shall be adequate for the occupancy.

[b] The first line of sprinklers adjacent to the EPS shall be Quick Response. If the available density is at least 24 mm/min, the first line may be Standard Response.

2.12.4 *Wet pipe systems*

Where perimeter sprinklers are required for wet pipe systems they shall be installed to the following details:

(a) The water demand for these heads shall be added to the ceiling sprinkler demand;
(b) There shall be a row of sprinklers 600 mm (± 50 mm) from any panel wall. Starting with the first head of each row 600 mm from each corner;
(c) Maximum spacing along the wall of 3.0 m;
(d) The minimum flow from the sprinkler adjacent to the wall shall be 115 L/min;
(e) The sprinkler shall be quick response, 68°C (or 30°C above the highest ambient temperature);
(f) Minimum of 10 wall heads discharging in addition to roof level demands;
(g) Ceiling sprinklers shall be positioned so that they are at staggered intervals to the perimeter sprinklers and shall be positioned to provide the normal minimum clearance spacing – see Part 5.

NOTE – Where these perimeter sprinklers are being retrofitted to existing installations, existing ceiling sprinkler spacing should be considered. Existing sprinkler heads may need to be moved or perimeter heads shielded to prevent wetting of adjacent sprinklers.

2.12.5 *Dry pipe systems*

Where perimeter sprinklers are required for EHH dry pipe systems they shall be installed to the following details:

(a) The water demand for these heads shall be added to the ceiling sprinkler demand;
(b) There shall be a row of sprinklers 600 mm (± 50 mm) from any panel wall, starting with the first head of each row 600 mm from each corner;
(c) Maximum spacing along the wall of 3.0 m;
(d) The minimum flow from any sprinkler adjacent to the wall shall be 115 L/min;
(e) The sprinkler shall be quick response, 68°C (or 30°C above the highest ambient temperature);
(f) Minimum of 14 perimeter wall heads operating at 115 L/min each;
(g) Ceiling sprinklers shall be positioned so that they are at staggered intervals to the perimeter sprinklers and shall be positioned to provide the normal minimum clearance spacing – see Part 5.
(h) Water shall be available at the most remote head within 30 seconds.

NOTE – Where these perimeter sprinklers are being retrofitted to existing installations, due regard should be given to existing ceiling sprinkler spacing. Existing sprinkler heads or the perimeter heads may need to be moved to prevent shadowing.

2.12.6 *Ceiling heights exceeding 9.0 m*

If ceiling heights exceed 9.0 m, any proposals for sprinkler protection shall be subject to consultation with an SSC for a specific system design and approval.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

2.12.7 *Alternative panel materials and suitable methods of sprinkler protection*

2.12.7.1

Where other foamed plastic materials or alternative core materials are used in insulated panels the proposed methods of protection shall be submitted to an SSC for determination.

2.12.7.2

In considering if the combustibility or fire ratings of other foamed plastic materials used in insulated panel construction requires additional sprinkler protection measures, an SSC will consider any full-scale test results from a reputable accredited fire test laboratory that can provide listed ratings and similar fire performance certificates.

2.13 Features likely to impair sprinkler efficacy

Consideration needs to be given to features likely to impair sprinkler efficacy. Examples of such features include:

(a) High volume low speed fans;
(b) Car park ventilation fans;
(c) Louvres; and
(d) Other ceiling coverings.

If the building contains features such as these, details of how the impact of the feature shall be mitigated are to be submitted to the SSC for review and acceptance.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

3 Types of installations

3.1 General

The types of installation covered by this standard are:

(a) Conventional sprinkler installations designed on:
  (i) Wet pipe installation (3.2.1)
  (ii) Dry pipe installation (3.2.2)
  (iii) Tail-end dry pipe installation (3.2.3)
  (iv) Pre-action installation (3.2.4)
  (v) Tail-end pre-action installation (3.2.5)"
  (vi) Antifreeze installation (3.2.5)
  (vii) Tail-end antifreeze installation (3.2.6);

NOTE – In relatively small areas involving flammable liquid hazards, conventional sprinkler installations may incorporate subsidiary special protection in the form of medium or high velocity sprayers.

(b) Deluge installations (using open sprinklers and medium or high velocity sprayers (3.3));
(c) Water mist systems (3.4).

3.2 Conventional sprinkler installations

3.2.1 *Wet pipe installation*

3.2.1.1

A wet pipe installation is a sprinkler installation permanently charged with water both above and below the installation alarm (wet pipe) valve.

3.2.1.2

Wet pipe installations shall be used whenever ambient temperatures remain at 4°C or above unless otherwise permitted or required by the standard. Wet pipe installations shall not be used if continuous ambient temperatures are below this limit. The use of wet pipe installations in areas subject to intermittent ambient temperatures, at or below this limit, shall be permitted only if the consequences of exposure to these temperatures have been considered and adequate protection measures taken (see Appendix L). Such protection measures shall be agreed with an SSC, taking into account the probability and consequences of freezing balanced with reduced reliability of other than wet pipe systems.

NOTE – Within a cool store, with average ambient temperature of 4°C or above, there may be both excessively low or very high temperatures as a result of cold air from cooling coils or radiant or convective heat from defrost devices (either in normal mode or testing mode). In areas of such stores where such low temperatures could occur, one of the technologies allowed for in this standard for dealing with below 4°C situations (for example, dry drop or antifreeze tail-end or a tail-end dry pipe installation) should be used. Sprinklers likely to be subject to short-term high temperatures should be of a sufficient temperature rating having regard to the temperature distribution and the location of sprinklers.

3.2.1.3

Sprinklers in wet pipe installations may be installed in either the upright, pendent, or horizontal position in accordance with their listing.

3.2.1.4

Except as allowed by 3.2.1.5, 3.2.1.6, and 3.2.1.7, wet pipe installations shall be designed so that the total floor area protected and controlled by one set of valves, excluding concealed spaces, does not exceed 11 000 m^2.

In open-plan buildings such as warehouses and manufacturing plants, any exterior canopies with open sides can be excluded from the area calculation.

3.2.1.5

A multistorey building, if supplied by an enhanced safety valveset, meeting the requirements of 4.5, may exceed a total floor area of 11 000 m^2 if the following additional requirements are met:

(a) The floor area served by any subsidiary stop valve does not exceed 11 000 m^2;
(b) Flow switches are installed in accordance with 2.11.5 and 4.7.4;
(c) The flow switch indication is provided on a fire indication panel complying with NZS 4512 in a location approved by the fire brigade;
(d) Subsidiary stop valves with supervisory devices are installed in accordance with 4.4.2.4 and 4.4.2.5;
(e) The subsidiary stop valves are located in:
  (i) Stairwells, clearly labelled and accessible from floor level by the fire brigade and service personnel, as required in 4.4.2.4, or

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(ii) A service cupboard, adjacent to a stairwell containing a hydrant riser, accessible from floor level by the fire brigade and service personnel, with a clear sign in 50 mm contrasting lettering stating 'Sprinkler Isolation Valve Inside', or

(iii) The sprinkler valve room, accessible from floor level by the fire brigade and service personnel, with a clear sign in 50 mm contrasting lettering stating the section that the valve serves.

(f) The location of the subsidiary stop valves are clearly identified on the block plan;

(g) A check valve is installed downstream of the subsidiary stop valve, and upstream of the flow switch to limit the amount of water that needs to be drained during a sprinkler discharge before any drop in pressure alarm functions (see Figure 3.1).

(h) A drain valve of at least one-third the distribution pipe diameter, but in no case less than 25 mm nominal bore (NB) is installed downstream of each subsidiary stop valve and is connected to a permanently piped drain (which is drained to the appropriate public utility installation, via a drain arrangement of adequate capacity to provide full flow from the floor drain valve to allow satisfactory exercising of the floor check valve);

(i) A pressure gauge fitted downstream of the check valve;

(j) Each subsidiary floor valve arrangement/zone isolation assembly is uniquely identified and labelled in a prominent position directly adjacent to the zone isolation valve;

(k) A plan clearly identifying each zone is permanently displayed adjacent to each subsidiary floor valve arrangement/zone control assembly and a warning stating that 'prior to refilling zone, isolate the DBA from the brigade and sounders' is included on this plan;

(l) An engraved label with lettering of 25 mm is installed within the sprinkler valve enclosure and any FSI enclosures stating:

'FIRE BRIGADE PERSONNEL

THIS SYSTEM IS FITTED WITH SECTIONAL ISOLATION VALVES LOCATED WITHIN THE STAIRWELL.

PLEASE USE THESE SECTIONAL ISOLATION VALVES FOR STOPPING WATER FLOW IN ANY ACTIVE SYSTEM ZONES.

DO NOT ISOLATE THE SYSTEM VIA THE SYSTEM CONTROL VALVES.'

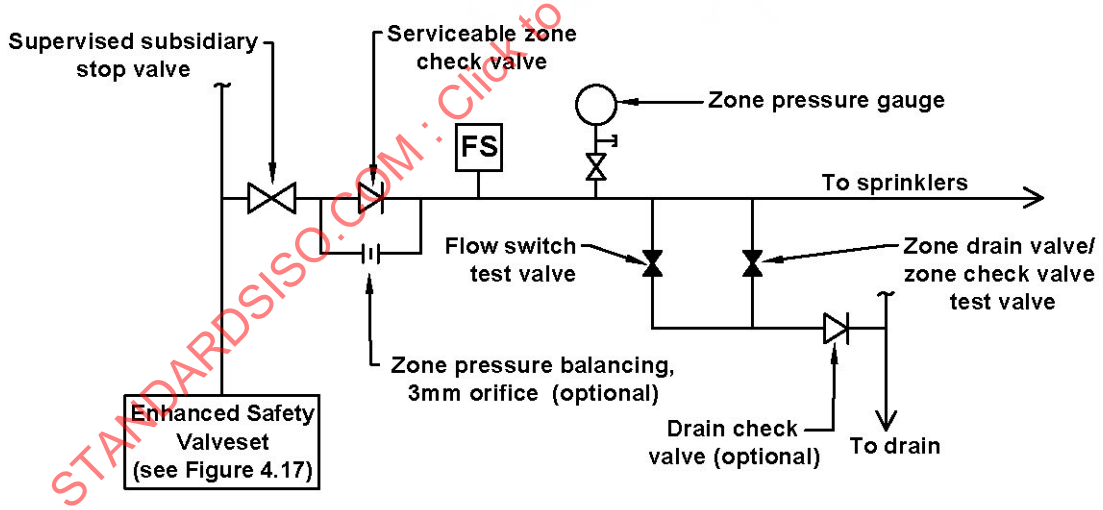


Figure 3.1 – Typical subsidiary floor valve arrangement

NOTE –

(1) When check valves are required under 3.2.1.5 (d), the riser may be prone to water logging, leading to potentially large pressure fluctuations, which can lead to over-pressurisation and false alarms. Suitable precautions to avoid this could include:

(a) A combination of an automatic jockey pump and pressure relief valve or an air over water bladder tank; or

(b) A 3 mm orifice bypassing a single zone check.

(2) If the subsidiary floor valve / zone isolation arrangement is not within the stairwell the location shall be included on the label specified by (l) above.

(3) It is permissible to also use the arrangements described in 3.2.1.5 for a building of less than 11 000 m^2 floor area.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

3.2.1.6

A large low rise building or a campus style building complex, if supplied by an enhanced safety valve set meeting the requirements of 4.5, may exceed a total floor area of 11 000 m^2 if the following conditions are met:

(a) The floor area served by any subsidiary stop valve does not exceed 11 000 m^2;
(b) Flow switches are installed in accordance with 2.11.5 and 4.7.4;
(c) Subsidiary stop valves with supervisory devices are installed in accordance with 4.4.2.4 and 4.4.2.5;
(d) The subsidiary stop valves are either:

(i) Located in a valve room or an enclosure, directly accessible from the exterior of the building, with a sign in 50 mm contrasting letters stating 'Sprinkler System Sectional Isolation Valve Inside'; OR

(ii) Located in a valve room or an enclosure, directly accessible from the building's main entrance, with a sign in 50 mm contrasting letters stating 'Sprinkler System Sectional Isolation Valve Inside'; OR

(iii) Located in the sprinkler valve room, accessible from floor level by fire brigade and service personnel, with a clear sign in 50 mm contrasting lettering stating the section that the valve serves.

(e) The location of the subsidiary stop valves are approved by the fire brigade and are clearly identified on the block plan;
(f) A check valve is installed downstream of the subsidiary stop valve and upstream of the flow switch to limit the amount of water that needs to be drained during a sprinkler discharge. This is to avoid triggering pressure drop alarms (see Figure 3.1).
(g) A drain valve of at least one-third the distribution pipe diameter, but in no case less than 25 mm nominal bore (NB) is installed downstream of each subsidiary stop valve and connected to a permanently piped drain. To allow satisfactory exercising of the floor check valve, this is drained to the appropriate public utility installation via a drain arrangement of adequate capacity to provide full flow from the floor drain valve;
(h) A pressure gauge is fitted downstream of the check valve;
(i) Each subsidiary floor valve arrangement/zone isolation assembly is uniquely identified and labelled in a prominent position directly adjacent to the zone isolation valve;
(j) A plan clearly identifying each zone is permanently displayed adjacent to each subsidiary floor valve arrangement/zone control assembly and a warning stating 'Before refilling zone, isolate the DBA fromthe brigade and sounders' is included on this plan; and
(k) An engraved label with lettering of 25 mm is installed within the sprinkler valve enclosure and any FSI enclosures stating:

'FIRE BRIGADE PERSONNEL

THIS SYSTEM IS FITTED WITH SECTIONAL ISOLATION VALVES LOCATED WITHIN THE STAIRWELL.

PLEASE USE THESE SECTIONAL ISOLATION VALVES FOR STOPPING WATER FLOW IN ANY ACTIVE SYSTEM ZONES.

DO NOT ISOLATE THE SYSTEM VIA THE SYSTEM CONTROL VALVES.'

NOTE –

(1) The term 'campus' is intended to describe a number of separate buildings or firecells on a single site. This could include shopping centres, prisons, schools, and other similar complexes.

(2) If the subsidiary floor valve/zone isolation assembly is not within the stairwell, its location must be included on the label as specified by (k) in 3.2.1.6.

(3) It is permissible to also use these arrangements for building complexes of less than 11 000 m^2 floor area.

3.2.2 *Dry pipe installation*

3.2.2.1

A dry pipe installation is a standard sprinkler installation in which the installation pipework is permanently charged with gas under pressure above the alarm (dry pipe) valve and with water under pressure below the valve. When a sprinkler head opens, the gas pressure drops. This allows the dry pipe valve to open and admit water to the installation. To speed up the opening of the valve, an accelerator or exhauster may be included in the installation.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

3.2.2.2

Dry pipe installations are normally allowed only in buildings where the temperature conditions are demonstrated to be below freezing such as climatic conditions, or as in freezers or cold stores, or where the temperature is maintained above 70°C as in drying ovens and the like. Special approval is required for dry pipe installations in other circumstances.

3.2.2.3

The volume of pipework controlled by any dry installation may be unlimited if it can be demonstrated that, with the installation in its dry mode, water is available at the most remote head within 60 seconds of sprinkler activation by one of the methods specified in 3.5. If this cannot be demonstrated, dry pipe installations shall be designed so that the volume of pipework controlled by one set of valves, including tail-end extensions, does not exceed 1900 litres, or 2800 litres if the installation is fitted with a listed quick opening device suchas an accelerator or an exhauster (see 4.4.5.1).

NOTE – The volumes above may be increased by 50% provided an automatic fire alarm system complying with NZS 4512 (and having declared functional requirements in accordance with items (a), (b), and (e) of 105 of that Standard) is installed in the same area as the sprinklers and arranged to open the dry pipe alarm valve prior to the activation of a sprinkler head. Failure of the detector system should not inhibit the normal activation of the installation.

3.2.2.4

Sprinklers shall be installed in the upright position above the line of pipes in dry pipe installations. An exception to this rule is allowed if listed dry pendent or dry sidewall pattern sprinklers are installed and no residual water can pond in any section of a drop.

Pipework shall be arranged with adequate slope for drainage as described in 4.3.11.

3.2.2.5

Where dry pipe installations are expected to be subject to continuous freezing conditions, the pressurising gas shall have a dew point at its appropriate pressure below the expected temperature.

3.2.2.6

Dry pipe installations shall not use gridded pipework arrays. This precludes the use of a common drain line linking the system's range pipes.

3.2.2.7

Dry pipe alarm valves shall comply with the requirements of 4.4.4.2.

3.2.2.8

The area served by a dry pipe installation valve set shall not exceed 11 000 m^2.

3.2.2.9

There are restrictions and special requirements on the use of dry pipe installations in EHH storage situations (see 9.3.3).

3.2.2.10

The design of dry pipe installations in freezers or cold stores shall be designed with provision to inspect them internally for ice plugs in accordance with 4.4.5.3.1 and tested in accordance with 12.2.5(k).

3.2.2.11

A low-pressure defect air pressure switch shall be provided at a set pressure halfway between the standing pressure and the trip pressure.

3.2.3 *Tail-end dry pipe installations*

3.2.3.1

These installations are essentially similar to dry pipe installations except that they are of comparatively small extent and form extensions to standard sprinkler installations.

3.2.3.2

Tail-end dry pipe installations are permitted:

(a) As extensions to a wet pipe installation in comparatively small areas where there is the possibility of frost damage in an otherwise adequately heated building;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(b) As extensions to a wet pipe installation in cold stores and high temperature ovens or stoves, when the tail-end installations would be on the dry pipe principle.

3.2.3.3

Sprinklers in tail-end dry pipe installations shall be installed in the upright position above the line of pipes and pipework shall be arranged with adequate slope for drainage. An exception to this rule is allowed if listed dry pendent or dry sidewall pattern sprinklers are installed.

3.2.3.4

The total volume of the pipework controlled by any one tail-end valve set shall not exceed 1900 litres.

3.2.3.5

To assist in the maintenance and testing of a tail-end dry pipe valve set supervised subsidiary stop valves in accordance with 4.4.2.4 and 4.4.2.5 shall be fitted immediately upstream and downstream of the tail-end dry pipe valves. Drain and test valves, drain pipes, and pressure gauges shall be fitted both upstream and downstream, between the tail-end dry pipe valve and the respective subsidiary stop valves. The drain pipes shall discharge to a location where it will not cause damage, or hygiene or safety hazards.

3.2.3.6

There are restrictions and special requirements on the use of dry pipe installations in EHH storage situations (see 9.3.3).

3.2.3.7

The design of tail-end dry pipe installations in freezers or cold stores shall be designed with provision to inspect them internally for ice plugs in accordance with 4.4.5.3.1 and tested in accordance with 12.2.5(k).

3.2.3.8

A low-pressure defect air pressure switch shall be provided at a set pressure halfway between the standing pressure and the trip pressure.

3.2.4 *Pre-action installation*

3.2.4.1

A pre-action installation is a form of dry pipe installation incorporating water discharge pipework fitted with closed sprinkler heads but charged with low pressure gas for supervision purposes. Water entry to this piping installation is controlled by a further installation of small diameter piping with closed heads charged with gas for control purposes, or an approved electronic detection system (see 3.2.4.8). Before water may be discharged, it is necessary that the sprinkler heads on both the discharge pipework and the detection devices (sprinklers or electronic detectors) operate.

Pre-action installations are commonly available as single interlock and double interlock designs.

Single interlock installations admit water into the pipework on operation of the detection devices. These are the installations that are most commonly installed to protect computer suites and the like.

Double interlock installations will only admit water into the pipework upon operation of both the detection device and automatic sprinklers. Double interlock installations shall be used only for freezer fire protection and shall not be used for protection of computer suites and the like.

NOTE – Non-interlock installations are also available. These admit water into the pipework when either the detection or discharge sprinkler operates. They are not commonly installed.

Where pre-action systems use electronic releasing mechanisms, the control system shall be independent of any building fire alarm system, albeit they may be linked for the purposes of alarm signalling or interface to other systems.

Each individual pre-action valve set shall have its own dedicated control panel.

3.2.4.2

Detection sprinkler devices shall be in the same area/zone as the discharge sprinklers and spaced at not more than 21 m^2 for ELH and OH systems, with 12 m^2 for EHH systems. Some EHH risks have specific requirements with spacing of detection devices to equal the discharge sprinkler spacing. Notwithstanding 4.2.4, the detector sprinklers may have a temperature rating of no less than 15°C above the highest expected ambient temperature.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

3.2.4.3

Unless the provisions of 3.2.2.3 are met, pre-action installations shall be designed so that the volume of pipework controlled by one set of valves, including tail-end extensions does not exceed 1900 litres, or 2800 litres if the installation is fitted with a listed quick opening device. A listed quick opening device includes an accelerator or air exhauster, or a smoke detection system or heat detection system installed in compliance with NZS 4512 and having the declared functional requirements in accordance with items (a), (b), and (e) of 105 of that standard. This detection system shall be installed in the same area as the sprinklers and arranged to open the pre-action alarm valve prior to the activation of a sprinkler head. Failure of the electronic detection system shall not inhibit the manual activation of the installation.

3.2.4.4

Sprinklers shall be installed in the upright position above the line of pipes in pre-action pipe installations. An exception to this rule is allowed if listed dry pendent or dry sidewall pattern sprinklers are installed. Pipework shall be arranged with adequate slope for drainage as described in 4.3.11.

3.2.4.5

Pre-action installations shall not use gridded pipework arrays. This precludes the use of a common drain line linking the system's range pipes.

3.2.4.6

Where pre-action pipe installations are expected to be subject to continuous freezing conditions, the pressurising gas shall have a dew point at its appropriate pressure below the expected temperature.

3.2.4.7

To assist in the maintenance and testing of pre-action installations, a supervised subsidiary stop valve shall be fitted immediately downstream of the pre-action valve. A drain and test valve shall be located between the pre-action valve and the downstream subsidiary stop valve to permit trip testing without flooding the installation. If a fire sprinkler inlet is attached to the installation it shall be connected to the installation upstream of the subsidiary stop valve to permit flow testing from the FSI without flooding the installation. For tail-end pre-action installations, a supervised subsidiary stop valve shall also be provided immediately upstream of the pre-action valve.

Where the drain and test valve is 25 mm NB or greater, and can be inadvertently left open, and thereby compromise the installation's performance, this valve shall be fitted with a listed supervisory device.

3.2.4.8

Full details of proposals for the installation of pre-action installations shall be submitted to an SSC before any erection work is commenced. When considering such proposals, an SSC shall normally approve installations which use pilot operated sprinklers as the primary means of detection, unless such detection is not practicable. Approved electronic detection systems may be used in parallel with pilot sprinkler operated detection systems to speed up the release of water into the sprinkler pipework.

Pre-action installations in freezers, cold stores, chillers, and so on may be of the double interlock type using approved electronic detection systems only. These detection systems shall be installed in the same area as the sprinklers with detection devices spaced as stated in 3.2.4.2. The electronic detection system and control panel shall not form part of the building fire alarm system; it shall be dedicated to the sole use of, and form part of, the fire sprinkler system.

NOTE – This clause allows an SSC to approve pre-action systems that do not use pilot operated sprinkler detection systems in certain circumstances. Given that electronic detection systems are inherently less reliable than sprinkler- based detection systems, such alternative systems should only be used as the primary release mechanism if pilot operated detection systems are not a practical option. An example of such a situation is where pre-action systems are used to prevent in-rack sprinklers freezing. In such an example, a listed lineal type thermal detection system would normally be deemed as being acceptable by an SSC. Where detection systems are installed to release pre-action systems in areas such as computer suites and the like, they should only be used in parallel to pilot sprinkler operated detection systems.

Where electronic detection is used for an in-rack pre-action system, activation of a ceiling-level sprinkler shall also trip the electronic element of the double interlock system. For the purposes of testing and maintenance, an isolation switch shall be fitted in the FBA to prevent tripping of the electronic pre-action stage when working on the main sprinkler system. The function of this switch shall be labelled and monitored to signal a defect when operated.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

3.2.4.9

The design of pre-action installations in freezers or cold stores shall be designed with provision to inspect them internally for ice plugs in accordance with 4.4.5.3.1 and tested in accordance with 12.2.5(k).

3.2.4.10

A low-pressure defect air pressure switch shall be provided at a set pressure halfway between the standing pressure and the trip pressure.

3.2.4.11

For tail-end pre-action systems, a rise-in-pressure defect switch shall be provided on the water discharge pipework, with a set alarm pressure halfway between the highest supervisory air pressure and the installation pressure at the point of connection.

3.2.5 *Antifreeze installation*

3.2.5.1

An antifreeze installation is defined as a conventional automatic sprinkler installation in which an entire installation is charged with an antifreeze solution and connected to one or more approved water supplies. The antifreeze solution, followed by water, discharges immediately upon actuation of the sprinkler heads. Unless specifically listed for that purpose, they shall not be used in storage occupancies.

3.2.5.2

Antifreeze solutions used in sprinkler systems installed to this standard shall be listed. A listed solution shall be prepared with a quality control procedure to ensure that the mixture remains homogenous.

On systems using PVC-C pipe, only glycerine-based solutions shall be used.

Antifreeze solutions shall comply with one of the following:

(a) Solutions shall be factory premixed antifreeze solutions of glycerine (chemically pure (CP) or United States Pharmacopoeia (USP) 96.5%) at a maximum concentration of 48% by volume;
(b) Solutions shall be factory premixed antifreeze solutions of propylene glycol (CP or USP 96.5%) at a maximum concentration of 38% by volume; or
(c) Another solution listed specifically for use in fire protection systems.

Antifreeze solutions used in existing systems installed in accordance with a previous version of the standard should comply with one of the following:

(d) The concentration of a glycerine solution should be limited to 50% by volume; or
(e) The concentration of a propylene glycol solution should be limited to 40% by volume.

NOTE – International research has shown that, when exposed to fire, propylene glycol in concentrations of 40% or greater by volume and glycerine in concentrations of 50% or greater by volume, may ignite when discharged through a sprinkler. The flammability of antifreeze in solution increases with higher concentrations.

Where previous editions of this standard permitted the use of antifreeze in solution, these systems may continue to be used. However, the concentration of antifreeze should be as low as permitted for the conditions, and there shall be sampling points as specified in 3.2.5.14.

However, ELH occupancies and occupancies listed under Table 2.1(should comply with 3.2.5.2 due to the potential for other types of antifreeze solution to lead to injury or loss of life if ignited.

3.2.5.3

An antifreeze solution shall have a freezing point at least 10°C below the minimum expected temperature including the temperature of the incoming cold air. The antifreeze solution shall have a tolerance of – 0%/+ 5% by volume of the required concentration in solution. See Table 3.1.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 3.1 – Properties of antifreeze solutions

Material	Solution (% by volume)	Freezing point (°C)	Room ambient temperature (°C)
Glycerine (CP or USP grade)	30	–12	–2
	35	–15.5	–5.5
	40	–19	–9
	45	–24	–14
	50	–28	–18
Propylene glycol	25	–10	0
	30	–12	–2
	35	–17	–7
	40	–21	–11

3.2.5.4

The density shall be determined by a hydrometer of suitable scale. The density of the solution shall take into account the temperature of the fluid to ascertain the freezing point of the solution. A suitable hydrometer and thermometer shall be provided at the installation control valves. Information on the testing of antifreeze solution is contained in 12.7.

3.2.5.5

Antifreeze installations shall be divided into areas with pipework subdivisions not exceeding approximately 100 heads.

NOTE – This is intended to limit the volume of antifreeze solution that discharges onto a fire, before water is applied to the fire.

3.2.5.6

This subdivision in 3.2.5.5 may be achieved by the use of tail-end control valves or, alternatively, check valves may be installed provided that supplementary drains are provided from the tail-end of each subdivision and the total area covered by one set of control valves does not exceed the limitations specified for wet pipe systems. Subsidiary stop valves are to be installed immediately upstream of the check valves to allow servicing and testing. See also 3.2.6.3.

3.2.5.7

An antifreeze collection reservoir constructed of material compatible with the antifreeze solution shall be provided. This reservoir shall have a capacity of not less than 1.25 times the total capacity of the pipework in the largest subdivision of the installation, plus the capacity of any antifreeze-filled feed main serving that subdivision.

3.2.5.8

Where check valves are used to subdivide the installation, supplementary drains of at least 25 mm nominal diameter shall be provided and arranged to discharge to the antifreeze reservoir. These drains shall be individually carried to the location of the antifreeze reservoir at which location they shall be fitted with controlling stop valves and pressure gauges. Downstream of the supplementary drain valve, the drains may be manifolded to discharge into the reservoir. Provision shall also be made to divert the drain flow to waste. Where such drains are provided on an installation which is protecting refrigerated areas, traps to prevent thermo-siphoning shall be provided where the drain emerges from the refrigerated area.

3.2.5.9

Unless otherwise listed or approved, sprinkler heads shall be installed in the upright position and pipework shall be arranged with adequate slope for drainage (see 4.3.11). An exception to this rule is allowed if listed dry pendent or dry sidewall pattern sprinklers are installed.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

3.2.5.10

An expansion chamber shall be provided downstream of any check valve forming part of the antifreeze installation, to ensure that the installation, or part thereof, is not over-pressurised by the thermal expansion of the antifreeze solution.

NOTE – An SSC may approve an alternative method of achieving this performance requirement, as part of an installation listing.

3.2.5.11

Clear maintenance and testing procedures shall be prepared and placed in a conspicuous position adjacent to the alarm valves and control valves.

3.2.5.12

The design of antifreeze installations in freezers or cold stores shall be designed with provision to inspect them internally for ice plugs in accordance with 4.4.5.3.1 and tested in accordance with 12.2.5(k).

3.2.5.13

Full details of proposals for the installation of antifreeze installations shall be submitted to an SSC before any erection work is commenced.

3.2.5.14

Permanent valved and plugged sampling points shall be incorporated at the distal point in the antifreeze pipework and at all low points. They will also be arranged to permit testing of antifreeze solution inaccordance with 12.7.

3.2.6 *Tail-end antifreeze installation*

3.2.6.1

These are portions of an installation which are arranged to protect a low temperature area by means of an antifreeze solution but as an extension of the conventional wet pipe installation.

3.2.6.2

Antifreeze solutions shall be in accordance with 3.2.5.2 and 3.2.5.3.

3.2.6.3

Antifreeze tail-ends shall be separated by a check valve with a pressure gauge and a subsidiary stop valve on either side of it. A device to permit draining, testing and re-pressurising of the antifreeze shall be provided on the downstream side of the check valve as shown in Figure 3.2. This control equipment shall be in a readily accessible position outside the low temperature area. An indelible set of instructions for testing and refilling the tail-end shall be permanently affixed.

NOTE – The check valve required by this clause may be in the form of a listed backflow prevention device.

3.2.6.4

Antifreeze installations shall be maintained at a pressure approximately 100 kPa above the installation water supply pressure to ensure that dilution of the antifreeze solution does not allow ice plugs to form in the installation.

This requirement may be met by the installation of an automatically controlled jacking pump, drawing antifreeze solution from a reservoir. It is recommended that such an installation is carefully engineered, and includes precautions, such as a relief valve discharging into the reservoir, to ensure that the system is not over-pressurised due to thermal expansion.

3.2.6.5

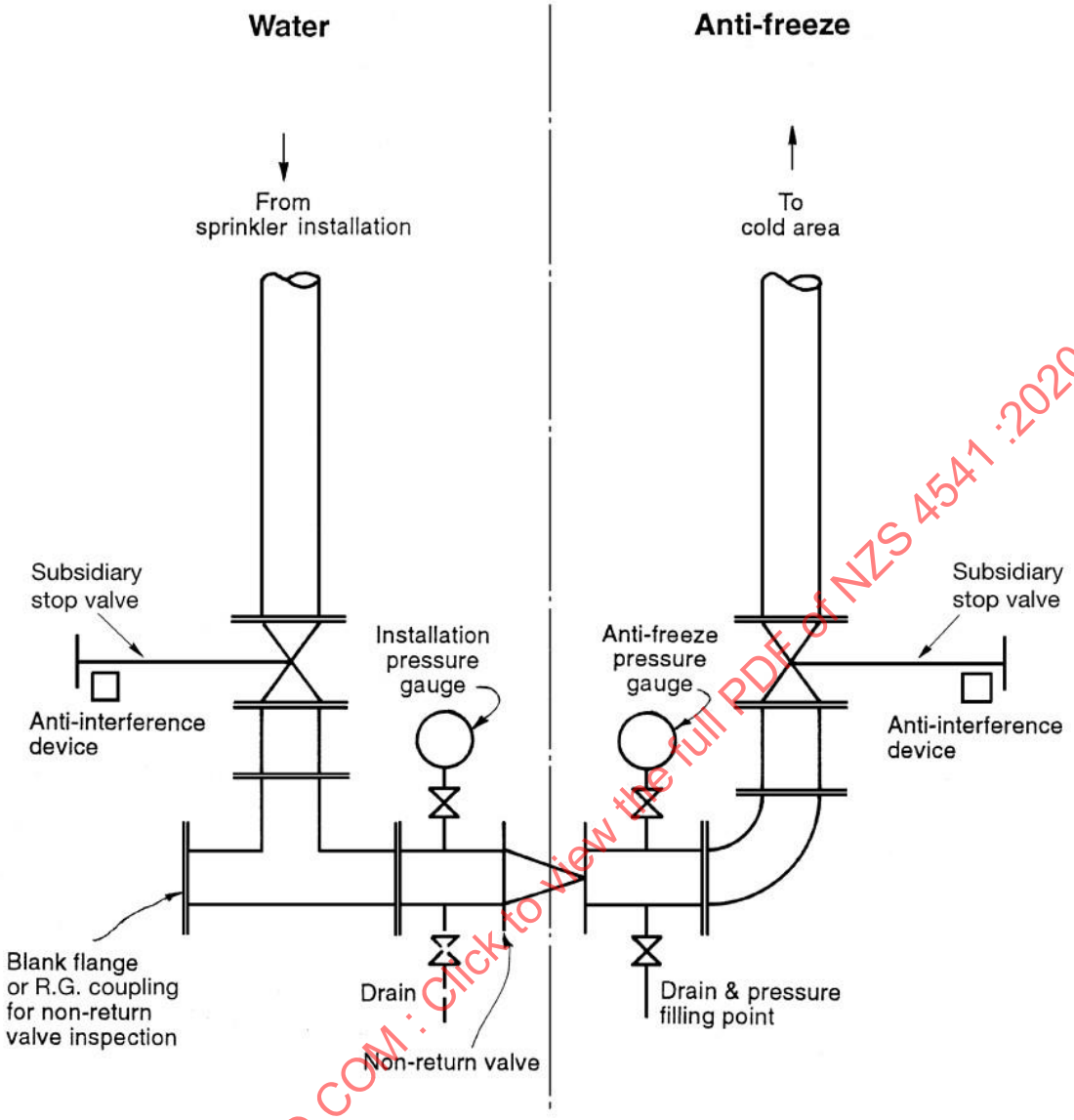
Unless otherwise listed, sprinkler heads shall be installed in the upright position and pipework shall be arranged with adequate slope for drainage (see 4.3.11). An exception to this rule is allowed if listed dry pendent or dry sidewall pattern sprinklers are installed. A plugged drain valve at the lowest point of the installation and located within the low temperature area is acceptable with tail-end installations of no more than 20 heads.

3.2.6.6

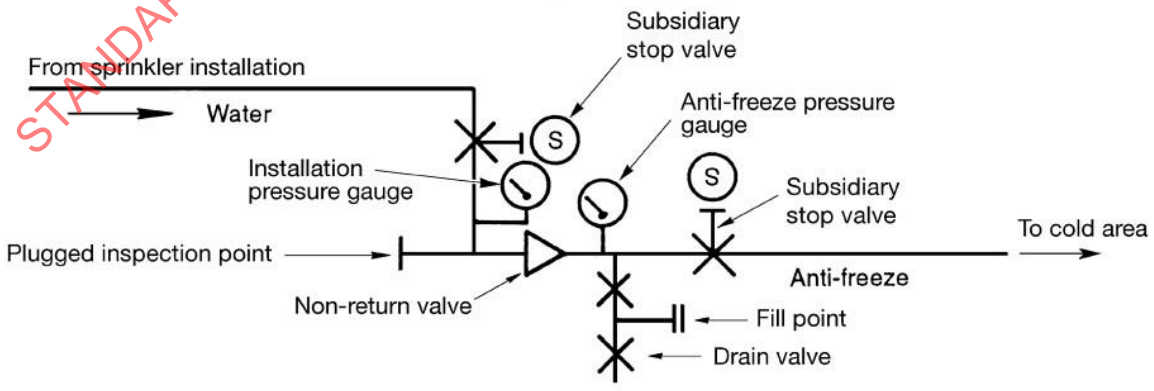
The total number of sprinklers controlled by any section of any one tail-end set of valves shall not exceed approximately 100.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



Typical arrangement 65 NB and larger



Typical arrangement up to 50 NB valves

NOTE – R.G. means rolled groove.

Figure 3.2 – Typical tail-end antifreeze installation valves

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

3.2.6.7

An expansion chamber shall be provided downstream of any check valve forming part of the antifreeze installation, to ensure that the installation, or part thereof, is not over-pressurised by the thermal expansion of the antifreeze solution.

An SSC may approve an alternative method of achieving this performance requirement, as part of an installation listing.

3.2.6.8

Full details of proposals for the installation of tail-end antifreeze installations shall be submitted to an SSC before any erection work is commenced.

NOTE – The design of tail-end antifreeze installations in freezers or cold stores shall provide the ability to dismantle the system for removal of ice plugs, and to be able to inspect all main runs by provision of inspection tees or short, easily removable sections of pipe. Extension of the main runs to outside the low temperature room, with straight line of sight, allows for visual inspection and lancing of ice plugs.

3.2.6.9

Permanent, valved, and plugged sampling points shall be incorporated at the distal point of the antifreeze pipework and at all low points, arranged to permit testing of antifreeze solution in accordance with 12.7.

3.2.7 *Antifreeze drops*

Antifreeze drops shall not be used to provide freeze protection to sprinklers in small freezers or other small spaces.

NOTE – This does not imply that antifreeze drops installed before the publication of the 2003 edition of this standard are to be replaced.

3.2.8 *Water storage tanks*

Where an antifreeze system is served by a water storage tank, it is not permitted to fill the tank with antifreeze solution. If the tank or its fittings and pipework are subject to freezing, protection against freezing shall be provided in another way.

3.3 Deluge installations

3.3.1

Deluge installations are installations of open sprinklers controlled by a quick opening valve (deluge valve), which is operated by an approved installation of heat detectors, smoke detectors, or sprinklers installed in the same areas as the open sprinklers.

3.3.2

These installations are designed primarily for EHH process risks where intensive fires with a very fast rate of fire propagation are expected, and it is desirable to apply water simultaneously over a complete zone in which a fire may originate by admitting water to open sprinklers or to medium or high velocity sprayers.

NOTE –NFPA codes or standards may provide design criteria for some risks normally protected by deluge systems.

3.3.3

Water spray installations use purpose designed open nozzles which may be controlled automatically or manually by quick opening valves. Water spray installations are designed for protection of special risks by extinguishment or by cooling to permit controlled burning or prevent heat damage.

3.3.4

The pipework for the open sprinklers or sprayers shall be fully hydraulically calculated to prove that the appropriate density of discharge will be available when all the sprinklers or sprayers in the installation are discharging.

3.3.5

If the deluge installation cannot operate without causing water damage, a supervised subsidiary stop valve shall be fitted immediately downstream of the deluge valve to assist in the maintenance and testing of the installation.

A drain and test valve shall be located between the deluge valve and the downstream subsidiary stop valve to permit trip testing without flooding the installation.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

If a fire sprinkler inlet is attached to the installation it shall be connected to the installation upstream of any subsidiary stop valve to permit flow testing from the FSI without flooding the installation. For tail-end deluge installations, a supervised subsidiary stop valve shall also be provided immediately upstream of the deluge valve.

3.3.6

A 15 mm plugged connection shall be located adjacent to the hydraulically most disadvantaged nozzle, to allow the nozzle pressure to be measured during commissioning.

3.3.7

Full details of proposals for installation of deluge installations shall be approved before any erection work is started.

3.4 Water mist installations

NOTE – Material on water mist installations is included in Appendix M of this standard.

3.4.1

Water mist installations use specially designed nozzles to suppress, control, or extinguish a fire. The nozzles can be closed nozzles individually controlled via a fusible element, such as a standard sprinkler bulb, or can be open nozzles controlled by a deluge valve arrangement.

3.4.2

Water mist installations may be used only if listed by an SSC. The listing criteria may take precedence over other requirements of this standard.

3.4.3

Water mist installations may be used as an equivalent to standard sprinkler installations, or to protect specialised risks, such as compartmentalised flammable liquid storage areas and machinery spaces, if they have been shown by full-scale testing to be suitable for the application.

3.4.4

Water mist installations may take the form of wet pipe, dry pipe, pre-action, or deluge installations. Water mist installations may be stand alone, or tail-end as an extension to a standard sprinkler installation.

3.5 Methods to determine water delivery for gas-filled sprinkler installations

3.5.1

Dry, tail-end dry, and pre-action installations have prescriptive volume limitations, where it is not demonstrated that water can be delivered to the most remote sprinkler head within 60 seconds of head operation. This section provides two alternative methods to demonstrate that water can be delivered to the most remote sprinkler within the permitted 60 seconds.

3.5.2

It is permitted to exceed the volume restrictions provided in 3.2.2.3, 3.2.3.4, and 3.2.4.3 if it can be demonstrated via on-site testing that water can be delivered to an inspector's test connection, fitted to the remote part of the installation, and fitted with an orifice equivalent to the smallest sprinkler orifice in the installation, in not more than 60 seconds, starting at the normal installation standing air pressure.

3.5.3

An acceptable alternative approach to the physical test method allowed under this clause is to demonstrate that water will be available at the remote sprinkler heads within the time given in Table 3.2 by calculation in accordance with the requirements specified in 3.5.4.

3.5.4

Calculations for water delivery time in gas-filled sprinkler installations shall be based on the occupancy hazard shown in Table 3.2.

The calculation programme and calculation method shall be approved by an SSC.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 3.2 – Gas-filled water delivery calculation design requirements

Occupancy hazard	Design number of remote sprinklers initially open	Maximum time of water delivery (seconds)
ELH (Residential sprinklers)	1	15
ELH (Spray sprinklers)	1	60
OH (Ordinary hazard)	2	50
EHH (Process risks)	4	45
EHH (High piled storage risks)	4[a]	40[a]
[a] Or as specified in the sprinkler design criteria, whichever is more onerous.		

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

4 System components

4.1 General

4.1.1 *Acceptable equipment*

Components that form part of a sprinkler system shall comply with the requirements of the standard and shall be listed where specified in this standard. However, notwithstanding the specific requirements of thisstandard, a SSC may deem new technology to comply with the standard. An SSC shall be satisfied that the technology will detect and control fires with at least the same adequacy and reliability as existing technology permitted by the standard.

4.1.2 *Component pressure ratings*

No component of a sprinkler system shall be subjected, either during normal conditions or during operation, to pressures in excess of that for which the component is rated. Such rating may arise from the particular technical standard with which the component complies or as a condition of any listing of that component.

NOTE – This requirement will be particularly relevant in the case of high buildings or where there is a high standing pressure in the town's main. See also 4.7.2.1 and 2.12.8.

4.1.3 *Component pressure ratings exceeding 1200 kPa*

If the normal standing pressure exceeds 1200 kPa, downstream of the alarm valve, a sign shall be installed in a normally visible place in the sprinkler control valve enclosure. The sign shall have 12 mm high lettering and read:

THE NORMAL STANDING PRESSURE OF THIS INSTALLATION EXCEEDS 1200 kPA. USE OF SYSTEM COMPONENTS WITH A WORKING PRESSURE OF (Installation Contractor to insert max. installation working pressure) kPa IS REQUIRED IF ANY ALTERATIONS ARE CARRIED OUT TO THIS SYSTEM.

4.2 Sprinklers

4.2.1 *General*

Sprinklers (including the make and type) shall be listed. They shall not be altered in any respect nor have any type of ornamentation or coatings applied after leaving the production factory except to provide corrosion resistance.

When a sprinkler has been removed from a fitting or welded outlet for any reason, it shall not be reinstalled.

4.2.2 *Types of sprinklers, sprayers, and multiple controls*

4.2.2.1

The following types of sprinklers are accepted for general use:

(a) *Conventional pattern*: These sprinklers are designed to produce a spherical type of discharge with a proportion of water being thrown upwards to the ceiling. They are usually designed with a universal type of deflector enabling the sprinkler to be erected in either the upright or pendent position. Some conventional pattern sprinklers are made in two types, one suitable for erection in the upright position and the other in the pendent position. The conventional pattern sprinkler is only suitable for installation on exposed pipes without the use of escutcheon plates. This standard precludes the use of conventional sprinklers in ELH and EHH occupancies; and

(b) *Spray pattern*: These sprinklers are designed to produce a hemispherical discharge below the plane of the deflector with little or no water being discharged upwards to wet the ceiling. They are made in two types, one suitable for erection in the upright position and the other in the pendent position. They are available in various orifice sizes, with K factors ranging from 2.0 to 48. There are restrictions on orifice sizes in relation to design densities of discharge for spray sprinklers detailed in Part 9 of this standard.

(c) *Sidewall pattern:* Designed for installation along the walls of a room close to the ceiling. The design of the sprinkler is usually similar to the conventional pattern sprinkler except for a special deflector which causes most of the water to be discharged to one side in a pattern somewhat resembling one-quarter of a sphere with a small proportion discharging on the wall behind the sprinkler. Sidewall sprinklers are available with standard and extended coverage patterns, and additionally, in residential models. They can be used with advantage in the case of drying tunnels and hoods over paper-making machines where condensate dripping from sprinklers and pipework at the ceiling might be troublesome. Also, in certain other locations such as sale-shop windows and under platforms having low headroom, where standard sprinklers would be subject to damage, or under machinery where the use of other types of sprinklers is not practicable;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTE –

(1) This standard requires the use of quick response sprinklers in certain circumstances. The terms 'quick response' and 'fast response' are not synonymous. The thermal sensitivity is a measure of how quickly a sprinkler will operate when it is mounted. The common measure of sensitivity is response time index (RTI), which is measured by plunging the sprinkler into a heat laminar air stream within a test oven.

(2) The RTI test is not applicable to all sprinklers including semi-recessed, concealed, and flush sprinklers.

(3) In most fire scenarios, the sprinkler activation times will be the shortest if the sprinkler thermal elements are between 25 mm and 75 mm below a smooth flat ceiling.

(4) For modelling purposes, NFPA suggests that a concealed sprinkler is considered equivalent to a pendent sprinkler, of the same sensitivity mounted 300 mm below the ceiling, while a semi-recessed sprinkler is considered equivalent to a pendent sprinkler mounted 200 mm below a smooth flat ceiling. Some listing or approvals bodies will not list semi-recessed or concealed sprinklers as quick response for this reason.

4.2.2.2 *Retracted deflector/concealed sprinklers*

Retracted deflector/concealed sprinklers are also accepted for general use subject to the qualifications mentioned below.

Sprinklers of this type have spray pattern deflectors that remain concealed until the sprinkler operates. They shall not be used in atmospheres which are corrosive or have a high dust content, nor in any area where spray sprinklers are not permitted, nor where the ceiling space above has a positive pressure.

4.2.2.3 *Special purpose sprinklers*

The following special purpose sprinklers are accepted for use in the particular circumstances described:

(a) *Dry pendent pattern*: Designed for use in portions of premises protected by a dry pipe system where it is not practical to install sprinklers in the upright position or on a wet pipe system where the sprinklers may be subject to freezing. They may also be used on pre-action and antifreeze systems where it is not practical to install sprinklers in an upright position. Apart from the valve arrangement, the sprinklers are of standard design having either conventional, pendent spray type, or sidewall deflectors. They are manufactured integral with drop pipes of varying lengths; the valve being so placed that there is no pocket or depression within which water can be trapped;

(b) *Dry upright pattern*: Essentially the same as the dry pendent sprinklers, except that if they are of the spray pattern an upright-type deflector is incorporated. They are used for the protection of unheated concealed roof spaces in connection with installations on the wet pipe system;

(c) *Dry sidewall*: Essentially the same as dry pendent sprinklers but are fitted with sidewall pattern deflectors. They are used to protect areas which may be subject to freezing. They are available in both horizontal and vertical patterns and, additionally, with extended coverage deflectors;

(d) *Residential*: Used in those portions of premises that are classified as ELH and as specified in Part 7 of this standard. They feature a very low RTI, a higher than usual discharge trajectory, and are available in pendent or sidewall configurations. Installation shall be in strict accordance with the listing concerning spacing, required pressure, and distance below the ceiling. Unless specifically listed, residential sprinklers shall not be used in ceilings with a slope greater than 33º degrees, or a ceiling height greater than 7 m.

(e) *Extended coverage ordinary hazard (ECOH)*: Spray pattern sprinkler designed to protect areas larger than 12 m^2/sprinkler within OH occupancies. Installation shall be in strict accordance with the listing. Large-scale fire tests have demonstrated that ECOH sprinklers installed in accordance with their listing provide equivalent fire control to standard sprinklers at 12 m^2 spacing. The use of ECOH sprinklers is limited to OH occupancies other than:
   (i) Warehouses, stock rooms, and other similar storage occupancies
   (ii) Spray application of flammable liquids
   (iii) Hydraulic equipment using flammable hydraulic fluids
   (iv) Vehicle assembly or repair areas where fuel is in fuel tanks
   (v) Any other occupancy involving flammable or combustible liquids;

   NOTE – To achieve comparable detection, ECOH sprinklers are fitted with a more responsive heat activated element but are not necessarily listed as quick response sprinklers.

(f) *Extra large orifice (ELO).* Spray sprinkler with a *K* factor greater than 11.5;

(g) *Extended coverage light hazard (ECLH):* Spray pattern sprinkler designed to protect areas larger than 21 m^2/sprinkler within ELH occupancies. Installation shall be in strict accordance with the listing. Their design criteria will reflect US-based light hazard design criteria, namely, a design density discharge of 4.1 mm/min, which may lead to a need to evaluate the cost benefits of a larger water supply, as against cost savings in greater coverage areas per sprinkler;

(h) *Specific application sprinklers:* Special purpose sprinklers listed for the protection of special and unique hazards. Such sprinklers are to be used in accordance with their listing criteria; and

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

NOTE – At the time of preparation of this standard, specific application heads included, but were not limited to, window sprinklers, attic sprinklers, sealed mist sprinklers, water spray nozzles, and combustible concealed space sprinklers.

(i) *Storage sprinkler:* Large orifice, closed head sprinkler with either a fast response or a standard response element and designated as a 'storage sprinkler'. They are permitted for use in those portions of the building classified as EHH or OH4 as specified in Part 8 or Part 9 of this standard. These sprinklers are predominantly designed to achieve fire suppression without the use of in-rack sprinklers. Installation shall be in strict accordance with the listing for spacing.

4.2.2.4 *Medium velocity and high velocity sprayers*

These are special purpose sprayers for use in water spray systems (which may or may not form part of normal sprinkler systems) intended for the extinguishing or control of fires involving flammable liquids and forthe cooling of storage tanks, process plants, and exposed structural steelwork against heat from an exposure to fire. These sprayers have directional discharge characteristics with cone angles ranging from40° to 180° and with orifice sizes varying from 5 mm to 13 mm.

Features of the two types are as follows:

(a) Medium velocity sprayers are produced either as sealed sprayers with glass bulbs or soldered links and levers as for normal sprinklers or as open sprayers. They are designed essentially for cooling purposes when dealing with fires involving low flashpoint liquid hazards (below 66°C) as, for example, liquefied petroleum gases. In such risks, the aim is not for automatic extinguishing but to control the burning within safe limits until the source of gas supply has been shut off, thus avoiding the danger following a fire incident of these heavier-than-air gases continuing to escape and collecting in low-lying areas producing an explosion hazard;

(b) High velocity sprayers are of the 'open' type and are designed for the extinguishing of fires involving high flashpoint liquids (above 66°C).

Nozzles in outdoor areas shall be fitted with proprietary blow-off caps or dust plugs.

NOTE – Care is to be taken to ensure that actual operating pressure of nozzles falls within the published pressure ranges for the spray distribution patterns required.

4.2.2.5 *Multiple jet controls (MJCs)*

These are heat-sensitive sealed valve controlled outlets, using either glass bulbs or soldered links and levers as the heat-sensitive device. They are for use in systems using sprinklers and medium velocity or high velocity sprayers of the open type in circumstances where it is required to operate small groups of sprayers simultaneously. The controls are made in various sizes relevant to the diameter of the valve and the number of sprayers that are to be fed from this valve. The sizes range from 20 mm to 80 mm.

4.2.3 *Classification of sprinklers*

4.2.3.1

Acceptable uses for each type of sprinkler head are indicated in Table 4.1.

4.2.3.2

The *K* factors for each type of sprinkler shall be in accordance with those indicated in Table 4.1 and 10.5.5 unless noted otherwise in the listing.

K factor is the constant in the formula

$$Q = K\sqrt{P} \quad \text{.....(Eq.1)}$$

Where:

Q = Flow in L/min

P = Pressure in kPa.

4.2.3.3

Sprinkler head pipe thread form shall be compatible with the pipework connection.

4.2.3.4

Sprinkler heads shall be marked with a sprinkler identification number (SIN) which will allow the sprinkler head characteristics to be identified from the manufacturer's published data;

NOTE – All sprinklers manufactured to Underwriters Laboratories Standards have a unique SIN.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

4.2.3.5

The types of sprinkler which are acceptable for each hazard class are set out in Table 4.1.

Table 4.1 – Acceptable types of sprinklers

Hazard class	Type of sprinkler	Orifice (*K* factor)
Extra light	Spray (10 mm) (see Note 1)	5.7
	Spray (15 mm)	8.0
	Sidewall (10 mm) (see Note 1)	5.7
	Sidewall (15 mm)	8.0
	Sidewall (20 mm)	11.5
	Residential	(see listing)
	ECLH	(see listing)
Ordinary	Conventional	8.0
	Spray	8.0
	Spray	11.5
	ELO	16.1 or 24.2
	ECAD	36
	Sidewall	8.0
	ECOH	(see listing)
Extra high	Spray (see Note 2)	8.0
	Spray (see Note 2)	11.5
	Storage Sprinklers	16.1, 20.2, 24.2, 32, 36.3, 40.4, or 48.7
	IRS	8.0, 11.5, 20, 32, or 36

NOTE –

(1) 10 mm sprinklers are permitted only when replacing 10 mm standard response sprinklers in sleeping areas or for extensions and/or alterations of existing systems protected with such sprinklers.

(2) *K*8 and *K*11.5 sprinklers are not permitted for use in protection of storage risks but may be permitted for special commodities and process risks.

4.2.3.6 *Sprinkler head jet reaction*

Where storage sprinklers are installed on arm pipes more than 200 mm long, or where eccentric loads may be otherwise applied to pipes, additional bracing, including rigid clamping of the pipe where necessary, shall be provided according to the calculated forces involved.

4.2.4 *Temperature rating*

4.2.4.1

Sprinklers are available in nominal temperature ratings ranging from 57°C to 343°C. Table 4.2 illustrates the colour codes and the temperature classification to distinguish sprinklers of different nominal temperature ratings.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Table 4.2 – Temperature classification of sprinklers – Rating and colour

Maximum ceiling temperature (°C)	Temperature classification	Sprinkler head	
		Fusible link (temperature rating (°C) & colour)	Glass bulb (temperature rating (°C) & colour)
40	Ordinary	55/77 (Natural)	57 (Orange)
			68 (Red)
65	Intermediate	80/107 (White)	79 (Yellow)
			93 (Green)
105	High	121/141 (Blue)	141 (Blue)
150	Extra high	163/191 (Red)	182 (Purple)
190	Very extra high	204/246 (Green)	204/246 (Black)
245	Ultra high	260/302 (Orange)	260/302 (Black)
330	Ultra high	320/343 (Black)	343 (Black)

NOTE –
(1) For normal conditions, in temperate climates, ratings between 68°C and 79°C for commercial and industrial premises and between 57°C and 68°C for residential occupancies will be generally suitable.
(2) See 3.2.4.2 for temperature ratings in pre-action systems.
(3) See section 4.2.4.4 and Table 4.3 for sprinkler location requirements near heat sources.

4.2.4.2

Unless the following exceptions apply, sprinklers in any compartment shall be of the same thermal sensitivity, including temperature ratings and response time index:
(a) If required by other parts of this standard;
(b) If the sprinklers are separated by a draft curtain or bulkhead, with no storage or furniture underneath it;
(c) If sprinkler heads of an elevated temperature rating are required because of proximity to a heat source; or
(d) If detection sprinklers for a pre-action installation are installed they may be of different temperature and RTI to the discharge sprinklers.

NOTE – If higher temperature rated heads are required in an area using quick response sprinklers and listed quick response heads at that temperature rating are not manufactured, then standard response heads may be used.

When existing systems are altered and extended, and the installation of quick response sprinklers isrequired, then all sprinklers within that compartment shall be changed.

4.2.4.3

Unless the maximum temperature to which the sprinkler will be subject can be determined, the following practices shall be observed:
(a) Sprinklers located within 300 mm to one side and below, or 750 mm above uncovered steam mains, heating coils, or radiators shall be intermediate temperature rated sprinklers;
(b) Sprinklers located within 300 mm to one side and below, or 750 mm above heating ducts and diffusers, or 750 mm in the direction of discharge, shall be intermediate temperature rated sprinklers. This does not apply to heating ducts that discharge air that is less than 38 °C;
(c) Sprinklers under glass or plastic skylights exposed to the direct rays of the sun where hot air can accumulate shall be intermediate temperature rated sprinklers;
(d) Sprinklers in an unventilated roof space, under an uninsulated roof, or in an unventilated attic shall be the intermediate temperature rated sprinklers;
(e) Sprinklers in unventilated show windows having high-powered electric lights near the ceiling shall be intermediate temperature rated sprinklers;
(f) Sprinklers protecting commercial-type cooking equipment and ventilation systems shall be high or extra high temperature rated sprinklers;
(g) Sprinklers located in unvented laundry enclosures shall be intermediate temperature rated sprinklers.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(h) Any other situation where elevated temperatures are expected shall require the use of intermediate temperature (or higher) rated sprinklers.

The following table identifies the minimum separation distances from some commonly found heat sources.

Table 4.3 – Minimum distance from edge of heat sources to nearest sprinkler

Heat source	Ordinary temperature rated sprinklers (mm)	Intermediate temperature rated sprinklers (mm)
Side of open or recessed fireplace	900	300
Front of recessed fireplace	1500	900
Coal or wood-burning stove	1050	300
Kitchen range	450	225
Wall oven	450	225
Hot air flues	450	225
Uninsulated heat ducts	450	225
Uninsulated hot water pipes	300	150
Hot water heater or furnace	150	75
Light fixture: 0 W – 250 W	150	75
Light fixture: 250 W – 499 W	300	150

NOTE – Further guidance may be available in NFPA 13.

4.2.5 *Sprinkler guards*

4.2.5.1

In situations where sprinklers are liable to accidental or mechanical damage, sprinklers can be protected by listed or approved guards.

4.2.6 *Protective treatment of sprinklers*

4.2.6.1

Sprinklers used where corrosive vapours are prevalent shall be protected against corrosion. This may be either by a listed corrosion-resistant sprinkler suitable for the ambient temperature, or with a factory applied wax coating. Wax coatings shall be made good after installation.

4.2.6.2

Sprinkler heads located in areas of fouling may be protected from build-up by the installation of a lightweight paper bag fitted over the sprinkler head.

4.2.6.3

Where sprinklers are located in external environments (such as under canopies, balconies, decks, and any external sprinklers), a sprinkler with a listed corrosion-resistant coating shall be used, unless the exceptions listed below apply:

(a) Exception 1: The type of sprinkler used is not available with a corrosion coating; or
(b) Exception 2: Is in an exposure zone B, as defined in NZS 3604.

NOTE – It will be necessary to consider microclimatic considerations in exposure zone B, as required by NZS 3604 4.2.4.

Sprinkler heads used in areas subject to freezing shall be kept free from ice deposits. Ice on sprinkler heads shall not be removed by mechanical means.

NOTE – Ice formations on sprinkler heads can prevent early fire detection and may interfere with the discharge spray pattern. Mechanical removal of ice formations is likely to result in damage to the sprinkler head.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

4.2.7 *Replacement sprinklers*

4.2.7.1

Unless otherwise allowed by 4.2.7.5, the contractor shall provide at the control valves, or at the fire pump enclosure, a cabinet or bracket to contain spare sprinklers. Such sprinklers shall be kept in a place where the ambient temperature does not exceed 38°C.

4.2.7.2

The contractor shall provide six spare sprinklers of the type and temperature ratings used widely in the installation.

4.2.7.3

Where small quantities of sprinkler heads are used in the installation, at least one spare sprinkler shall be provided.

NOTE – This clause is to ensure that a sprinkler system can be readily recommissioned following sprinkler activation. Examples of spares that are required to be provided for compliance under this clause would include a spare dry barrel sprinkler of each length, deflector type, and temperature rating used in the installation, and a spare high temperature head of each temperature rating used to protect a kitchen extraction hood. If large quantities of these specialised heads are used in an installation, the number of spare sprinklers maintained on the site should be increased accordingly.

4.2.7.4

The contractor shall also provide a spanner suitable for each type of sprinkler installed.

4.2.7.5

Where the installation is within 100 km of the service provider, the requirement to provide standard spare sprinklers as defined in the table below is waived, on the premise that the service provider will undertake to carry standard spares in their after-hours, call-out vehicle.

Standard sprinklers are defined standard and quick response as follows:

Sprinkler orifice size	**Type of sprinkler**	**Temperature rating**
15 mm	SSP or SSU	68°C or 93°C

In the context of this clause, concealed plate sprinklers are not considered standard sprinklers.

4.2.7.6

Sprinklers requiring replacement shall be replaced by a sprinkler of equivalent type.

For residential sprinklers, replacement sprinklers shall have the same discharge coefficient and deflector pattern as existing sprinklers.

4.2.8 *Escutcheon plates*

Escutcheon plates, including decoration, shall be of metal or thermosetting plastic and designed and fixed not to adversely affect the water distribution or detection functions of the sprinkler. They shall not be used to support a ceiling or other structures. One-piece escutcheon plates meeting these criteria do not require listing.

Two-piece or recessed escutcheon plates shall be listed, either as individual units, or in conjunction with the listing of sprinklers. Two-piece escutcheon plates shall only be listed for use in accordance with the relevant sprinkler data sheet specifications.

NOTE – This is not intended to apply to extension type plates, where the plate cannot impact on sprinkler discharge.

Two-piece escutcheon plates shall not be used with conventional (C/UP) sprinklers, unless included in the specific sprinkler listing.

Any escutcheon plates used in external or corrosive environments shall be manufactured from a suitable grade of stainless steel.

NOTE – Examples of external environments include apartment balconies, open-sided car parks, canopies, and covered porches.

4.2.9 *Flexible droppers*

Listed flexible stainless steel droppers may be used in sprinkler installations if installed according to listing requirements. Listed flexible sprinkler hose fittings and their anchoring components intended for use in installations connecting the sprinkler system piping to sprinklers, shall also be installed to meet listing requirements and manufacturers' installation instructions, including any special dimension requirements and friction loss data.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Installation drawings shall detail how the flexible drops are to be installed and shall be specific for the ceiling structure of the project. Details such as the minimum bend radius, the number of bends, the fixing details, and any other project specific details, shall be provided on the installation drawings.

Listed flexible droppers shall be made of corrugated stainless steel tube protected by a braided stainless steel sleeve. As part of the listing process, the type of dropper shall pass a fatigue test of at least 50 000 cycles of repeated flexing.

4.2.10 *Extension fittings*

Extension fittings may be used with sprinklers of *K*11.5 or smaller, in occupancies of OH3 or lower.

The internal diameter (ID) of the extension fitting shall be the same diameter as the bore of the sprinkler.

Unless specifically listed, the maximum length of an extension fitting is 50 mm.

NOTE –

(1) This requirement is expected to preclude the use of 'male and female' type galvanised malleable iron nipples.

(2) It is not necessary to allow for hydraulic losses in extension fittings unless they are listed items longer than 50 mm.

4.3 Pipework

4.3.1 *Compliance with standards*

Pipework shall comply with the provisions of this section.

4.3.1.1 *Minimum pipe size and permitted types*

The minimum acceptable waterway pipe size shall be 20 mm ID. Only the following types of pipes and jointing options as shown in Tables 4.4 and 4.5 are permitted.

Table 4.4 – Pipe and jointing options for underground pipework

Pipe	Jointing options
Unplasticised polyvinyl chloride (PVC-U) to AS/NZS 1477, modified polyvinyl chloride (PVC-M) to AS/NZS 4765 or oriented polyvinyl chloride (PVC-O) to AS/NZS 4441	Solvent cement, elastomeric seal, or flanged joints; all shall be installed to AS/NZS 2032 NOTE – Elastomeric seal joints are not allowed downstream of the alarm valve
Polyethylene to AS/NZS 4130	Butt-fusion, socket-fusion, electro-fusion jointing, or mechanical compression using fittings to AS/NZS 4129, installed to AS/NZS 2033
Polybutylene to AS/NZS 2642.2	Butt-fusion, socket-fusion, electro-fusion jointing, or by using mechanical compression fittings to AS/NZS 2642.3
Ductile iron in combination with polyethylene sleeving such as for connections and risers	Flanged, full faced with 316 stainless steel bolting

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 4.5 – Pipe and jointing options for above-ground pipework

Pipe	Jointing options
Mild steel to:	
25 mm to 100 mm. BS EN 10255 or AS 1074 light wall	Flanged, mechanical coupling (roll grooved only)
25 mm to 250 mm. ASTM A795 Schedule 10	Flanged, mechanical coupling (roll grooved only)
25 mm to 125 mm. ASTM A135 Schedule 10	Flanged, mechanical coupling (roll grooved only)
10 mm to 150 mm. BS EN 10255 /AS 1074 medium wall	Screwed, flanged, mechanical coupling (roll grooved only)
10 mm to 150 mm. API/ASTM Schedules 40, 80	Screwed, flanged, mechanical coupling (roll grooved only)
150 mm to 600 mm. API/ASTM Schedules 20, 40, standard weight	Flanged, mechanical coupling (roll grooved only)
150 mm to 600 mm. API/ASTM Schedules 40 and standard weight	Flanged, mechanical coupling (roll grooved or cut grooved)
200 mm to 250 mm. API 4.78 mm wall thickness	Flanged, mechanical coupling (roll grooved only)
20 mm to 50 mm ASTM Schedule 10	Proprietary systems approved by FM Approvals or listed by UL
Copper to NZS 3501	Brazed joint or capillary fitting
Chlorinated polyvinyl chloride (PVC-C) to ASTM F442 with SDR of 13.5	Solvent cement with PVC-C fittings to ASTM F439 subject to limitations of 403.1.321
Stainless steel to ASTM A312	Welded joints or fittings to ASTM A403
Schedules 10, 40, and 80; all sizes	Mechanical coupling (roll grooved or cut grooved subject to wall thickness) also subject to limitations of 403.1.3.2
Any other pipe listed by the SSC and meeting the requirements to AS 4118.2.1	In accordance with the listing.
NOTE – (1) For ASTM standards refer to ASTM A795, ASTM A135, ASTM A53, and ASTM A106 Grade B. (2) For API standards refer to API 5L Grade B. (3) Attention is drawn to the need to consider dissimilar metal corrosion, such as may occur between copper and galvanised steel pipework. (4) Particular care is required when grooving light wall pipe.	

4.3.1.2 *Pipes upstream of alarm valves*

All steel pipes upstream of alarm valves shall be galvanised internally.

NOTE – This is intended to protect steel pipework upstream, any backflow prevention device, and the alarm valve from internal corrosion.

4.3.1.3 *Specific piping requirements*

4.3.1.3.1 Chlorinated polyvinyl chloride pipe and fittings

Chlorinated polyvinyl chloride (PVC-C) pipe, fittings and solvent cements are permitted when:

(a) They are listed for fire sprinkler use and installed in accordance with the listing criteria and associated instructions and:
  (i) Are limited to ELH and OH1 occupancies
  (ii) Any pipe supplying room sprinklers shall have quick response sprinklers or be protected behind a continuous barrier of not less than 1.6 kg/m^2 density
  (iii) Pipe may only be used in ceiling spaces which are free from combustible materials or are sprinkler-protected using quick response sprinklers.

(b) The manufacturer's recommended cure time prior to the pressurisation of the system does not exceed 6 h at 15.5°C; and

(c) The system is installed and supported in accordance with the manufacturer's requirements.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Sprinkler heads shall not be fitted to PVC-C pipework before the jointing cement has cured, to avoid rundown of cement into the sprinkler.

NOTE – The listing of PVC-C pipe for fire protection use requires that the pipe contains water.

4.3.1.3.2 Unplasticised polyvinyl chloride pipework

Unplasticised polyvinyl chloride (PVC-U) pipework may be used downstream of the installation valve only when completely buried underground and the depth of cover and installation complies with NZS 7643, and it is subject to the following limitations:

(a) The pipework is laid by the open trench method, with granular bedding and surround fill to Type D of Appendix D of NZS 7643, and no part is encased in concrete;
(b) PVC-U to PVC-U joints shall be solvent welded or use elastomeric seals;
(c) PVC-U to metal joints shall be either:
  (i) Threaded, using solvent welded moulded thread adaptors with the PVC-U being the male thread, or
  (ii) Flanged using solvent welded socket stub flanges with metal backing rings;
(d) Pipework pressure rating shall be 1.5 times the system maximum pressure, but not less than 1200 kPa. Working pressures shall be de-rated as per NZS 7643 for soil temperatures above 20°C (such as in the New Zealand geothermal belt); and
(e) The soil, at the depth of the pipe, is not subject to frost.

4.3.1.3.3 Stainless steel pipework

Stainless steel pipe is permitted provided that:

(a) Pipe and fittings are only grades 304, 304L, 316, and 316L;
(b) Threaded joints are used only for schedule 40 and 80 pipes of up to 50 mm diameter; and
(c) Welded joints and joints made with welded fittings are post heat treated as required by ASTM A312 for the grade of steel concerned.

4.3.1.4 *Mechanical couplings*

Mechanical couplings (such as roll grooved, cut grooved, and slip on joints) shall be listed.

Where mechanical couplings and clamp on tees are galvanised, any nuts and bolts used in external or corrosive environments shall be galvanised and supplied by the coupling manufacturer.

NOTE – Bolts used with couplings are of a high tensile rating specific to the coupling. Use of bolts procured from alternative sources could lead to catastrophic failures if not of an adequate tensile rating.

Rolled or cut grooved mechanical couplings used in dry or pre-action systems shall be of the type that will preclude water being trapped in a cavity within the gasket.

NOTE – Such gaskets are of the type designed generally for use within freezers.

4.3.2 *Underground pipework*

4.3.2.1 *Steel pipe underground*

Steel pipe shall not be used underground.

NOTE – It is not intended to allow stainless steel pipe underground.

4.3.2.2 *Protection against corrosion and vehicle traffic*

Underground pipes shall be protected against corrosion where necessary. Where pipes are carried under vehicle traffic areas, the pipe covering shall be such as to maintain the load on the pipe within safe tolerances.

4.3.2.3 *Exposed plastic pipe transition pieces*

Except as permitted below, exposed plastic pipe may only be used if listed for that purpose.

Plastic spool pieces of no more than 300 mm in length may be used for transition pieces between buried and above-ground pipes, if the following are met:

(a) If located in a plant room, the pipework shall be protected from exposure to any ignitable liquids, such as diesel fuel used to power pumps or generators;
(b) If any ignitable liquids are present, the pipes shall be encased in frangible mortar to allow subsequent repairs to be effected if necessary;
(c) The plastic pipes shall be protected from direct exposure to sunlight; and
(d) No loads shall be placed upon the plastic pipes from unsupported pipework.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

4.3.2.4 *Testing of underground fire mains and pump start lines*

The installation contractor shall be responsible for carrying out all tests and inspections of the underground fire mains and shall complete a flushing test certificate (see Appendix N).

A certificate shall be compiled and signed by both the contractor's and the property owner's representatives. Copies of the test certificate shall be held on site with the site fire systems logbooks and a copy of the test certificate shall be submitted to the SSC.

4.3.2.4.1 Flushing of underground pipe

It is important that all underground pipework that has been exposed during construction shall be inspected and flushed/cleaned prior to connection to a sprinkler or fire suppression system.

System contaminants such as mill scale, jointing compounds and building debris will inevitably be found in newly fabricated or altered water mains. If allowed to remain in the system these contaminants will make the system prone to blockages at strainers and may impair control valves, sprinkler range pipes and sprinkler heads. They may also initiate further corrosion and encourage the growth of microorganisms.

Flushing of the water mains shall be done initially to remove any debris left in the pipe after installation and this must be done prior to connecting any fire system to the water supply to prevent ingress of debris into the fire suppression installations.

For alterations to existing mains when flushing/cleaning and inspection procedures are required, impairment of sprinklers or other fire protection installations during flushing must be handled according to company procedures.

4.3.2.4.2 Minimum velocities for flushing underground pipework

Underground mains shall be flushed prior to connection to a sprinkler installation at minimum velocities as detailed in Table 4.6 below.

Working from the water supply flush each section of the fire main and any lead-in connections to fire system risers. If water is supplied from more than one source or from a gridded system, control valves should be closed to produce a high velocity flow through each single line.

Minimum flushing velocities of 3 m/s shall be used (see below table for recommended flow rates) for a period of:

(a) Not less than 2 minutes; or

(b) Until the water runs clear and that there are no further signs of debris being discharged from one or more fire hydrants, sprinkler test/FS outlet, blow-off valves, or from purposely installed outlets adequately sized to discharge the designed flows.

A water supply producing velocities of 3 m/s may not be available under all circumstances. If such a velocity is not available, then the fire system's maximum anticipated demand should be simulated to clear all debris that may obstruct the pipework.

It is advised that to ensure all debris is adequately flushed from the main, flushing at the designed flows shall be continued for at least one second per metre of pipe work installed.

Table 4.6 – Rates of flow required for flushing mains pipe diameters

Pipe diameter **mm NB**	**Required flow rate** **L/min**
100	1500
150	3300
200	5900
250	9200
300	12 800
NOTE – Flow rates based on nominal values of pipe diameters.	

4.3.2.4.3 Major and minor work on underground pipe work

For all major work on underground mains the full requirements for flushing fire mains detailed in Appendix N shall be implemented.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

However, where that has been only a short length of underground pipe exposed (> 10 m) the following shortened flushing process may be carried out:

(a) Working from the water main supply control valve flush the short section of the main through one or more fire hydrants, sprinkler test/FS outlets, blow-off valves, or purposely installed outlets of adequate size to discharge the designed flow for a period of not less than 2 minutes, or until water runs clear, or there is there is no collection of foreign materials in strainers.

(b) A minimum flushing velocity of 3 m/s should be used (see above table) for a period of not less than 2 minutes and continued until the water flows with no further signs of debris being discharged. If such a velocity is not available, then the system's maximum anticipated demand should be simulated to clear debris, sand, or any other matter that may obstruct the pipework.

4.3.2.4.4 Alternative method of inspection and cleaning of pipework

With the approval of the SSC where the minimum flushing velocities of 3 m/s cannot be provided an alternative method of flushing using a proprietary pipe cleaning company who use high pressure cleaning pigs and CCTV inspection systems may be considered.

4.3.2.4.5 Completion of test certificates

Upon completion of any flushing work on an underground fire main or pipework the system shall be inspected and tested to the satisfaction of the approving authority and a test certificate (Appendix N) shall then be completed.

Any defects identified during flushing shall be rectified and the system retested if required. Once completed the system shall be handed over to the owners and left in service before contractors leave site.

A copy of the test certificate shall be held on site with the site fire systems logbooks and a copy of the test certificate submitted to the SSC.

4.3.3 *Hot work jointing*

4.3.3.1

Provided responsibilities of all parties under the Health and Safety at Work Act 2015 are met, any pipe joints may be joined using hot work subject to the following restrictions:

(a) All welding of steel pipes shall be carried out to the requirements specified in 1.10;

(b) Welding of galvanised pipes is not permitted;

(c) Except in exceptional circumstances, in the case of sprinklers being installed during the construction of the protected building, only pipes of 50 mm NB or greater may be joined by hot work *in situ*. Hot work in smaller pipes shall be fabricated in the contractor's workshop;

(d) Where sprinklers are being installed in an existing building, *in situ* hot work shall not be permitted except in exceptional circumstances and then only in accordance with 11.5; and

(e) For service or alteration work on existing sprinkler systems, 'cut-in' hot work operations are onlypermitted to the extent specified in 11.5.

4.3.4 *Concealment of pipework*

4.3.4.1

Sprinkler pipework should not be embedded in concrete except where short sections are required tonegotiate structural members and sleeving is not practical. Bends are preferred to joints in this section but otherwise the pipe shall be welded, pressure tested, and wrapped before immersion in concrete. The wrapping shall extend beyond the edge of the concrete.

NOTE – Embedding of pipework is restricted to avoid problems of corrosion and difficulties in making subsequent alterations to the system.

4.3.5 *Feed pipes in high temperature areas*

4.3.5.1

Sprinklers in ambient temperatures above 100°C shall be on a dry pipe installation or the feed pipes thereto shall rise up to the sprinklers (or group of sprinklers) so as to restrict the thermal circulation of the heated water in the pipes.

4.3.6 *Pipework restriction in unsprinklered firecells*

4.3.6.1

Sprinkler pipework shall not pass through, or be supported on, an unsprinklered firecell unless there is no practical alternative, in which case 4.3.6.2 shall apply.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

For pipework, valves, and fittings in buildings or sections of premises in which particularly hazardous processes are carried on, or an explosion hazard exists, special precautions apply (see 4.4.11).

4.3.6.2

The sprinkler pipework shall be accessible for inspection and contained within a protected shaft or surrounded with fire resistant materials. It shall be supported by elements having an FRR no less than the property rating as specified in the supporting documents to NZBC Clause C Protection from fire.

If the building structure in the unprotected area, including the supporting columns, is concrete, protection may be provided by sprinkler(s) protecting the pipe and its supports, with the sprinkler heads spaced tospray over pipework supports and braces. The design number of sprinklers shall be specifically approved by the SSC. This will normally include all sprinklers fitted to unprotected pipework in the unprotected firecell.

NOTE –
(1) Small orifice sprinklers with a discharge coefficient of 2.0 L/min.kPa$^{-0.5}$ may be used.

(2) The above conditions are intended to prevent damage or collapse of the pipework in the event of a major fire in the unprotected building.

4.3.7 *Protection of pipework against corrosion*

4.3.7.1

Unpainted or otherwise unprotected mild steel pipe is permitted for interior use if there are no corrosive environmental conditions present and the pipe has not been subjected to corrosive conditions prior to installation.

NOTE – Attention is drawn to differences in corrosive conditions that can occur in particular areas of a building (such as toilets) or in different areas of a city (such as areas close to the sea), or in different parts of New Zealand (such as Rotorua) and to the requirements of some owners (such as hospitals and industrial plants) of colour code various piping systems.

4.3.7.2

Where corrosive conditions exist, pipework should be thoroughly cleaned and protected by suitable corrosion-resistant means.

NOTE –

(1) In some corrosive environments galvanising may be adequate provided that the threaded ends of the pipes are adequately sealed with a suitable protective coating; and/or

(2) The pipes may be wrapped in a suitable protective tape system in accordance with the manufacturer's instructions.

4.3.7.3 *Earthing*

All sections of the fire sprinkler conductive piping system shall be equipotentially bonded to the building electrical installation main earth bar. The fire sprinkler piping system shall not be used as an earth continuity conductor.

NOTE –

(1) Equipotentially bonding means bonding together to prevent voltage differences between earthed items in the electrical installation and the fire sprinkler conductive piping system.

(2) The cross-sectional size and conductor material requirements of the equipotential bonding cable shall be to AS/NZS 3000 requirements.

(3) Each and every building on the installation that is fed downstream of an underground installation connection will require earthing in accordance with the above clause.

4.3.8 *Protection of system against traffic or mechanical damage*

Sprinkler pipework should not be erected in locations where it is prone to damage by forklift trucks and other mobile equipment. In particular, it should not cross gangways where such equipment is used unless the headroom is in excess of the height of the equipment concerned. Where it is impracticable to avoid areas subject to such traffic, the pipework should be protected by adequate guards. Where installation valves or risers are situated in such areas, in addition to guard rails, safety guidelines should be marked out.

4.3.9 *Gravity pipe support*

4.3.9.1 *Fixing of pipe supports*

Fixings and hangers shall be ferrous and installed so that they are designed to support a minimum five times the weight of the water-filled pipe plus 100 kg. Supports shall allow for thermal movement.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Non-ferrous components that have been shown by fire tests to be suited for the support of sprinkler pipework are acceptable.

All beam clamps require restraining straps unless product listing shows otherwise. Beam clamps shall only be used as per the applications they have been approved for, that is,. hanging vertical pipe only, and therefore shall not be used as a component in a seismic brace assembly.

Except for intermediate hangers, pipe 65 mm and greater may not be hung from secondary timber or non-structural steel, for example timber infill and inter-purlin braces.

4.3.9.1.1 Listing

All components of pipe support assemblies that attach to pipes or the building structure shall be listed, except the following, which are not required to be listed:

Mild steel rods;

Generic items used with hanger rods and fasteners such as bolts, screws, washers, nuts, and lock nuts;.

NOTE – Listings by organisations such as Underwriters Laboratories Inc and FM Approvals do not necessarily mean that their loadings are suitable for listing against the requirements of NZS 4541.

4.3.9.2 *Fixing of other services*

Other than linear heat detection cable and heat tracing cable, electrical wiring or other services, fittings, or fixtures shall not be attached to, or supported by, sprinkler pipework.

Sprinkler pipework should not be supported from other services unless the supports have been engineered to the requirements of AS/NZS 1170 series. When sprinkler pipework is supported from other services or shares a common support system, the required strength of the support system shall be calculated based on the total load the system carries. The strength required shall be no less than that determined by 4.3.12.1(a) for the building structure as a whole.

4.3.9.3 *Suitable support dimensions*

Suitable supports for horizontal simply supported steel pipes are given in Table 4.7 or shall be calculated such that the maximum deflection will not exceed 1/300 of the distance between supports when the pipes are full of water.

Table 4.7 – Suitable supports

Pipe size (mm)	Max. spacing (m)	Min. hanger threaded rod diameter (mm)
20	2.4	10
25	3.7	10
32	3.7	10
40	4.6	10
50	4.6	10
65	4.6	10
80	4.6	10
100	4.6	10
150	4.6	12
200	4.6	12
Over 200	6.5	≥ 16 by calculation

The unsupported length between the end sprinkler and the last hanger on a range of two sprinklers or more shall not be more than 900 mm for 25 mm pipe and 1200 mm for 32 mm pipe and larger.

Hangers are not required on range pipes under 600 mm long fed directly from distribution pipes with rigid connectors.

Where the distance between supports for distribution pipes exceeds the maximum permissible span, the intermediate distribution pipe hanger may be omitted provided the range pipes are supported from each purlin adjacent to the distribution pipe.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Support systems for pipes of other materials shall be by specific design.

PVC-C pipes shall be supported according to the listing instructions of the manufacturer (see 4.3.1.3.1).

Spring-mounted pipe hangers are not permitted.

Threaded rod shall not be formed nor bent.

4.3.9.4 *Special provision for factory formed insulated panels*

Special precautions are required for fixing to factory formed insulated panels. The design for fixings shall be approved by an SSC and may require certification by a CPEng. Alternatively, the design for fixings shall include the following:

(a) When attaching sprinkler range pipework to the underside, or bridged or cantilevered off the side, of factory formed insulated panels, the fixings shall penetrate both skins of the panel. Suitable load spreading plates shall be provided with the fixings on both sides of the panel;

(b) Where factory formed insulation panels are designed for a temperature controlled atmosphere or for weather protection, any fixings penetrating the panels shall be thermally insulated to reduce heat transfer and all external fixings shall be sealed against the ingress of water;

(c) The use of pop rivets, or self-tapping screws, or similar fixings to support ranges from the underside or from the side of a panel is not permitted;

(d) For pipework of 65 mm nominal bore and under, supports may be fixed to the top of the panel using pop rivets, self-tapping screws, or similar fixings;

(e) Distribution pipework shall not be affixed to factory formed insulated panels unless a specific engineered solution has been provided by a CPEng and approved by an SSC; and

(f) The use of plastic fasteners, such as nylon through bolts, is not permitted.

NOTE:

(1) The requirement to preclude plastic fasteners is based on a review of a number of failures, where the fasteners have catastrophically failed, with the system falling from the building ceilings. A review of literature has indicated that nylon will embrittle when in contact with moisture, zinc, and the chemicals used to provide fire retarding to expanded polystyrene. These materials are usually all present with sprinkler system supports.

(2) The requirement which precludes pop rivets and the like is based on a review of range pipe support failures following two significant fires in 2005.

4.3.9.5 *Additional restraint for sprinklers*

Additional piping restraint shall be provided:

(a) To restrict movement for all return bends, armovers, and similar piping arrangements regardless of the horizontal length when the sprinkler system piping is connected using grooved flexible couplings; and

(b) To restrict movement for all return bends, armovers, and similar piping arrangements when the sprinkler system piping is more than 600 mm horizontally in length and connected by any other acceptable means of pipe connection.

4.3.10 *Pipe size*

4.3.10.1 *System pipework*

For all new sprinkler systems, the sizing of the system pipework shall be by full hydraulic calculation in accordance with Part 10 of this standard.

In the case of extensions to existing systems installed according to superseded editions of this standard, the tabular method of pipe sizing may be used as permitted by Part 7 for ELH or Part 8 for OH classifications. Detailed requirements for extra light and ordinary hazard classifications are set out under their respective sections.

Existing sprinkler systems of EHH classification, installed according to superseded editions of this standard, may be extended to a maximum of 18 sprinkler heads based on the requirements of the edition of this standard to which the existing system was installed.

4.3.10.2 *Water supply pipework*

Pipe sizes for pump suctions from tanks are specified in 6.6.3.7. Other pipework is sized by the designer by hydraulic calculation according to the nature and parameters of the supply.

4.3.10.3 *Orifice plates*

Where it is considered necessary to fit orifice plates to assist in balancing a system hydraulically or to meet pump characteristic curves, the diameter of the orifice shall not be less than 50% of the diameter of the pipe into which the plate is to be fitted. Such orifice plates are allowed only in pipes of 50 mm diameter or larger.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

They shall be of brass or stainless steel with plain central holes without burrs and not less than the following thickness:

Pipe size (NB) (mm)	50	65	80	100	150	200
Min. plate thickness (mm)	3	3	3	6	6	9

They shall be situated not less than five pipe diameters upstream and downstream from any elbow or bend measured in the direction of flow. Orifice plates shall have a projecting identification tag which is readily visible on which is stamped the nominal pipe diameter and the *K* factor for the orifice. The relationship between the size of the orifice, the flow and the pressure loss may be calculated on the basis of the information given in Appendix O.

If the orifice plate is fabricated as a pipe spool, with the orifice plate retained by welding to a pipe groove, then:
(a) The groove shall be downstream in the direction of flow;
(b) The pipe spool shall be marked with an arrow showing the direction of flow; and The
(c) spool shall have a welded identification tag with *K* factor details stamped on it.

4.3.11 *Slope of pipes and provision for drainage*

4.3.11.1

The distribution and range pipes of all gas-filled and antifreeze-filled systems shall be sloped to suitably placed installation drain points. The slope on pipes of 50 mm and over shall be at least 1 in 500 and on smaller pipes at least 1 in 250.

4.3.11.2

The drain point shall be fitted with a normally closed and plugged or locked drain valve at least one-third the diameter of the supply pipe to the part of the installation being drained. Where practicable, these drain valves should be positioned to discharge into a disposal sump or drain so as not to cause flooding within the building.

4.3.11.3

For wet pipe systems, normally closed and plugged or locked drain valves shall be provided to allow all distribution pipes to be substantially (although not necessarily completely) drained.

4.3.12 *Seismic resilience of pipework – design*

4.3.12.1

The sprinkler system pipework shall be provided with a support system designed to resist seismic loads appropriate to the site and importance level (IL) (as defined by clause A3 of the New Zealand Building Code) of the building by either:
(a) A qualified seismic analysis such that the pipework system performance shall be at least equal to that of the building structure under the earthquake loadings of NZS 1170.5 (parts category P.4); or
(b) Complying with the requirements of 4.3.12.2 to 4.3.13.7 inclusive.

If any part of the sprinkler system is to be braced in common with any other trade, then the support system shall be in accordance with 4.3.12.1(a), taking into account the most onerous requirements of any element that is being supported.

NOTE –

(1) There are three flow charts in Appendix P of this standard which may assist in following this section.

(2) Applying the requirements of 4.3.12.2 to 4.3.13.7 inclusive may result in an increase in the number and size of braces compared to NZS 1170.5, but it eliminates the need for a more detailed study.

(3) The design of the support system to resist seismic loads on pipework is based on the following principles:

(a) Lateral supports are of sufficient stiffness to force piping to move with the immediate support structure;

(b) Lateral supports are spaced to limit pipe deflections under resonating dynamic load such that pipe joints and intermediate vertical supports are not over-stressed;

(c) Lateral supports are ductile and fixings are designed over-strength; and

(d) Stresses due to differential movements of building structures are minimised through the use of piping flexibility or clearances.

(e) The seismic loads are based on the weight of the water-filled pipe. This is different from hangers which have additional safety factors.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

4.3.12.2

All pipework shall be designed to resist repeated forces due to seismic acceleration acting horizontally on the mass of the pipework in any direction in addition to the gravity force and vertical forces induced through braces installed out of the horizontal plane.

The seismic acceleration expressed by the lateral force coefficient C shall be determined by:

$$C = 2.7C_H ZC_p R_c \text{ but not greater than } 3.6$$

Where:

C_H = 3.0 for components above ground or 1.0 at or below ground floor level.
Z = zone factor (shall be determined from Table 4.8 or interpolated from Figure 4.1(a) or (b)).
C_p = performance factor = 0.85
R_c = component risk factor is determined from Table 4.9.

NOTE –

(1) The equation for C is derived from NZS 4219.

(2) Z factors have been adopted from NZS 1170.5.

Table 4.8 – Zone values and shortest major fault distances *D* for New Zealand locations (north to south)

Reproduced from NZS 1170.5 and verification method B1/VM1 of the compliance documents to the NZBC

#	Location	Z	D (km)[a]
1	Kaitaia	0.13	–
2	Paihia/Russell	0.13	–
3	Kaikohe	0.13	–
4	Whangarei	0.13	–
5	Dargaville	0.13	–
6	Warkworth	0.13	–
7	Auckland	0.13	–
8	Manukau City	0.13	–
9	Waiuku	0.13	–
10	Pukekohe	0.13	–
11	Thames	0.16	–
12	Paeroa	0.18	–
13	Waihi	0.18	–
14	Huntly	0.15	–
15	Ngaruawahia	0.15	–
16	Morrinsville	0.18	–
17	Te Aroha	0.18	–
18	Tauranga	0.20	–
19	Mount Maunganui	0.20	–
20	Hamilton	0.16	–
21	Cambridge	0.18	–
22	Te Awamutu	0.17	–
23	Matamata	0.19	–
24	Te Puke	0.22	–
25	Putaruru	0.21	–
26	Tokoroa	0.21	–
27	Otorohanga	0.17	–
28	Te Kuiti	0.18	–
29	Mangakino	0.21	–
30	Rotorua	0.24	–
31	Kawerau	0.29	–
32	Whakatane	0.30	–
33	Opotiki	0.30	–

#	Location	Z	D (km)[a]
34	Ruatoria	0.33	–
35	Murupara	0.30	–
36	Taupo	0.28	–
37	Taumarunui	0.21	–
38	Turangi	0.27	–
39	Gisborne	0.36	–
40	Wairoa	0.37	–
41	Waitara	0.18	–
42	New Plymouth	0.18	–
43	Inglewood	0.18	–
44	Stratford	0.18	–
45	Opunake	0.18	–
46	Hawera	0.18	–
47	Patea	0.19	–
48	Raetihi	0.26	–
49	Ohakune	0.27	–
50	Waiouru	0.29	–
51	Napier	0.38	–
52	Hastings	0.39	–
53	Whanganui	0.25	–
54	Waipawa	0.41	–
55	Waipukurau	0.41	–
56	Taihape	0.33	–
57	Marton	0.30	–
58	Bulls	0.31	–
59	Feilding	0.37	–
60	Palmerston North	0.38	8 – 16
61	Dannevirke	0.42	10
62	Woodville	0.41	≤ 2
63	Pahiatua	0.42	8
64	Foxton/Foxton Beach	0.36	–
65	Levin	0.40	–
66	Otaki	0.40	–

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

#	Location	Z	D (km)[a]
67	Waikanae	0.40	15 – 20
68	Paraparaumu	0.40	14 – 20
69	Masterton	0.42	6 – 10
70	Porirua	0.40	8 – 12
71	Wellington CBD (north of Basin Reserve)	0.40	≤ 2
72	Wellington	0.40	0 – 8
73	Hutt Valley – south of Taita Gorge	0.40	0 – 4
74	Upper Hutt	0.42	≤ 2
75	Eastbourne – Point Howard	0.40	4 – 8
76	Wainuiomata	0.40	5 – 8
77	Takaka	0.23	–
78	Motueka	0.26	–
79	Nelson	0.27	–
80	Picton	0.30	16
81	Blenheim	0.33	0 – 5
82	St Arnaud	0.36	≤ 2
83	Westport	0.30	–
84	Reefton	0.37	–
85	Murchison	0.34	–
86	Springs Junction	0.45	3
87	Hanmer Springs	0.55	2 – 6
88	Seddon	0.40	6
89	Ward	0.40	4
90	Cheviot	0.40	–
91	Greymouth	0.37	–
92	Kaikoura	0.42	12
93	Harihari	0.46	4
94	Hokitika	0.45	–
95	Fox Glacier	0.44	≤ 2
96	Franz Josef	0.44	≤ 2
97	Otira	0.60	3
98	Arthurs Pass	0.60	12
99	Rangiora	0.33	–
100	Darfield	0.30	–
101	Akaroa	0.30	–
102	Christchurch	0.30	–
103	Geraldine	0.19	–
104	Ashburton	0.20	–
105	Fairlie	0.24	–
106	Temuka	0.17	–
107	Timaru	0.15	–
108	Mt Cook	0.38	–
109	Twizel	0.27	–
110	Waimate	0.14	–
111	Cromwell	0.24	–
112	Wanaka	0.30	–
113	Arrowtown	0.30	–
114	Alexandra	0.21	–
115	Queenstown	0.32	–
116	Milford Sound	0.54	–
117	Palmerston	0.13	–
118	Oamaru	0.13	–
119	Dunedin	0.13	–
120	Mosgiel	0.13	–
121	Riverton	0.20	–
122	Te Anau	0.36	–
123	Gore	0.18	–
124	Winton	0.20	–
125	Balclutha	0.13	–
126	Mataura	0.17	–
127	Bluff	0.15	–
128	Invercargill	0.17	–
129	Oban	0.14	–

[a] The near-fault factor $N(T,D)$ should be considered for locations with the distance D to the nearest major fault specified

NOTE – The New Zealand Building Code B1/VM1 may have more onerous requirements for the Canterbury Earthquake Region.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

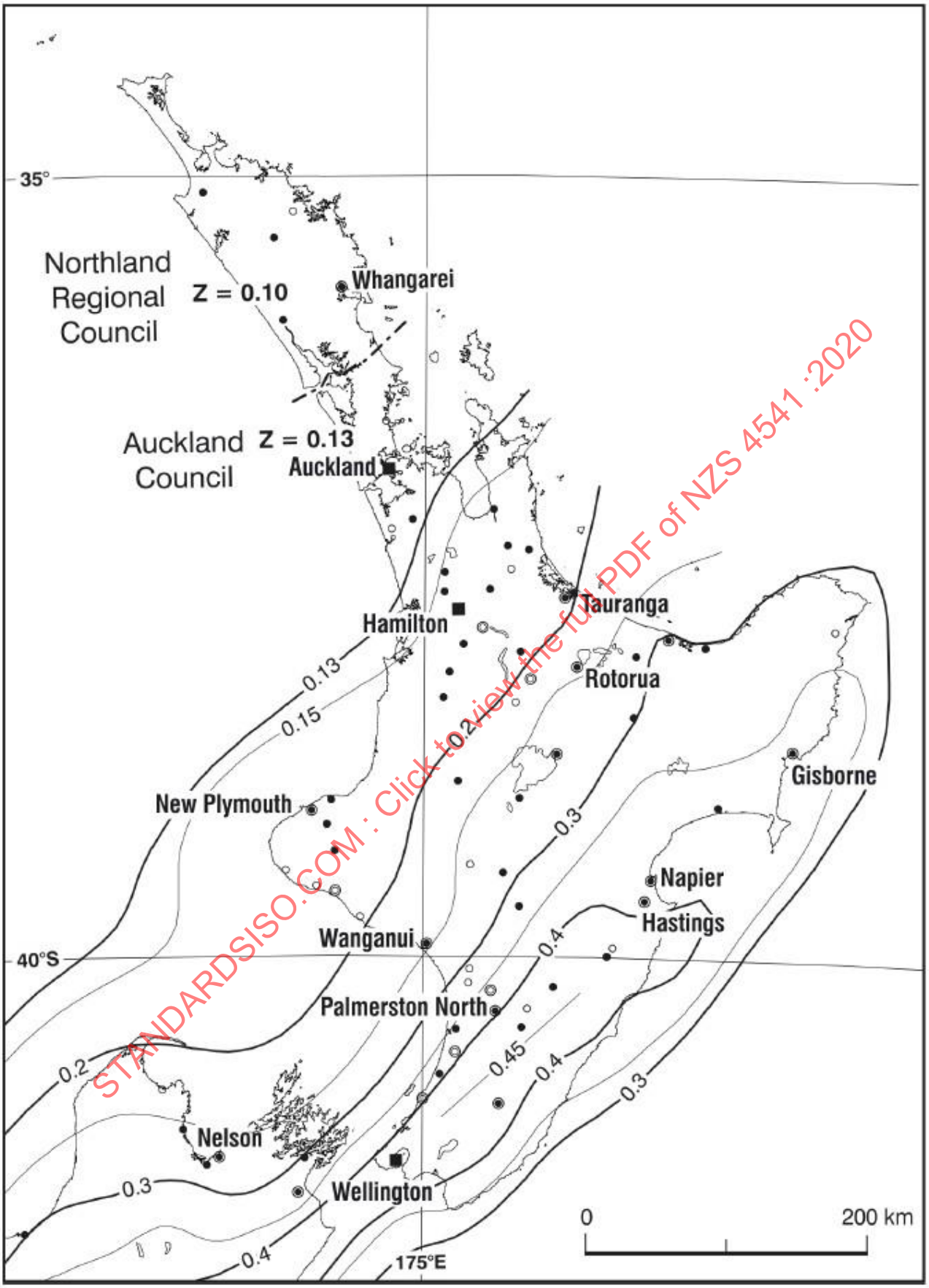


Figure 4.1(a) – Hazard factor, *Z*, for the North Island

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

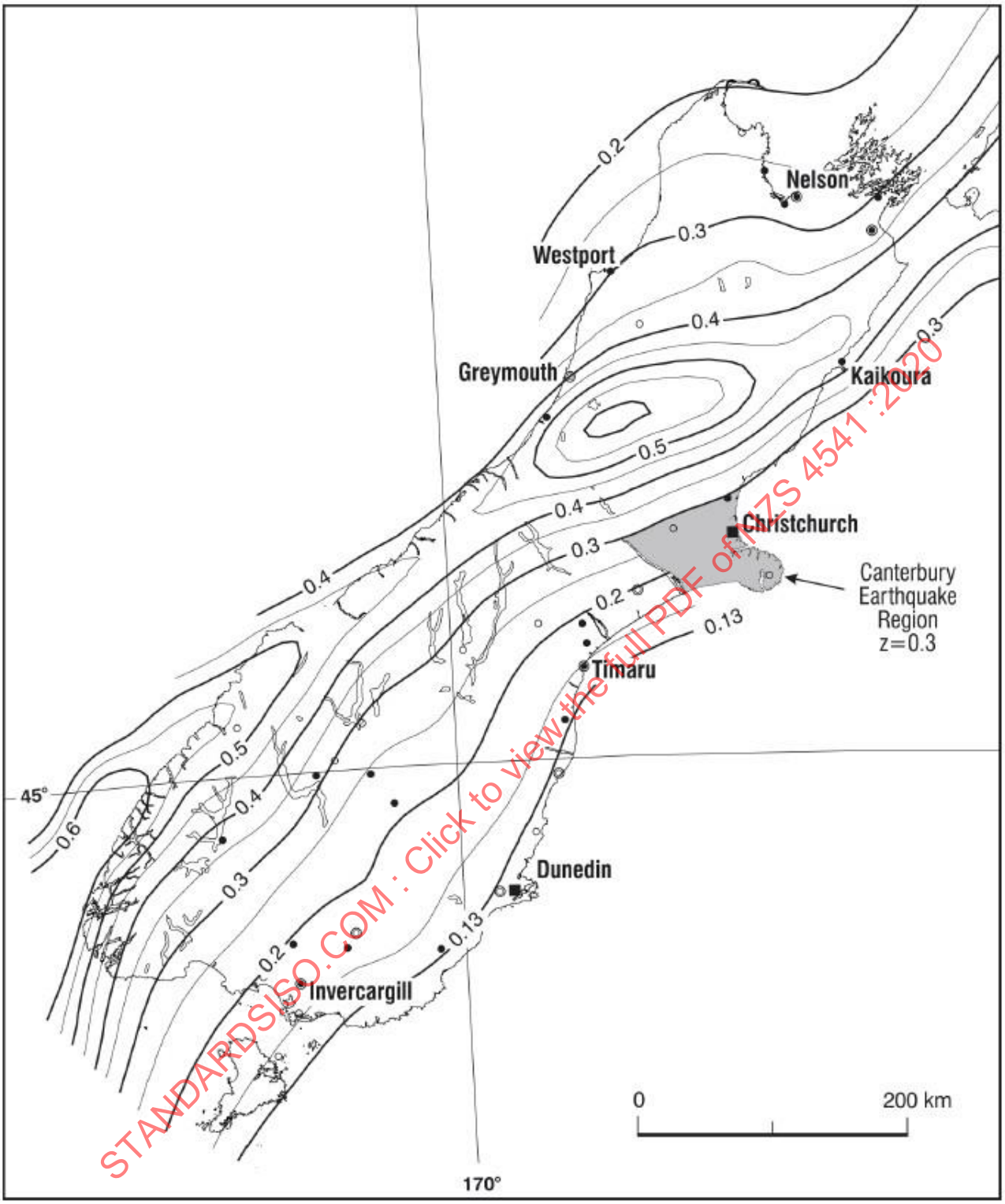


Figure 4.1(b) – Hazard factor, *Z*, for the South Island

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 4.9 – Component risk factor per building importance level

Building importance level *IL*	**1, 2, 3, and 4**	**4**
Parts category	**P.6**	**P.5**
Component risk factor R_c	0.5	1.0

NOTE –

(1) This table is derived from NZS 4219 Table 5.

(2) Sprinkler systems are classified as parts category P.6 in Table 8.1 of NZS 1170.5, except if they are required for NZBC compliance for ongoing occupancy of IL4 buildings, in which case they are parts category P.5.

4.3.12.3

The seismic coefficient *C* shall be included in the design parameters provided to the SSC.

4.3.12.4

Bracing shall be provided to restrain pipework under seismic load in two orthogonal horizontal directions (see Figure 4.2).

Sway bracing shall be permitted to be omitted when pipes are individually supported within 150 mm of the structure, measured from the top of the pipe to the point of structural attachment, **and** either of the following conditions are met:

(a) The pipe diameter is 50 mm or less; or

(b) Seismic coefficient *C* as calculated in 4.3.12.2 is 0.5 or less, and the pipe diameter is 150 mm or less.

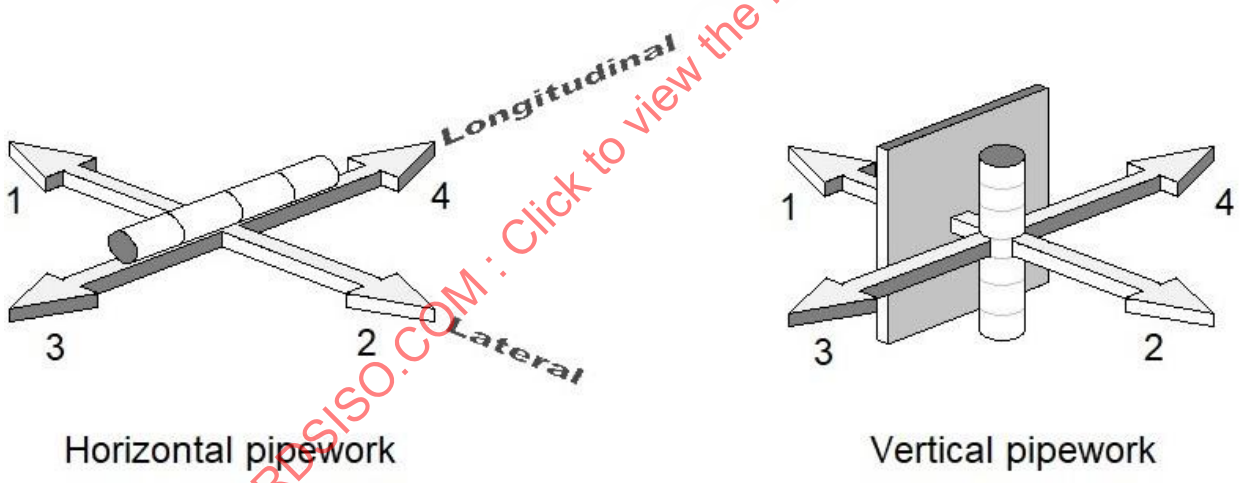


Figure 4.2 – Bracing in two orthogonal horizontal directions

4.3.12.5

Bracing shall be positioned and aligned in conjunction with flexible couplings such that no bracing is subject to seismic load from pipework outside its immediate vicinity and in accordance with 4.3.13.2. Typical locations of pipework bracing within a building are shown in Figure 4.4.

The tributary lengths of pipe L_p for each brace shall be determined in accordance with 4.3.13.2.5. Typical tributary lengths per brace are as shown in Figures 4.5(a) and 4.5(b). Alternatively, each pipe can be individually and seismically braced to suit.

These shall be used with the data in Table 4.10 to calculate the mass of pipework to be braced.

The earthquake load demand *F* for each brace shall be determined in accordance with 4.3.12.6.

NOTE – Where the same brace (same components, configuration, and structural attachment) is used in many instances in an installation, then only the worst case (highest earthquake load) for that brace needs to be demonstrated to be adequate, as it can be concluded that all other instances will also be adequate.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

Braces shall be selected that are adequately sized and configured, in accordance with 4.3.13.3.

Fixings for structural attachments for braces shall be in accordance with 4.3.13.3.6.

The net vertical force that results from placement of braces on horizontal pipe shall be resisted in accordance with 4.3.13.3.5.5.

Table 4.10 – Mass of water-filled pipe

Pipe size (nominal diameter) (mm)	Mass including water (W_p) (kg/m)	Material
25	3.05	BS EN 10255 medium screwed and socketed tube
32	4.19	
40	5.03	
50	7.37	
65	10.30	
80	13.70	
100	21.10	
150	38.80	
200	62.60	BS 3600 tube
NOTE – For other pipes with different wall thicknesses, the mass of water-filled pipe can be determined from other reputable sources, such as FM Global Data Sheet 2-8.		

4.3.12.6

The earthquake load demand F for braces shall be determined by:

$F = C\,W$

Where:

F = Earthquake load demand (kN)
C = lateral force coefficient from 4.3.12.2.
W = Weight of water-filled pipe in the zone of influence (kN) = $0.00981\,W_p\,L_p$

Where:

W_p= Mass per metre of the water-filled pipe (from Table 4.10) (kg/m)
L_p= Tributary length of pipe for that brace, determined from 4.3.13.2.5 (m).

NOTE – The earthquake load demand F may differ in each orthogonal direction due to the different tributary length of pipe being braced in each orthogonal direction (such as where there is a four-way brace) the load in the lateral direction is likely to differ from the load in the longitudinal direction.

4.3.13 *Seismic resistance of pipework – installation*

4.3.13.1 *General*

The requirements of 4.3.13 are applicable to steel pipework only and apply to all sprinkler pipework above ground, including between any tank suction pipe and pump. Specific design solutions will be required for other materials.

4.3.13.2 *Location of pipework braces*

4.3.13.2.1

The maximum allowable spacing for lateral braces shall be determined from Table 4.11 or Figure 4.3. These spacings may be interpolated.

NOTE – These are a maximum spacing only. Lateral braces may be required to be located at closer spacing to ensure they are not overloaded by the earthquake design load, or to coincide with building primary structure.

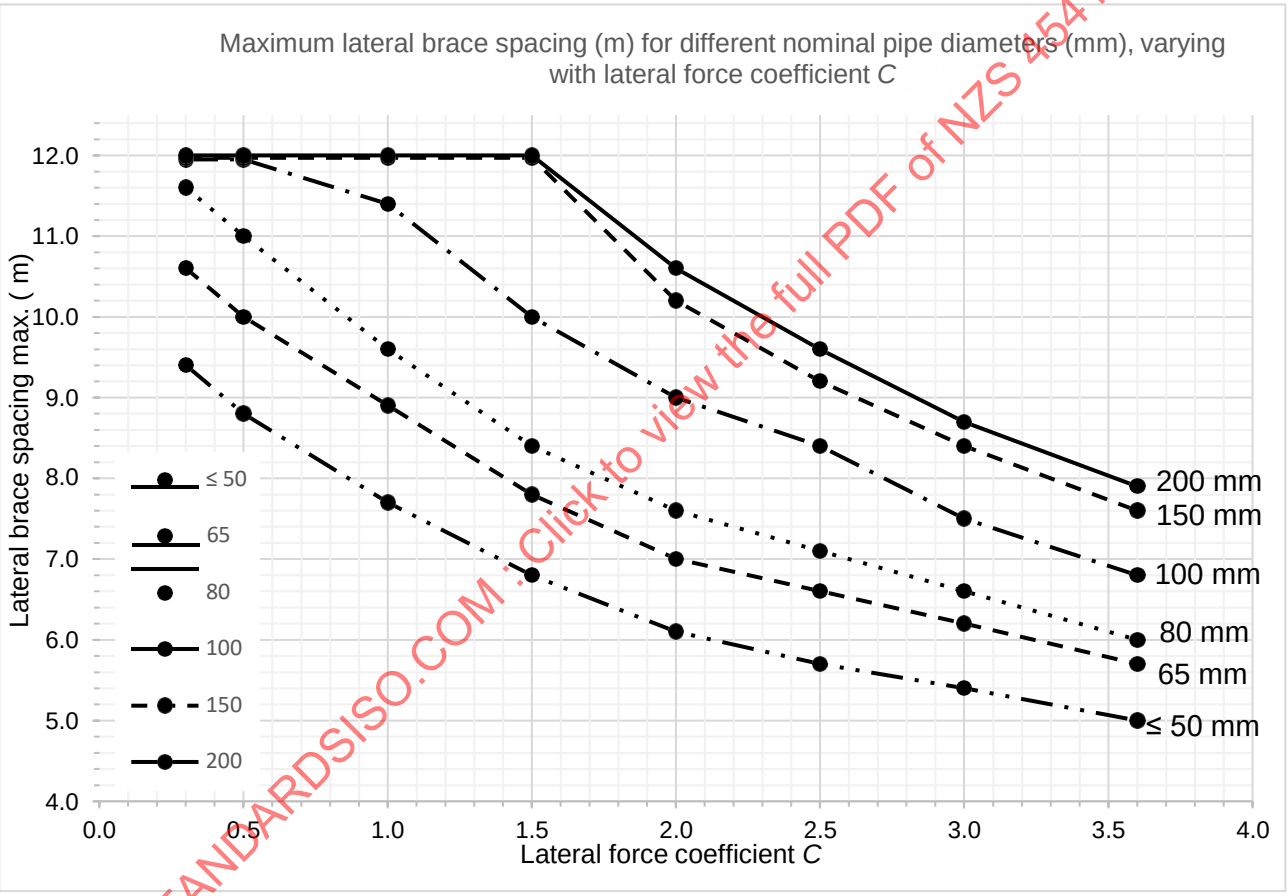
STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

Table 4.11 – Maximum allowable lateral brace spacing (m)

Maximum allowable lateral brace spacing (m)								
Nominal pipe size (mm)	**Lateral force coefficient *C***							
	0.3	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.6**
≤ 50	9.4	8.8	7.7	6.8	6.1	5.7	5.4	5.0
65	10.6	10.0	8.9	7.8	7.0	6.6	6.2	5.7
80	11.6	11.0	9.6	8.4	7.6	7.1	6.6	6.0
100	12.0	12.0	11.4	10.0	9.0	8.4	7.5	6.8
150	12.0	12.0	12.0	12.0	10.2	9.2	8.4	7.6
200	12.0	12.0	12.0	12.0	10.6	9.6	8.7	7.9



▪ **Figure 4.3 – Maximum lateral brace spacing**

4.3.13.2.2

Lateral bracing for horizontal pipe shall be provided:

(a) At the spacing as determined in 4.3.13.2.1 as a maximum. Braces are permitted closer together as required;
(b) Within 1.8 m of the end of each pipe, or the last hanger for a range pipe;
(c) Within 600 mm of a flexible coupling (on at least one side);
(d) Within 600 mm of both sides of a seismic separation assembly (SSA) of seismic loop crossing a structural separation;
(e) Within 600 mm of a change in direction, if the pipe run is 1.8 m or more and the pipe remains in the horizontal plane; and
(f) For horizontal manifolds greater than 1.8 m, or where a flexible coupling exists on the riser stub below the manifold.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020
Copyright

Calculations are required to prove that the proposed lateral bracing has sufficient strength capacity to meet this spacing.

NOTE – The lateral brace of one pipe can also provide longitudinal bracing for a pipe that is attached to it at a right angle, or teed off it, provided the lateral brace has sufficient capacity to withstand the imposed longitudinal force.

4.3.13.2.3

Longitudinal bracing for horizontal pipe shall be provided:
(a) With a maximum spacing of 24 m; and
(b) Within 12 m of the end of each pipe (be it a distribution main or range pipe).

Calculations are required to prove that the proposed longitudinal bracing has sufficient strength capacity to meet this spacing.

NOTE – This is a maximum spacing only. Longitudinal braces may be required at closer spacing to ensure they are not overloaded by the earthquake design load, or to coincide with main building structural elements.

4.3.13.2.4

Four-way bracing for vertical risers and droppers shall be provided:
(a) Where the length of the vertical pipe is ≥ 1.8 m;
(b) Within 0.6 m of the top and bottom; and
(c) At a maximum spacing of 6 m.

NOTE –

(1) Where a pipe comes out of the ground, it is considered braced by the ground.

(2) Bracing on the horizontal pipe within 0.6 m of the top of the riser can act as bracing for the vertical pipe. Conversely, riser bracing within 0.6 m of the top can act as bracing for the horizontal pipe.

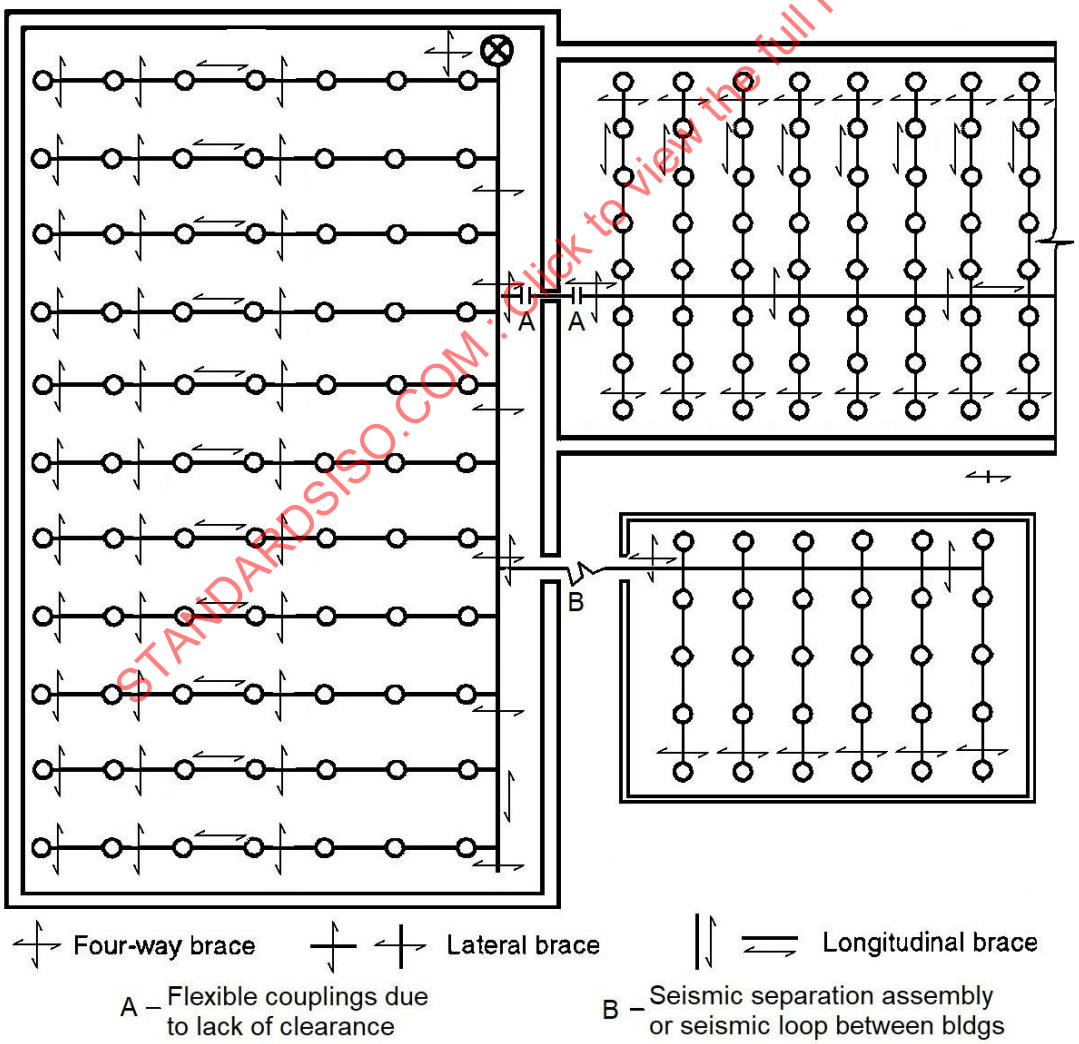


Figure 4.4 – Location of pipework bracing

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

4.3.13.2.5

The length of pipe L_p for each brace shall be determined.

This defines the zone of influence for that brace.

Where a brace is used to brace more than one pipe (as allowed in 4.3.13.2.2), the zone of influence will include those tributary pipes being braced:

(a) Four-way bracing at risers, vertical distribution pipes, and drops:
   (i) Where the four-way brace restrains only the vertical pipe (for example, an intermediate riser brace where there is no attached distribution main) the zone of influence includes the length of the vertical pipe above and below the brace that is tributary to that sway brace (that is half the length of pipe to the next four-way sway brace above plus half the length of pipe to the next four-way sway brace below). Use the resulting length of pipe as L_p
   (ii) Where the four-way sway brace for the vertical pipe also serves as a lateral and longitudinal brace for an attached horizontal pipe, the four-way sway brace zone of influence is determined as follows.
      (A) In the lateral direction of the horizontal pipe, add the tributary length of vertical pipe above and below the brace, plus the tributary lengths of distribution pipe and range piping, as described below in item (b) for lateral two-way bracing, located between the four-way brace and the first lateral brace on the horizontal pipe
      (B) In the longitudinal direction of the horizontal pipe, add the tributary length of vertical pipe above and below the brace, plus the tributary lengths of distribution pipe and range piping, as described below in item (c) for longitudinal two-way sway bracing, located between the four- way brace and the first longitudinal brace on the horizontal pipe
      (C) The length L_p for manifolded bracing design includes the total load for the risers being braced;

(b) Lateral two-way bracing:
   (i) For distribution mains, the zone of influence includes the length of the distribution main to the left and right of the brace that is tributary to that brace (that is half the length of pipe to the next braceto the left plus half the length of pipe to the next brace to the right)
   (ii) For distribution mains with range pipes attached, the zone of influence includes the tributary length of distribution main being braced plus the length of all range pipes attached to that section of distribution main that are not distributed to range pipe longitudinal bracing
   (iii) For range pipes that require bracing, the zone of influence typically includes the length of the range pipe to the left and right of the brace that is tributary to that brace. The tributary length of pipe between the first lateral brace location and the distribution pipe connection may either be based on an equal distribution to the distribution pipe longitudinal bracing and the first lateral bracing location (see item (c) ii for longitudinal two-way bracing below) or may be totally distributed to the first lateralbracing location;

(c) Longitudinal two-way bracing:
   (i) For distribution pipes the zone of influence includes the length of the distribution pipe to the left and right of the brace that is tributary to that brace (that is half the length of pipe to the next brace to the left plus half the length of pipe to the next brace to the right)
   (ii) For distribution pipes with range pipes attached, the zone of influence includes the tributary length of distribution main being braced; do not include loads from ranges, except when a portion of range pipe lateral bracing is being included as described above in item (b) iii for lateral two-way bracing
   (iii) For ranges that require bracing, the zone of influence typically includes the length of the range pipe to the left and right of the brace that is tributary to that brace. The tributary length for the piping between the distribution pipe and the first bracing location should be based on an equal distribution between that bracing location and the distribution main lateral brace as described above in item (b) ii for lateral two-way bracing.

NOTE – A common way to determine the zone of influence for each brace is to draw it on the pipework layout drawing. Figures 4.5(a) and 4.5(b) show the zones of influence for the braces acting in each of the orthogonal axis, east-west and north-south, respectively.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

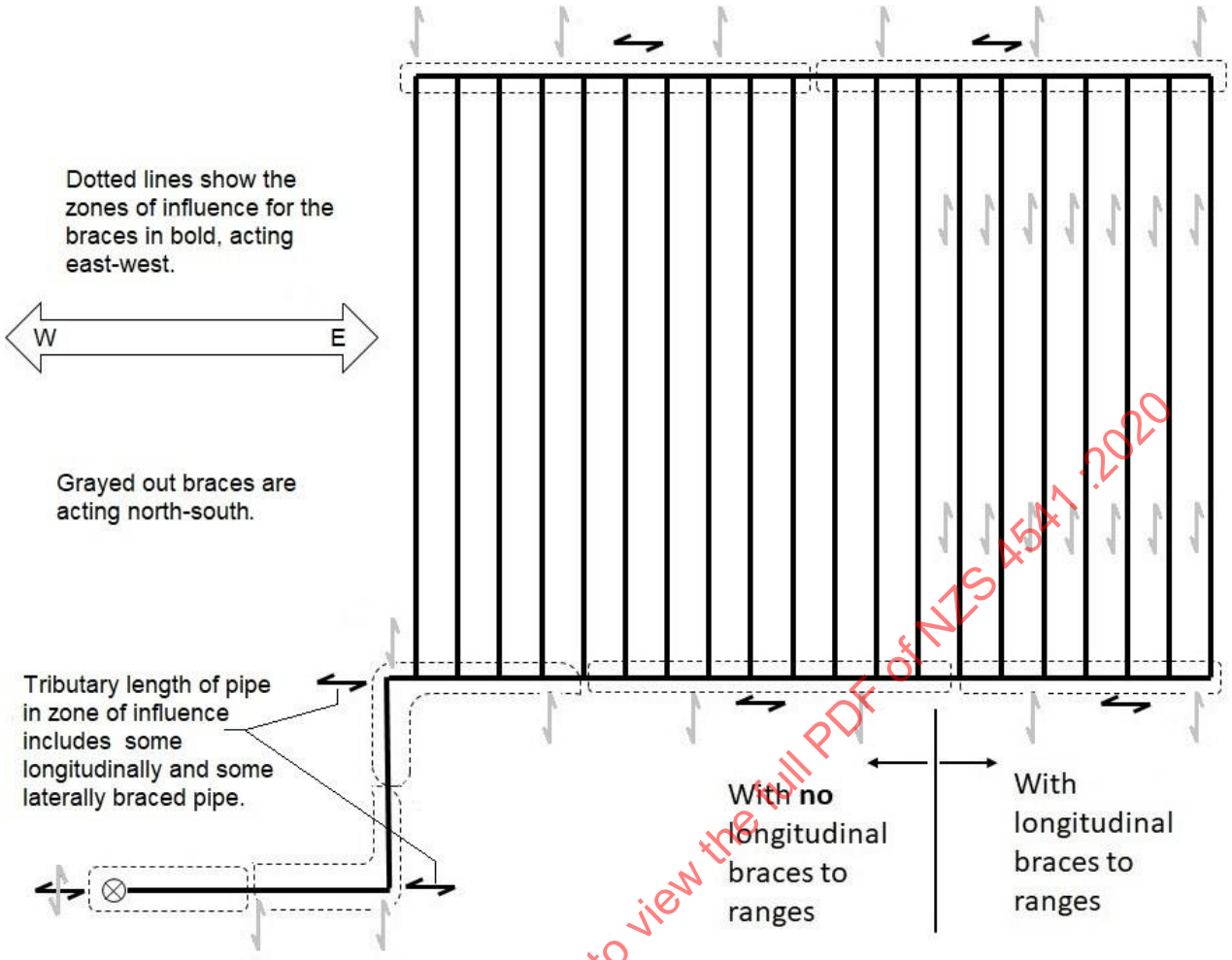


Figure 4.5(a) – Examples of tributary lengths of pipe in the zone of influence for braces (east-west)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

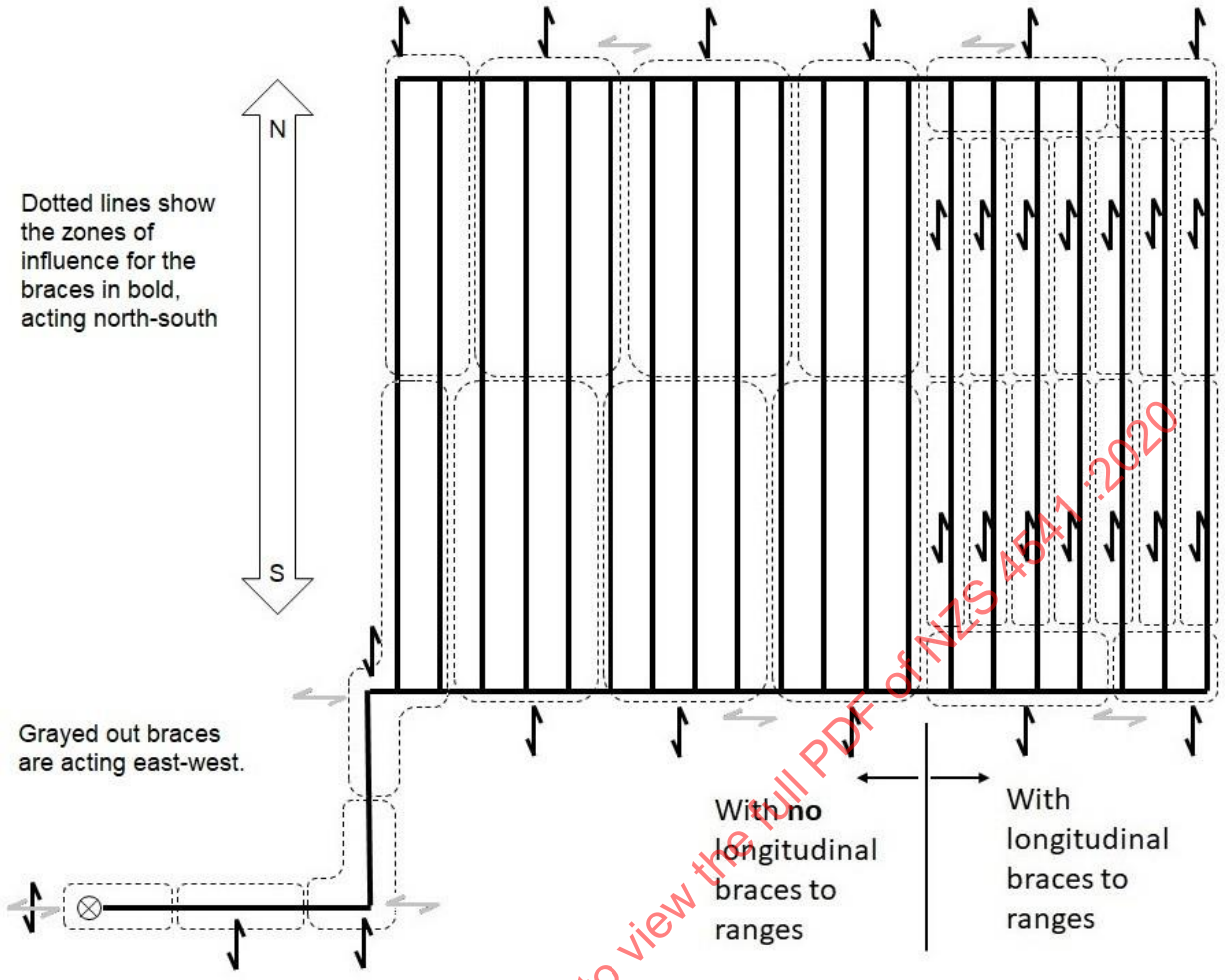


Figure 4.5(b) – Examples of tributary lengths of pipe in the zone of influence for braces (north-south)

4.3.13.3 *Configuration and design of braces*

4.3.13.3.1

Braces shall be designed to withstand the horizontal earthquake load demand *F* as calculated in 4.3.12.6.

The horizontal design load capacity F_{uls} for each brace shall be greater than the horizontal earthquake load demand *F.*

NOTE – This requirement includes that each component that makes up the brace has adequate load capacity.

4.3.13.3.2

The building element to which the brace is fixed shall be capable of withstanding the force which the brace imposes on it.

Unless approved by the structural engineer, braces shall be fitted to primary structural elements; that is columns, loadbearing walls, primary beams (beams that are directly supported by columns or loadbearing walls), or concrete floor slabs.

NOTE – Sprinkler pipework layout may require modification at the design stage for braces to coincide with suitable structural elements.

4.3.13.3.3

Pipe-attached components and structure-attached components shall be listed for seismic use, with a load capacity provided for the intended configurations. These can be either individually listed, or as an assembly complete with brace element.

The listing shall provide the ULS design load capacity as determined through empirical testing in accordance with *American National Standard for Seismic Sway Braces for Pipe, Tubing and Conduit* ANSI/FM Approvals 1950-2016 or equivalent.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

NOTE –

(1) This listing requirement is not intended to require the components or assemblies to have the ANSI or FM Approval mark, but rather be tested in accordance with this methodology, including using cyclical loading.

(2) If using components or assemblies known to be listed using Allowable Stress Design (ASD), such as FM Approved products, the capacities can be increased by a factor of 1.5 to be used with the Ultimate Limit State Design methodology in this standard.

Where the brace element is pipe, angle, flat, or rod, this element shall not require listing. It shall be demonstrated that the element is able to resist the earthquake design force F for its given length and configuration.

NOTE – A brace element may form part of a listed assembly.

4.3.13.3.4

A U-bolt used as a lateral brace for horizontal pipe or as a four-way brace for vertical pipe shall fasten the pipe directly to, and hold the pipe tightly against, a structural supporting member.

NOTE – Consideration of the net vertical force is not required when using this configuration.

The maximum horizontal seismic design load capacity F_{uls} of the U-bolt shall be determined based on the assumption that F is resisted in shear by one leg of the U-bolt.

The gross area (A_g) of the rod leg (even if the rod is threaded) and the tensile strength of the steel (F_u) shall be used, following the formula:

$F_{uls} = 0.255\, F_u\, A_g$

Where for typical steel $F_u = 400$ MPa

F_{uls} that can be resisted by a U-bolt can be taken from Table 4.12.

Table 4.12 – Horizontal design loads for U-bolts

U-bolt thickness (mm)	Maximum horizontal design load F_{uls} (kN)
8	5.13
10	8.01
12	11.54
16	20.51

U-bolts that clamp to the edge of beam or other structural member that are not through-bolted into the structure shall be listed as a brace assembly and used within its load capacity. U-bolts shall not be provided in combination with beam clamps to provide seismic support unless specifically tested to ANSI/FM Approvals 1950-2016 or equivalent.

U-Bolts can be used in longitudinal braces in the following cases;

(a) Where they are part of a listed brace assembly with suitable load rating;

(b) When the pipe is clamped hard to a building element and calculations are provide to ensure that; the clamping force, friction coefficient, and torque settings of the U-bolt is specified, such that the assemblies' capacity exceeds the calculated longitudinal seismic force with a minimum safety factorof 2.

4.3.13.3.5

For bracing that consists of individual diagonal element(s) or diagonal plus vertical elements, these elements shall be configured and sized in accordance with 4.3.13.3.

Typical bracing configurations are shown in Figures 4.6 to 4.8, showing the elements that make up the bracing.

NOTE – Attention is drawn to 4.3.13.3.2 to ensure the brace is attached to a suitable building structural element.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

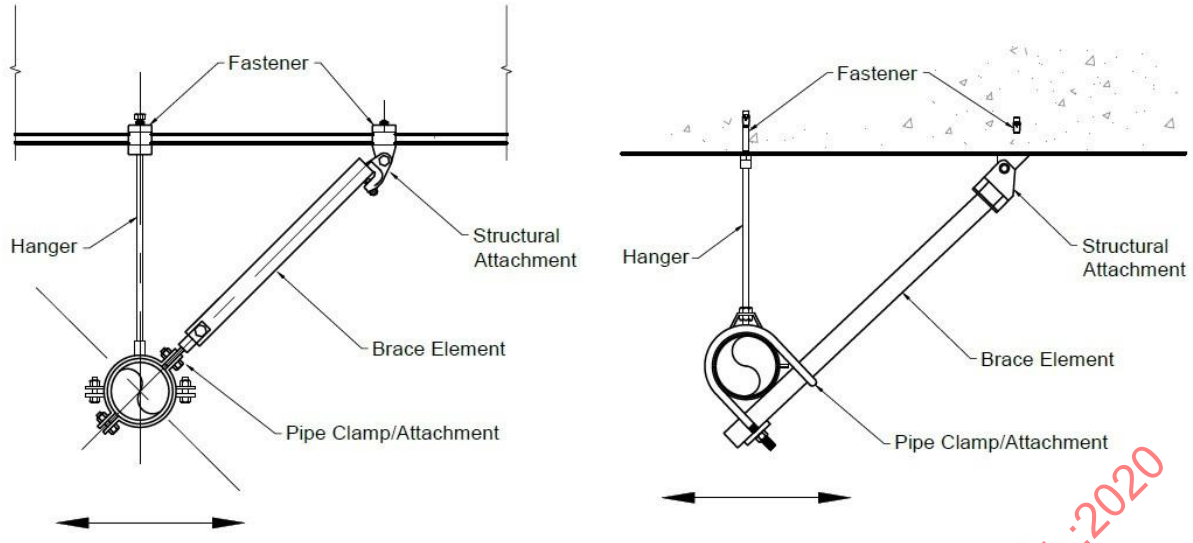


Figure 4.6 – Elements of lateral braces for horizontal pipe

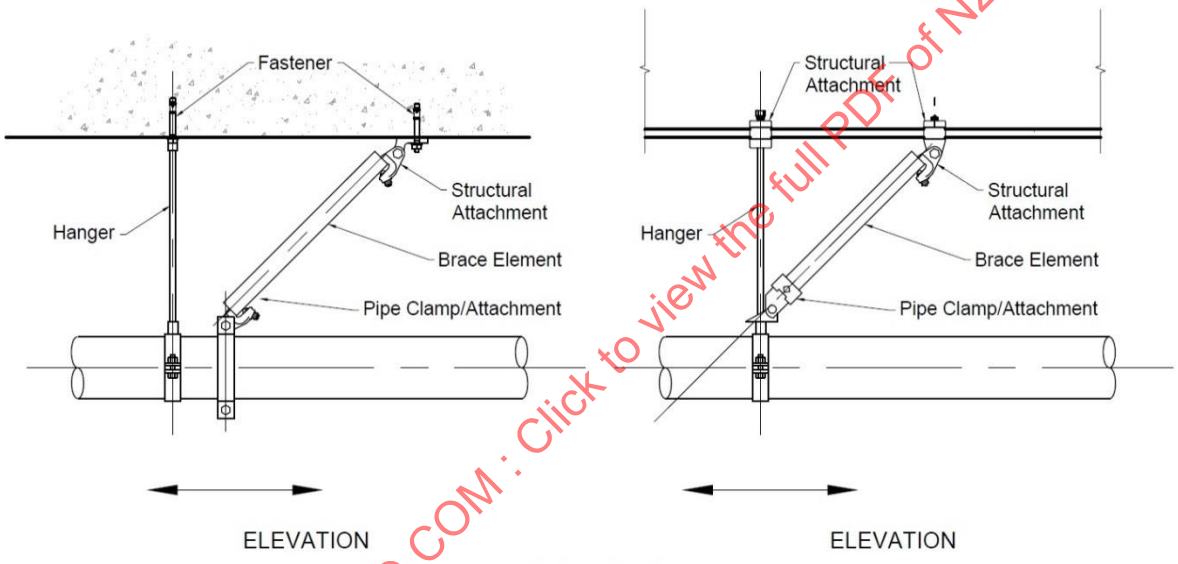


Figure 4.7 – Elements of longitudinal braces for horizontal pipe

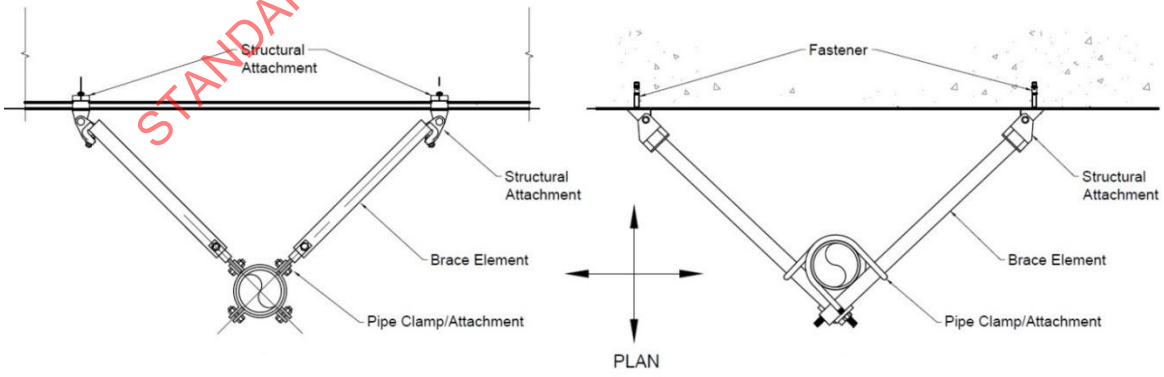


Figure 4.8 – Elements of braces for vertical pipe

4.3.13.3.5.1.

Braces for horizontal pipe shall be at an angle to the vertical of not less than 30°. See Figure 4.9.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

4.3.13.3.5.2.

Where two opposing braces are used in tension and compression for horizontal pipe, the earthquake load *F* is distributed between the braces.

The angle from vertical of each brace shall be as close as possible to equal, and not more than 15° different.

See Figure 4.10 for this configuration.

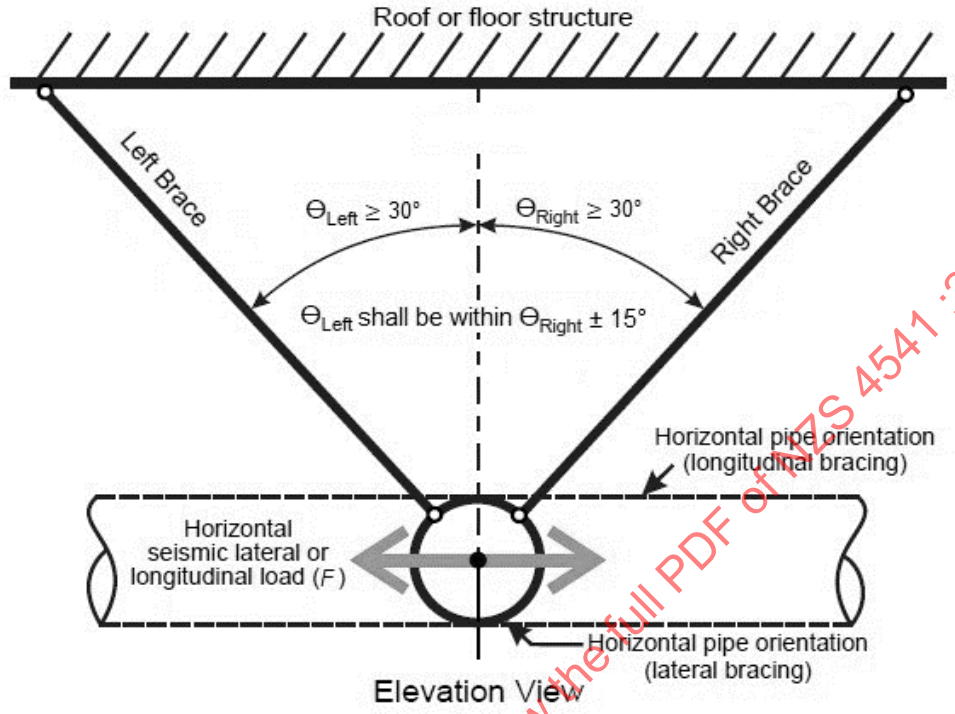


Figure 4.9 – Option to brace horizontal pipe using two opposing diagonal elements

4.3.13.3.5.3.

Braces for vertical pipe shall be oriented at an angle of not less than 30° to each principal axis.

The angle from the principal axis of each brace shall be as close as possible to equal, and not more than 15° different.

See Figure 4.10.

NOTE –

(1) Ideally these braces will be 90° to each other.

(2) An alternative is to use a U-bolt in accordance with 4.3.13.3.4, provided the U-bolt is attached to a structural member or additional braced members that have been calculated to be able to withstand the seismic forces.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

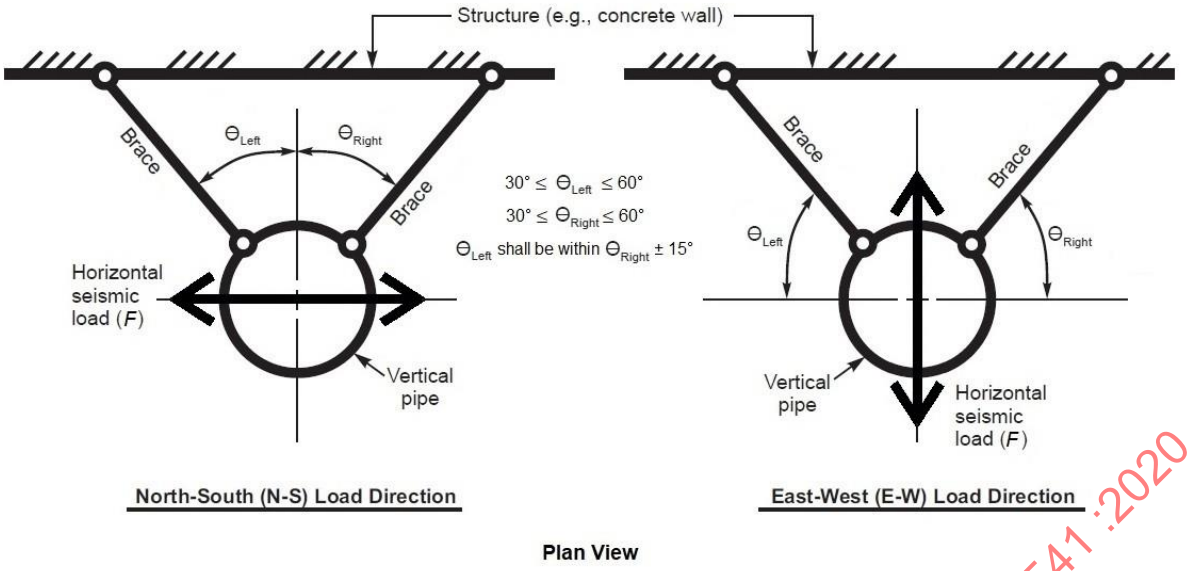


Figure 4.10 – Four-way bracing on vertical pipe using two diagonal elements

4.3.13.3.5.4.

The maximum horizontal seismic design load capacity F_{uls} of the pipe-attached component, the brace element, and the structure-attached component shall be determined.

The capacities of the pipe-attached component and the structure-attached component shall be obtained from the listing for that component.

The capacity of the brace element shall be obtained from engineering calculations based on the least radius of gyration, individual listings, or from this standard.

4.3.13.3.5.5.

It shall be determined if there is a net vertical load to resist that occurs as a result of brace placement on horizontal pipe. This can occur where a single brace is used in tension and compression, or two braces used in tension only (such as listed cable bracing). See Figure 4.11

The vertical element shall be provided to resist any net vertical force component.

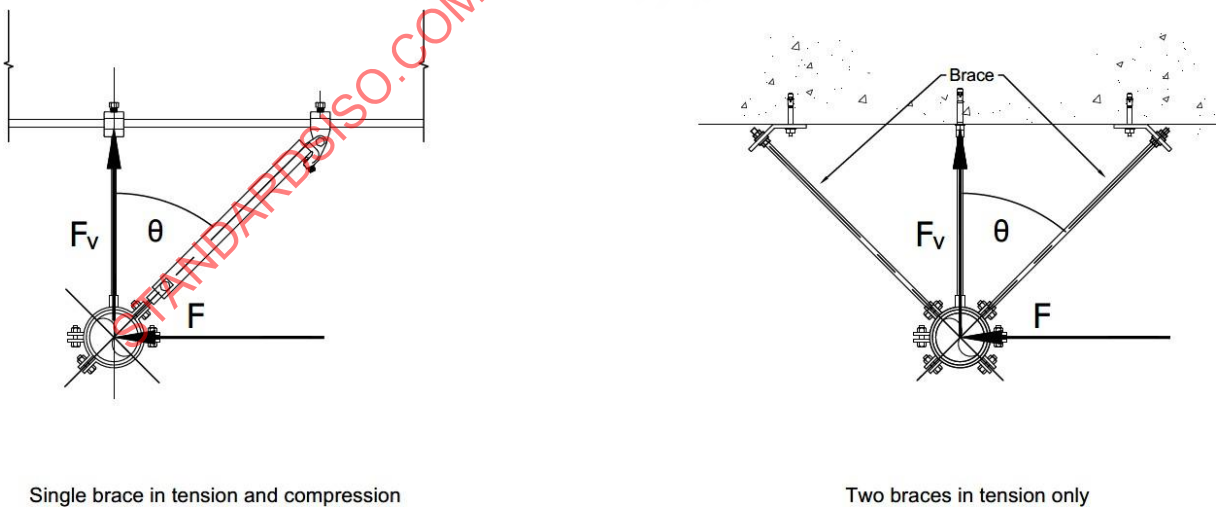


Figure 4.11 – Diagram of vertical force component F_v

The net vertical force F_v is calculated using:

$$F_v = \frac{F}{\tan\theta\theta} - WW$$

Where :

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

F = the earthquake design load as calculated in 4.3.12.6 (kN)
Θ = angle of brace from vertical
W = weight of water-filled pipe in the zone influence, as calculated in 4.3.12.6 (kN).

NOTE –:

(1) The horizontal earthquake load F may differ in the lateral and longitudinal directions.

(2) Resistance to buckling is not required to be determined from the vertical acceleration of the earthquake.

(3) When the calculated valve of F_v is a positive number this means that the vertical element is in compression hence it is possible that buckling mode can occur. Compliance with the following sections will avoid this occurrence.

This vertical element is permitted to be a hanger if it is within 150 mm of the brace and is able to resist F_v.

Where threaded rod is used as the vertical support, the net vertical force F_v does not need to be calculated if the maximum length of rod is taken from Tables 4.13 to 4.15.

Lengths of threaded rod greater than these shall have a stiffener, such as a sleeve, installed in increase the slenderness ratio.

Table 4.13 – Maximum permitted rod length without sleeving for Θ = 30° to vertical

Maximum permitted rod length without sleeving (mm)							
For Θ = 30° to vertical		Lateral force coefficient value C					
		C = 1.0	C = 1.5	C = 2.0	C = 2.5	C = 3.0	C = 3.6
Nom pipe size (mm)	Nominal rod size (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)
50	10	350	250	225	200	175	150
65	10	275	200	175	150	125	125
80	10	225	150	125	125	100	100
100	10	175	125	100	75	75	75
150	12	175	125	100	75	75	75
200	16	275	175	150	125	125	125

Table 4.14 – Maximum permitted rod length without sleeving for Θ = 45° to vertical

Maximum permitted rod length without sleeving (mm)							
For Θ = 45° to vertical		Lateral force coefficient value C					
		C = 1.0	C = 1.5	C = 2.0	C = 2.5	C = 3.0	C = 3.6
Nom pipe size (mm)	Nominal rod size (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)
50	10	405	405	350	275	250	225
65	10	405	350	275	225	200	200
80	10	405	300	225	175	175	150
100	10	405	225	150	125	125	100
150	12	490	225	150	125	125	100
200	16	675	325	250	200	175	175

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Table 4.15 – Maximum permitted rod length without sleeving for Θ = 60° to vertical

Maximum permitted rod length without sleeving (mm)							
For Θ = 60° to vertical		Lateral force coefficient value *C*					
		C = 1.0	*C* = 1.5	*C* = 2.0	*C* = 2.5	*C* = 3.0	*C* = 3.6
Nom pipe size (mm)	Nominal rod size (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)	Maximum rod length (mm)
50	10	N/A	N/A	405	405	405	350
65	10	N/A	N/A	405	405	325	275
80	10	N/A	N/A	405	350	275	225
100	10	N/A	N/A	405	250	200	175
150	12	N/A	N/A	425	250	200	175
200	16	N/A	N/A	625	375	300	275

NOTE – In the case where the threaded rod needs to be sleeved, this can be achieved with 25 mm NB pipe or other suitable structural member with a cross-sectional second moment of area sufficient to resist buckling. All connection details for 'sleeving' the threaded rod need to be sufficiently rigid and fixed tight.

4.3.13.3.5.6.

Braces that resist tension and compression shall have a slenderness ratio *l*/*r* that does not exceed 200, where:

l = length of brace; and
r = least radius of gyration of brace element.

The maximum horizontal loads that can be resisted by compression braces at various brace angles are shown in Table 4.16 for *l*/*r* = 100 and Table 4.17 for *l*/*r* = 200.

The maximum horizontal loads that can be resisted by various lengths of the three most common brace elements are provided in Table 4.18 for 25 NB medium wall pipe, Table 4.19 for 10 mm threaded rod, and Table 4.20 for 12 mm threaded rod.

NOTE –

(1) These tables are based on AISC 360-16 methodology.

(2) Different cross-section elements have different capacities to resist buckling in compression. This is determined by the slenderness ratio. Beyond 200, the brace element's ability to resist compression is not sufficient.

(3) In practice, brace elements will vary in length and can be any length up to the maximum for that shape brace that results in a slenderness ratio of 200.

(4) Table 4.17 shows the capacity (maximum horizontal loads) for various types of brace element at different brace angles, at the longest possible use of that brace element.

(5) Table 4.16 is included to provide the capacity for the same braces, when the brace elements are half the maximum length. It is important to note that the brace capacity is not proportional to its length.

(6) Tables 4.18, 4.19, and 4.20 are included to provide even further refined brace capacities for differing lengths of the most common brace elements in use.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 4.16 – Maximum capacity of horizontal loads of typical pipework brace elements with *l/r* = 100 (ULS design)

Shape and size (mm)	Maximum horizontal load				
	Brace length for *l/r* = 100 (m)	30° to 44° from vertical (kN)	45° to 59° from vertical (kN)	60° to 89° from vertical (kN)	Horizontal (kN)
Mild steel threaded rod					
M10	0.20	3.42	4.85	5.93	6.85
M12	0.25	4.81	6.80	8.33	9.61
M16	0.34	9.25	13.08	16.02	18.50
M20	0.42	14.55	20.58	25.20	29.10
Mild steel rod (ends threaded only)					
10 dia.	0.25	5.05	7.14	8.74	10.09
12 dia.	0.30	7.27	10.28	12.59	14.53
16 dia.	0.40	12.92	18.27	22.38	25.84
20 dia.	0.50	20.19	28.55	34.96	40.37
BS EN 10255 medium tube					
20 NB	0.87	12.98	18.35	22.48	25.96
25 NB	1.07	19.57	27.68	33.90	39.15
32 NB	1.38	25.13	33.53	43.52	50.25
40 NB	1.59	28.90	40.87	50.06	57.80
50 NB	1.99	40.86	57.78	70.77	81.72
65 NB	2.58	53.13	75.14	92.02	106.26
Mild steel flat					
40 x 6	0.17	15.71	22.21	27.20	31.41
50 x 8	0.23	25.81	36.50	44.69	51.61
50 x 10	0.29	31.98	45.23	55.39	63.96
Mild steel angle					
25 x 25 x 3	0.49	9.04	12.79	15.66	18.08
30 x 30 x 5	0.58	17.79	25.16	30.81	35.58
40 x 40 x 5	0.78	24.16	34.16	41.84	48.31
50 x 50 x 5	0.98	30.61	43.29	53.02	61.22
60 x 60 x 6	1.18	43.91	62.10	76.05	87.82
80 x 80 x 6	1.58	59.52	84.17	103.09	119.03

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 4.17 – Maximum capacity of horizontal loads of typical pipework brace elements with *l*/*r* = 200 (ULS design)

Shape and size (mm)	Maximum horizontal load				
	Brace length for *l*/*r* = 200 (m)	30° to 44° from vertical (kN)	45° to 59° from vertical (kN)	60° to 89° from vertical (kN)	Horizontal (kN)
Mild steel threaded rod					
M10	0.41	1.01	1.43	1.75	2.02
M12	0.49	1.49	2.11	2.59	2.99
M16	0.68	2.80	3.95	4.84	5.59
M20	0.85	4.34	6.14	7.51	8.68
Mild steel rod (ends threaded only)					
10 dia.	0.50	1.53	2.16	2.65	3.06
12 dia.	0.60	2.20	3.12	3.82	4.41
16 dia.	0.80	3.92	5.54	6.78	7.83
20 dia.	1.00	6.12	8.65	10.60	12.24
BS EN 10255 medium tube					
20 NB	1.75	3.91	5.53	6.77	7.82
25 NB	2.15	5.90	8.34	10.22	11.80
32 NB	2.76	7.62	10.77	13.19	15.23
40 NB	3.18	8.75	12.37	15.15	17.50
50 NB	4.00	12.27	17.35	21.25	24.54
65 NB	5.17	16.07	22.72	27.83	32.14
Mild steel flat					
40 x 6	0.35	4.58	6.48	7.93	9.16
50 x 8	0.46	7.86	11.11	13.61	15.71
50 x 10	0.58	9.65	13.65	16.72	19.30
Mild steel angle					
25 x 25 x 3	0.98	2.74	3.87	4.74	5.47
30 x 30 x 5	1.17	5.34	7.55	9.25	10.68
40 x 40 x 5	1.56	7.34	10.38	12.71	14.68
50 x 50 x 5	1.97	9.21	13.03	15.96	18.43
60 x 60 x 6	2.36	13.30	18.81	23.03	26.60
80 x 80 x 6	3.17	17.97	25.42	31.13	35.95

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 4.18 – Maximum capacity of horizontal loads for various lengths of 25 NB medium wall pipe (ULS design)

Maximum horizontal load – 25 NB medium wall pipe				
Brace length up to max. for *l/r* = 200 (m)	Brace 30° to 44° from vertical (kN)	Brace 45° to 59° from vertical (kN)	Brace 60° to 89° from vertical (kN)	Brace horizontal (kN)
0.50	28.82	40.75	49.91	57.64
0.75	25.18	35.61	43.61	50.35
1.00	20.84	29.47	36.09	41.68
1.25	16.34	23.11	28.30	32.68
1.50	12.12	17.14	20.99	24.24
1.75	8.90	12.59	15.42	17.81
2.00	6.82	9.64	11.81	13.63
2.15	5.90	8.34	10.22	11.80

Table 4.19 – Maximum capacity of horizontal loads for various lengths of 10 mm threaded rod (ULS design)

Maximum horizontal load – 10 mm threaded rod				
Brace length up to max. for *l/r* = 200 (m)	Brace 30° to 44° from vertical (kN)	Brace 45° to 59° from vertical (kN)	Brace 60° to 89° from vertical (kN)	Brace horizontal (kN)
0.10	4.91	6.94	8.5	9.81
0.15	4.22	5.97	7.32	8.45
0.20	3.43	4.85	5.93	6.85
0.25	2.62	3.70	4.53	5.23
0.30	1.88	2.66	3.26	3.77
0.35	1.38	1.96	2.40	2.77
0.40	1.06	1.50	1.84	2.12

Table 4.20 – Maximum capacity of horizontal loads for various lengths of 12 mm threaded rod (ULS design)

Maximum horizontal load – 12 mm threaded rod				
Brace length up to max. for *l/r* = 200 (m)	Brace 30° to 44° from vertical (kN)	Brace 45° to 59° from vertical (kN)	Brace 60° to 89° from vertical (kN)	Brace horizontal (kN)
0.20	5.79	8.18	10.02	11.57
0.30	3.83	5.42	6.64	7.67
0.40	2.24	3.17	3.88	4.48
0.49	1.49	2.11	2.59	2.99

4.3.13.3.5.7.

Bracing shall be tight and concentric. All parts and fittings of a brace should be in a straight line to avoid eccentric loading on fittings and fastenings.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

4.3.13.3.5.8.

Bracing shall be:

(a) Perpendicular to the piping for lateral bracing; and
(b) Parallel to the piping for longitudinal bracing, and not offset from the edge of the braced pipe by more than what is required to connect the brace element to the pipe-attached component.

NOTE – Ideally the longitudinal brace will follow the centre line of the braced pipe.

4.3.13.3.5.9.

Lateral bracing for range pipes of 50 mm or less diameter is permitted to be provided by purlin clips or wrap-around U hooks with the legs bent out at least 30° from the vertical without need for further calculation.

4.3.13.3.6 Fixings of braces to structures

4.3.13.3.6.1.

Fixings of braces to the building structure shall be designed to resist the earthquake loading specified in 4.3.12.6.

The capacity of the fixing used for the structural attachment shall be obtained from the listing for that fixing, from available engineering publications, or from this standard.

The horizontal loads that can be resisted by typical fixings for various bracing configurations for horizontal piping are shown in Table 4.21 subject to the following provisions:

(a) Post-installed and proprietary anchors used in concrete or masonry shall be accessed against the seismic qualification test stipulated in ACI 355.2/355.2R-01 *Evaluating the performance of post-installed mechanical anchors in concrete and masonry*, or European Standard ETAG001 *Metal anchors for use in concrete*, or as otherwise listed by the SSC;

NOTE – Expansion fasteners in concrete that are secured by driving the fastener against a wedge at the bottom of the hole are not suited for use as part of a seismic restraint system. This type of expansion fastener has performed poorly in earthquakes.

(b) Bolts to steel members shall comply with the requirements (such as edge distances) of NZS 3404; and
(c) Bolted and screwed connections to timber shall comply with the requirements of NZS 3603.

NOTE – Pipework lateral supports are detailed for limited ductility and over-strength is required in fixings to prevent brittle failure at loadings greater than the design earthquake.

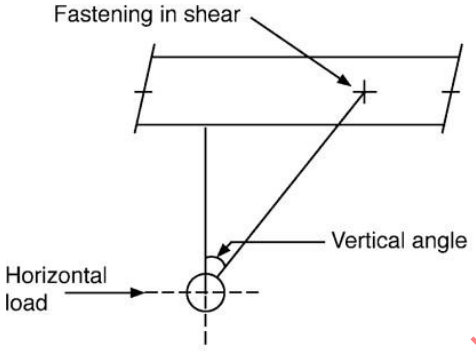
Table 4.21 – Horizontal load capacity of typical connections (ULS Design)

Fastening type	Horizontal load capacity					
	Vertical angle 30° to 44°		Vertical angle 45° to 59°		Vertical angle ≥60°	
	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)
Masonry anchors						
M6	2.55	1.95	3.60	3.00	4.35	3.90
M8	3.00	3.00	6.30	4.35	7.80	5.70
M10	6.60	4.35	9.30	6.45	11.40	8.25
M12	10.20	6.45	14.25	9.45	17.55	13.05
M16	18.00	8.55	25.50	13.05	31.35	18.00
Bolts to steel						
M6	2.55	2.85	3.60	3.90	4.35	4.50
M8	4.50	5.25	6.30	6.90	7.80	8.10
M10	7.05	8.25	10.05	10.95	12.15	12.75
M12	10.20	11.85	14.25	15.75	17.55	18.45
M16	18.00	21.60	25.50	28.65	31.35	33.00
Bolts to BP 450 purlins						
M6	2.55	–	3.60	–	4.35	–
M8	4.35	–	6.15	–	7.50	–
M10	5.40	–	7.65	–	9.30	–

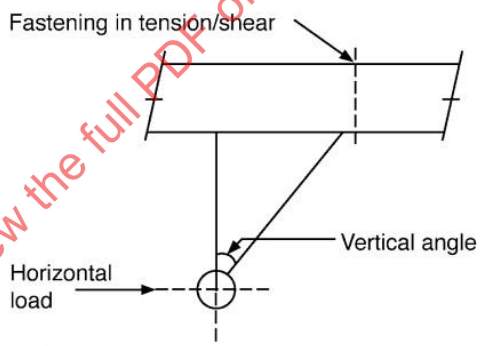
STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

Fastening type	Horizontal load capacity					
	Vertical angle 30° to 44°		Vertical angle 45° to 59°		Vertical angle ≥60°	
	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)
M12	6.45	–	9.15	–	11.10	–
M16	8.55	–	12.15	–	14.85	–
Bolts to timber						
M12	3.15	–	4.95	–	6.60	–
M16	4.35	–	7.20	–	10.65	–
M20	5.55	–	9.60	–	15.00	–
Coach screws to timber						
M8	–	1.13	–	1.43	–	1.65
M10	–	1.95	–	2.70	–	3.30
M12	–	2.70	–	3.90	–	5.10
M16	–	4.50	–	6.30	–	8.40
M20	–	6.45	–	9.30	–	12.60



Type A



Type B

NOTE –

(1) Bolted shear (type A) connections to timber assume a nominal timber thickness of 50 mm.

(2) Tension/shear (type B) connections to timber assume coach screws penetrate timber 10 times the shank diameter and have a minimum thread length 6 times the shank diameter.

(3) The loads for timber connections are for dry timber. For green timber reduce the loads by 30%.

4.3.13.3.6.2.

Bracing for piping of diameter 80 mm or larger shall not be restrained by timber members which are less than 100 mm in the direction(s) of the plane(s) of bending. The distance of the point of fastening from any edge of the timber shall be not less than 30 mm or 4 fastener diameters, whichever is the greater.

4.3.13.3.6.3.

Braces shall not be welded to cold rolled sections 3 mm or less in thickness.

4.3.13.3.6.4.

Explosive or hammer driven fasteners shall only be used if listed.

4.3.13.4 *Flexibility*

4.3.13.4.1

The requirements of 4.3.13.4 are applicable to steel pipework only. Specific design solutions are required for other materials.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

4.3.13.4.2

Flexibility shall be provided to prevent over-stressing of pipes, hangers, and braces under seismic load.

Flexibility shall be permitted to be omitted when either of the following conditions is met:

(a) The pipe diameter is less than 50 mm and flexibility is not required in accordance with 4.3.13.4.4; or

(b) Seismic coefficient *C* as calculated in 4.3.12.2 is 0.5 or less, and the pipe diameter is 150 mm or less.

4.3.13.4.3

Flexible couplings are only required where specified in section 4.3.13.4. Where additional flexible couplings are installed, additional lateral bracing shall be installed within 600 mm of those flexible couplings.

4.3.13.4.4

An SSA or listed flexible pipe loop shall be installed on all fire protection system piping that

(a) Crosses a building seismic expansion joint, or

(b) Crosses other separations between two independent buildings or structures, above ground level.

The SSA shall have the nipple lengths calculated in accordance with the coupling manufacturer's data or in accordance with Figure 4.12 to ensure the desired movement can be catered for by the assembly.

No braces shall be attached to the SSA or loop itself.

The end of the pipe on each side of the SSA or loop shall be treated as the end of the pipe and be braced according to 4.3.13.2

Hangers supporting the SSA or loop should accommodate horizontal movement.

The SSA or loop shall accommodate the horizontal movement as provided by the building design engineer.

If this is not available, then the following shall apply:

(a) For horizontal pipe spans across a seismic expansion joint within a building or spans between two independent buildings or structures up to 500 mm apart: horizontal movement in any direction equal to half the seismic separation. For example, for 200 mm seismic separation assume each building can move 100 mm in any horizontal direction.

(b) For separation distances larger than 500 mm: horizontal movement in any direction equal to 4% of the height of that pipe above grade. For example, at 12.0m above ground assume each building or structure can move 240 mm in each horizontal direction (480 mm total relative movement).

NOTE –

(1) An SSA able to accommodate seismic movement is shown in Figure 4.12.

(2) A horizontal pipe feeding an in-rack sprinkler system or other non-structural element, such as a piece of machinery or equipment, is considered to be crossing between two separate structures.

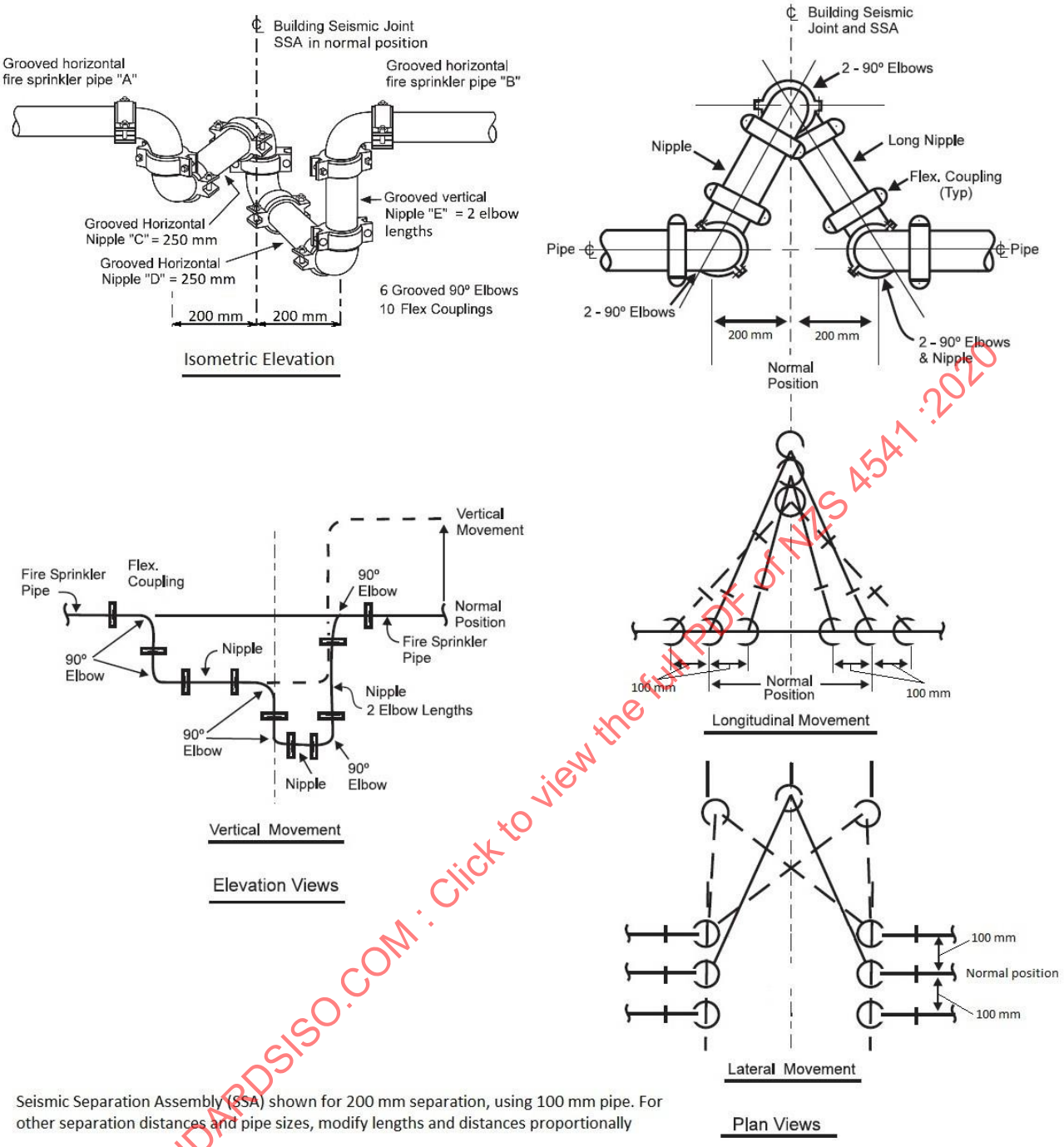
(3) A single length of braided hose or multiple flexible couplings in-line may not provide three planes of movement.

(4) Following best practice, range pipes will not cross structural separations.

(5) Sacrificial hangers may be installed to support a SSA or seismic loop.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



Seismic Separation Assembly (SSA) shown for 200 mm separation, using 100 mm pipe. For other separation distances and pipe sizes, modify lengths and distances proportionally

Figure 4.12 – Seismic separation assembly (SSA)

4.3.13.4.5

Vertical pipes greater than or equal to 1.8 m long shall have a flexible coupling located within 0.6 m of the top and bottom.

Flexible couplings shall be provided within 0.6 m above or below intermediate points of bracing of vertical pipes.

When multiple risers are connected to a manifold fed by underground pipe, flexible couplings shall be provided for each vertical pipe above the manifold, within 0.6 m of the connection. The manifold shall be located within 0.9 m of the ground and shall have a rigid coupling or flanged connection to the underground riser stub and be braced in accordance with 4.3.13.2.

4.3.13.4.6

Risers in multilevel buildings shall have additional flexible couplings at each floor level.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

When the vertical pipe does not penetrate a floor slab or plate, or clearance is provided in accordance with 4.3.13.5, the flexible coupling shall be located within 0.3 m, either above or below the floor.

When clearance is not provided in accordance with 4.3.13.5, flexible couplings are required within 0.3 m both above and below the floor.

Exception: if there is a horizontal pipe fed from the vertical pipe that is immediately below the floor, the flexible coupling shall be below the horizontal pipe.

4.3.13.4.7

Where a horizontal pipe penetrates a wall and requirements for clearances are not provided in accordance with 4.3.13.5, a flexible coupling shall be provided within 0.3 m on both sides of the wall.

4.3.13.4.8

Vertical feeds to more than one sprinkler on or beneath non-structural elements, such as rack storage, machinery, walk-ways, or other items, shall have flexible couplings located within 0.6 m of the top of the pipe connection and 0.6 m above the first point of bracing on the racks or other element.

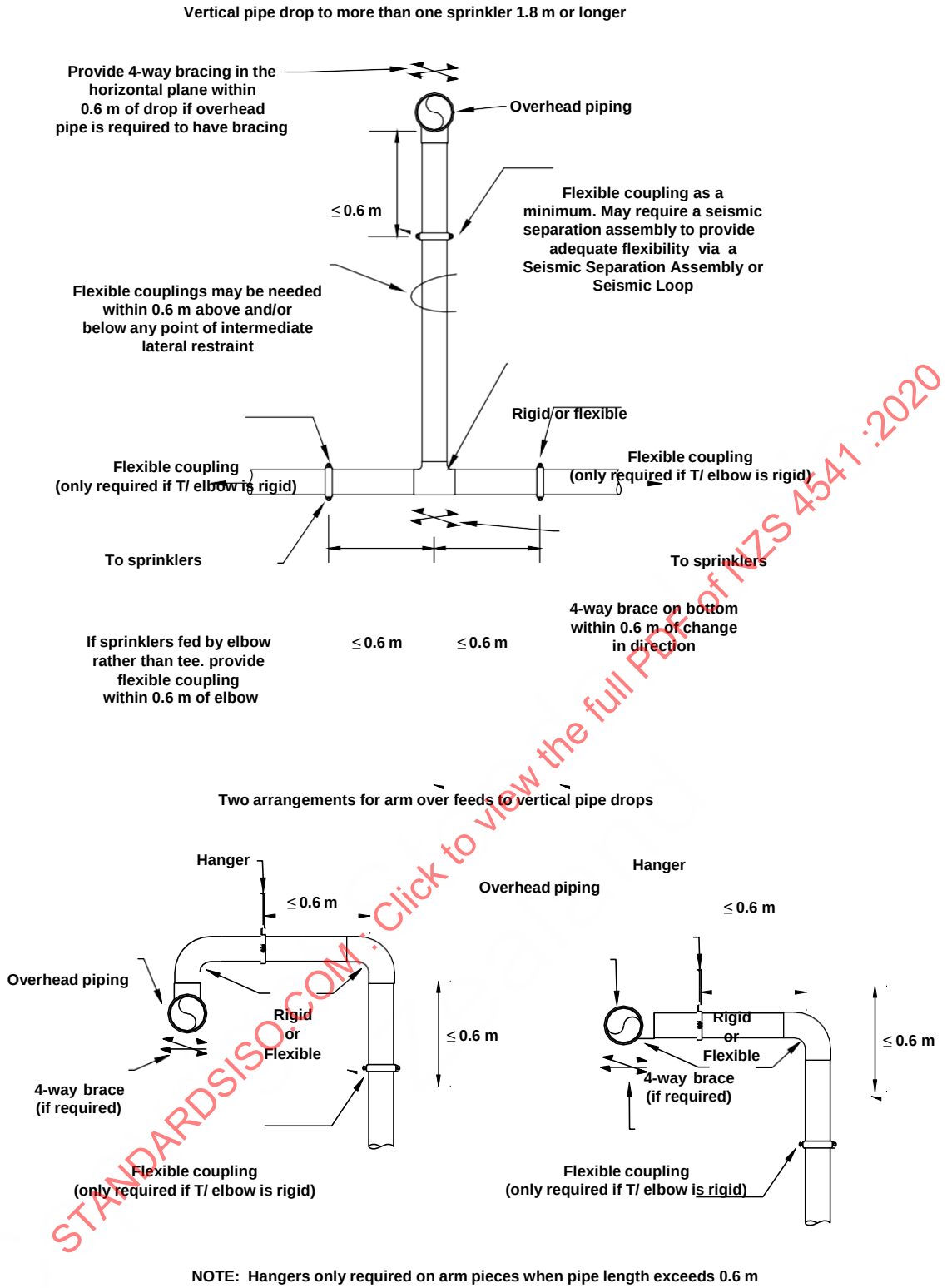
Flexible couplings that allow for angular deflection from centre line not less than that needed to accommodate the expected total lateral deflection shall be used. Unless calculated otherwise, the lateral deflection of each structure shall be taken to be 4% of the height from the base to the point of connection.

NOTE – This may require the use of an SSA or loop.

Flexible couplings shall be provided on the horizontal portion of pipe in racks, within 0.6 m of the connection to vertical pipe. See Figure 4.13.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



NOTE: Hangers only required on arm pieces when pipe length exceeds 0.6 m

Figure 4.13 – Droppers to non-structural elements

4.3.13.5 *Clearance*

4.3.13.5.1

Clearance, as specified in 4.3.13.5.2, shall be provided around all pipe extended through building elements such as walls, floors, beams platforms, and foundations.

4.3.13.5.2

Minimum clearance from sprinkler system pipework and components on all sides from building elements shall be not less than one of the following:

(a) 50 mm from other restrained components;

(b) 150 mm horizontally and 50 mm vertically from unrestrained components;

(c)

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

50 mm. For penetrations through structures such as walls and floors or as excepted by (d). The gap is permitted to be sealed provided that a flexible or frangible material is used;

(d) Penetrations through structures are permitted to be less than 50 mm, if the pipe is provided with flexibility in accordance with 4.3.13.4.6 or 4.3.13.4.7; or

(e) 25 mm from sprinklers that penetrate fixed or braced ceilings. The gap shall be filled with an oversized escutcheon plate, ring, sleeve, or adaptor.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Alternatively, if a flexible hose is used to connect to the sprinkler, and the assembly is connected to the ceiling, the clearance is permitted to be less than 25 mm and a standard escutcheon used. See Figure 4.14 for drops less than 1.2 m and Figure 4.15 for drops greater than or equal to 1.2 m.

NOTE –

(1) Sprinkler systems braced in accordance with this standard are considered restrained components for use in this clause.

(2) A sprinkler pipe that is rigidly attached to the structure is permitted to have zero clearance, for example in the case of a beam clamp, provided the necessary flexibility is provided where the zero clearance is for a penetration.

(3) In this clause 'components' is used as defined in NZS 4219.

(4) The above requirements can be reduced or omitted provided that a CMEng NZ qualified Structural Engineer provides a PS1 stating that the proposed design meets all areas of seismic separation compliance.

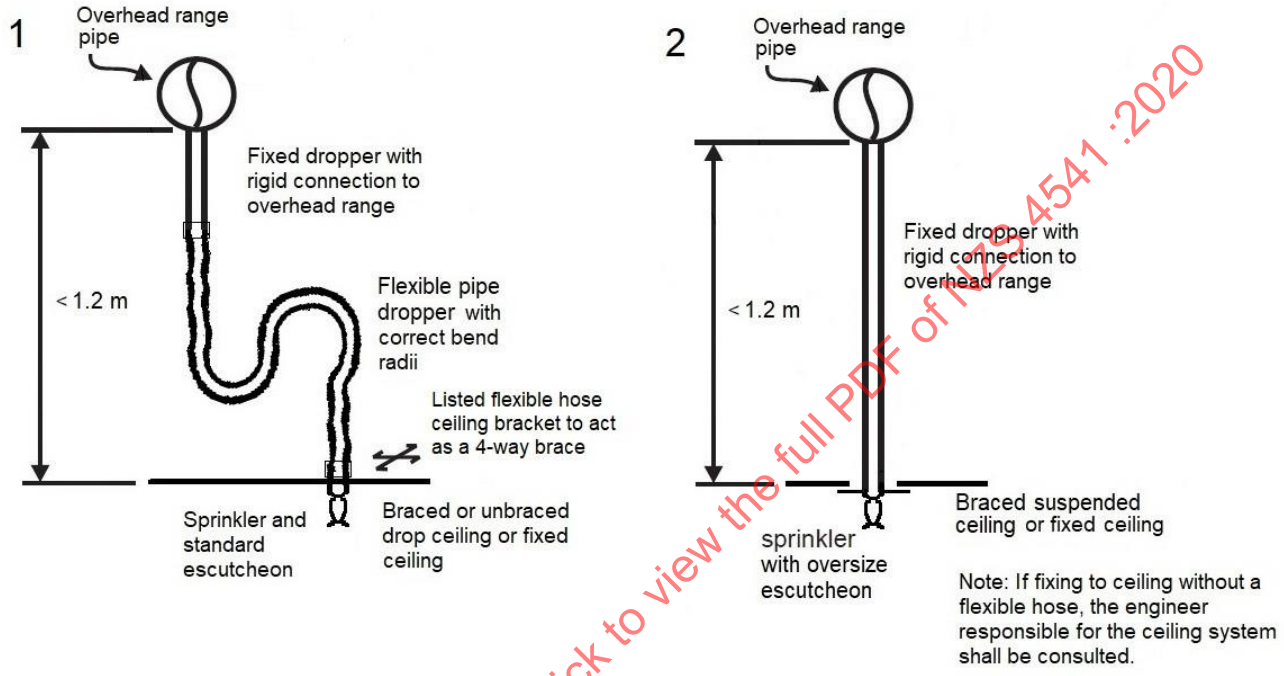


Figure 4.14 Short droppers

4.3.13.5.3

No clearance is required for piping passing through partitions or walls of frangible materials (such as gypsum board) unless the wall is required to have an FRR.

4.3.13.5.4

In building elements required to be fire rated, the gap shall be filled with a flexible material which will preserve the fire rating of the building element.

4.3.13.5.5

Pipework supplying in-rack sprinklers shall be plumbed to facilitate isolation of that pipework without causing isolation of the roof-level sprinkler protection.

NOTE – This is to facilitate the reinstatement of roof level sprinklers in the event of rack collapse post-earthquake.

4.3.13.6 *Hangers*

Hangers shall be connected to the piping and to the immediate support structure by fixings that cannot detach in an earthquake.

Beam clamps shall be fitted with retaining straps unless otherwise specifically listed.

Hangers shall limit the vertical movement between the pipe and the hanger bracket or clamp to a maximum 13 mm.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

4.3.13.7 *Long droppers*

Drops to individual sprinklers, using pipework less than or equal to 40 mm, that are greater than or equal in length to 1.2 m, shall be in accordance with one of the arrangements shown in Figure 4.15:

(a) Overhead range pipes shall have both lateral and longitudinal braces; and

(b) If fixed dropper is greater than 1.2 m, four-way bracing shall be provided at the bottom of the fixed pipe.

Drops that use pipework greater than 40 mm shall be provided a flexible coupling at the connection to the overhead range pipe and in all other ways be in accordance with Figure 4.15.

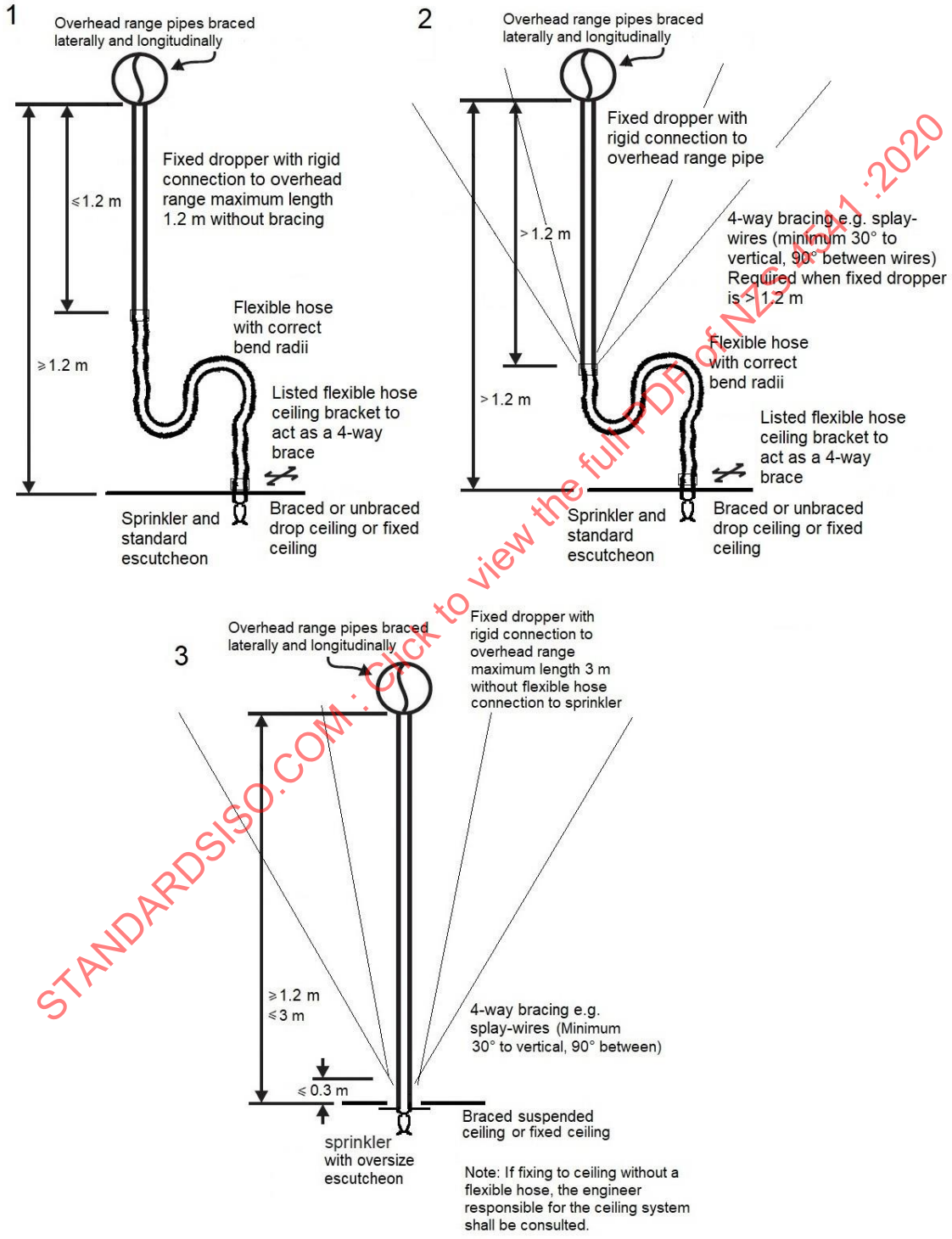


Figure 4.15 – Long droppers

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

4.4 Valves

4.4.1 *Installation control valves*

4.4.1.1 *General*

Each installation shall be provided with a set of installation control valves comprising:
(a) A main stop valve each side of the alarm valve;
(b) An alarm valve (wet pipe, dry pipe, composite or a deluge valve);
(c) A water motor alarm and gong;
(d) Drain valves.

Figures 4.17, 4.18, and 4.19 show typical layouts including ancillary equipment.

4.4.1.2 *Enclosure*

The sprinkler installation control valves shall be protected and secured in a sprinkler-protected enclosure, exclusive to the sprinkler installation. This enclosure shall be of sufficient size to allow adequate access to all parts of the sprinkler control valves and associated equipment, together with due provision for artificial lighting, adequate ventilation and heating (the latter as necessary). It shall also permit installed equipment to remain in a weather-protected environment when servicing is undertaken.

NOTE –

(1) Where there is no danger of freezing, a robust, locked, wire-mesh enclosure within a protected building will comply with this requirement.

(2) The need to comply with the Electricity (Safety) Regulations should be noted. AS/NZS 3000 is a suggested means of compliance. As sprinkler control valve enclosures can be wet areas on occasions, the provisions of 2.9.2.5 and 6.7 should be considered. The use of residual current devices (RCD) is also recommended for the protection of socket outlets (refer to 2.6).

(3) The SSC may give approval to the location of other services in the enclosure if these will not adversely affect the correct security or reliability functionality of the sprinkler system or impede fire brigade access.

(4) Access to the enclosure shall not be unduly tortuous

(5) Consideration should be given to the need to prepare a traffic management plan to allow flow tests.

4.4.1.3 *Location*

Control valves need to be designed, arranged and provided in locations that allow for the carrying out of all the required testing, inspection and maintenance. In this regard adequate drainage is required for the flow of water for testing and inspection of water supplies.

NOTE – The fire brigade may have regional preferences of the specification of locks.

4.4.2 *Stop valves*

4.4.2.1 *General*

All stop valves shall be suitable in all respects for the proposed application. Valves which exceed 50 mm diameter and are subject to a pressure exceeding 100 kPa shall be so constructed that the operating mechanism has a mechanical efficiency of less than 50%.

Stop valves that are below ground (or floor level), are only accessible via toby boxes and are key operated shall be used only on the water supply. Such valves shall close in the anti-clockwise direction.

All other valves shall have a handwheel or a lever permanently affixed and handwheel operated valves shall close in the clockwise direction. Handwheel and lever operated valves shall have a permanently fixed indicator to show if the valve is open or closed and shall be clearly marked to show the direction of closing oropening.

4.4.2.2 *Main stop valves*

These shall comply with the following:
(a) Each installation shall be provided with a main stop valves each side of the alarm valve, which when closed will shut off all supply of water to the installation. All water supplies shall be connected before passing through the upstream main stop valve;
(b) Main stop valves shall be fitted with a supervisory device, and secured open by a padlocked chain;
(c) The main stop valve shall be labelled ‘Main Stop Valve’;
(d) The location of the main stop valve shall be identified by a location plate fixed on the outside of an external wall and if necessary a further plate on any opaque door within the building which has to be opened in order to gain access to the main stop valve. Such plates shall bear the following words in raised letters or other approved type of letters:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

SPRINKLER
STOP VALVE
INSIDE

The words ‘SPRINKLER STOP VALVE’ should be in letters of at least 35 mm and the word ‘INSIDE’ of at least 25 mm in height. It is recommended that the words be painted white on a black background.

4.4.2.3 *Stop valves controlling water supplies*

Except as noted in 4.4.2.1, all stop valves controlling water supplies shall be secured open by a padlocked chain. In the case of elevated private reservoirs and gravity tanks the stop valve shall be fixed immediately adjacent to the reservoir or tank outlet and shall be upstream of any flexible couplings. All water supply stop valves within the pumproom shall be fitted with a listed supervisory device.

4.4.2.4 *Subsidiary stop valves*

Stop valves subsidiary to the main stop valve shall be fitted with a listed supervisory device. They shall be located in a prominent position, clearly labelled, and accessible from floor level or by a permanent access ladder/platform provided for the fire brigade and service personnel.

A drain valve of at least 25 mm NB shall be installed downstream of each subsidiary stop valve and connected to a permanently piped drain (which is drained to the foul water system). Rack and car stacker installations may be provided with a permanently plugged drain valve.

NOTE – In high rise buildings, the floor isolation valves should be normally located within a common stairwell likely to be used by fire brigade personnel to access the fire floors. Refer to 3.2.1.5 for guidance as to when subsidiary stop valves are required to be installed in such stairwells.

Stop valves subsidiary to the main stop valve are permitted only under the following circumstances and subject to the following conditions:

(a) To isolate individual floors in multistoreyed buildings as per 2.11;
(b) To isolate individual buildings fed from a single installation;
(c) To isolate individual or groups of tenancies within buildings such as shopping malls;
(d) To isolate buildings or sections of premises, as per 4.4.11, where either hazardous processes are carried out or conditions exist which are liable to result in an explosion;
(e) To facilitate maintenance and testing of:
    (i) Dry pipe installations (see 3.2.2)
    (ii) Tail-end dry pipe installations (see 3.2.3)
    (iii) Pre-action installations (see 3.2.4)
    (iv) Antifreeze installations (see 3.2.5)
    (v) Tail-end antifreeze installations (see 3.2.6)
    (vi) Deluge installations (see 3.3)
    (vii) Backflow prevention units (see 4.4.3.4);
(f) With specific approval, when frequent shutdown of a section of a sprinkler installation is required to gain access to equipment or to clean sprinklers;
(g) To isolate a section of in-rack sprinklers (see 9.4.2.7.7);
(h) To isolate vehicle stacker systems see 8.3;
(i) Where subsidiary stop valves are installed to allow sectional isolation of sprinkler installations, as outlined in (a), (b), (c), (e), (f), and (g) above, then the following conditions apply:
    (i) It is not permissible to have looped connections which require more than one valve to be operated to sectionally isolate part of the installation, AND
    (ii) Except to allow isolation of a tail-end system, multiple subsidiary stop valves shall not be installed in series.

4.4.2.5 *Valves with supervisory devices*

Supervisory devices shall be listed. They may be listed as part of a valve assembly or as an individual unit. For normally open or normally closed valves the supervisory device shall detect and activate when the spindle of the valve is rotated any more than two revolutions from the normal position, or, for quarter turn valves, the valve opening changes by more than 15° from the normal position.

The signalling function shall be either line powered by the FBA transmission system, or alternatively, powered by a power supply complying with 4.7.2.5.

Activation of the supervisory device, due to either valve closure or interference with the device, shall cause transmission of a FIRE signal by the FBA within 60 s. The signalling path and any supplementary source shall be supervised in such a way that open circuit or loss of power will also cause transmission of a FIRE signal.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Isolation devices on the alarm signalling function (to permit authorised valve closure of a subsidiary stop valve) shall be located in the FBA unit and be appropriately labelled. Activation of the isolation device shall cause the FBA to signal DEFECT.

Valves other than those required to be supervised by this standard may be fitted with supervisory devices if required. In such cases, operation of the supervisory device shall not preclude the ability of the FBA to transmit a FIRE signal.

4.4.2.6

Taps, hose reels, or other attachments for drawing water from an installation other than those specified in this standard are strictly forbidden.

4.4.2.7

All test valves, drain valves, and drains about the sprinkler control valves shall be separately piped into a tundish, or equivalent. This requirement also applies to tail end control valves.

All installation drains shall terminate in the foul water system.

4.4.3 *Protection of potable water supplies*

4.4.3.1

Backflow prevention shall be installed to protect public and on-site potable water supplies. The method of protection shall be as required by acceptable solutions or verification methods addressing NZBC Clause G12 Water supplies.

NOTE –

(1) Backflow protection for the building is required in accordance with acceptable solutions or verification methods addressing NZBC Clause G12 Water supplies.

(2) 'Buildings' are as defined in section 3 of the Building Act.

4.4.3.2

Devices to provide backflow prevention installed in the supply to a sprinkler system shall be listed and any strainers fitted shall be listed and comply with 4.4.10.

4.4.3.3

Backflow prevention devices shall be readily accessible for testing and maintenance. Backflow prevention devices located upstream of installation valve sets shall be located in a secure area. This secure area shall be either within the sprinkler valve house or sprinkler pump room, or where a TA requires a backflow prevention unit to be installed at the property boundary its location and security shall be subject to SSC approval. In the latter case the contractor shall provide an SSC with copies of documentation from the TA specifying their required location.

Backflow prevention devices require valves upstream and downstream for testing and maintenance purposes. If fit for purpose, the street valve and main stop valve may meet this need. Alternatively, additionalstop valves may be fitted. If above ground, these devices shall be supervised. If below ground, or in a pit, an alternative provision for supervision shall be approved by the SSC. This may include locking the valves orthe pit, or use of sluice valves with a toby box assembly.

NOTE – The Health and Safety issues involving the installation of devices in pits needs to be considered. The pits will be considered a confined space. Testing of the back flow preventions will require adequate risk mitigation procedures.

Reduced pressure zone devices shall always be located above ground, and unless specifically recommended by the manufacturer, be located horizontally with the relief valve facing vertically downward and not less than 300 mm above the surrounding surface.

Double check valve assemblies may, if absolutely necessary, be installed below ground with specificapproval of the TA and provided that:

(a) The double check valve assembly is located in a permanent (concrete) pit that is a suitable size to allow for inspection, testing, maintenance and replacement;
(b) The pit is suitably drained and covered to prevent water pooling or silting; and
(c) The location is clearly indicated on the block plan.

Backflow prevention devices located outside the sprinkler valve or pumproom shall be protected from freezing.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

4.4.3.4

A drip tight valve and pipework are required to be installed downstream of any backflow prevention device to allow it to be tested. The main sprinkler stop valve, or valves, may provide this function. Valves are required upstream of backflow prevention devices for maintenance purposes. The town's main isolation valve may provide this function.

NOTE – In some cases, the main sprinkler stop valve will not be sufficient to allow the backflow prevention device to be tested. One possible scenario would be if the device is installed upstream of a fire pump with a packed gland. In normal circumstances, it would be expected that any backflow prevention device be installed downstream of a pump, to avoid hydraulic disturbances, which would impact on pump performance. Specific approval is required for such installations, which would detail the requirements for security and monitoring of any valving installed on the supply to the sprinkler system.

4.4.4 *Alarm valves*

4.4.4.1 *Alarm (wet pipe) valves*

Wet pipe alarm valves shall be of a listed type.

4.4.4.2 *Alarm (dry pipe) valves*

Dry pipe alarm valves shall be of a listed type and shall comply with the following:

(a) They shall be fixed on the main supply pipe immediately above the main stop valve (and the alarm (wet pipe) valve in the case of installations not employing a composite alarm valve) and before any connection is taken off to supply any part of the installation;

(b) In the case of installations maintained permanently under gas pressure, the water motor alarm shall be connected to the atmospheric chamber or the alarm motor auxiliary valve of the alarm (dry pipe) valve;

(c) In order to facilitate the carrying out of flow tests when the installation is under gas pressure, an additional 40 mm drain valve in the case of ELH installations or a 50 mm drain valve in the case of ordinary and EHH installations may be fitted below the alarm (dry pipe) valve. Alternatively, a subsidiary stop valve of a listed type may be installed immediately above the alarm (dry pipe) valve.

4.4.4.3 *Identification of alarm valves*

In buildings containing more than one installation each alarm valve shall have a number indicated thereon in bold figures.

4.4.5 *Dry pipe and pre-action installations in freezers*

FM Global Data Sheet 8-29 provides useful background information on the design of dry pipe installations for refrigerated storage applications.

4.4.5.1 *Accelerators or exhausters for alarm (dry pipe) valves*

When fitted, these devices which shall be of a listed type are designed to accelerate the operation of an alarm (dry pipe) valve. They shall be located as close as possible to the alarm (dry pipe) valve. Care shall be taken to ensure that the connection to the device from the system is so located that the restriction orifice and other operating parts are not likely to become flooded with priming water or back drainage under normal conditions (see also 3.2.2).

It is permissible to further enhance the speed of operation of a dry pipe installation to trip an accelerator or exhauster by means of a signal from a thermal or smoke detector system (see 3.2.2.3) which covers the area protected by the dry pipe system. Details of such arrangements shall be submitted for prior approval.

4.4.5.2 *Air supply*

Dry pipe installations shall be fitted with an air supply capable of restoring normal air pressure in 60 minutes.

Air pressure in the installation shall not exceed that recommended by the dry pipe valve manufacturer. A listed air pressure maintenance device shall control air pressure.

In cold storage applications, air shall be supplied through an adequately sized twin tower desiccant type regenerative air dryer, so its pressure dew point is 10°C below the nominal freezer temperature. The air dryer shall be installed upstream of the air pressure maintenance device.

Air intake for compressed air shall be taken from the freezer operating at the coldest temperature unless the air supply is listed as being able to draw ambient air. See Figure 4.16.

NOTE –

(1) Consideration should be given to redundancy in air supplies. It is recommended that twin air supply lines are used as shown in FM Global Data Sheet 8-29.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(2) Attention is drawn to the critical nature of this air supply. If the power supply fails, the dry pipe installation is at risk of tripping, with consequential freezing. It is recommended that the compressor be supplied from any site emergency power supply if available.

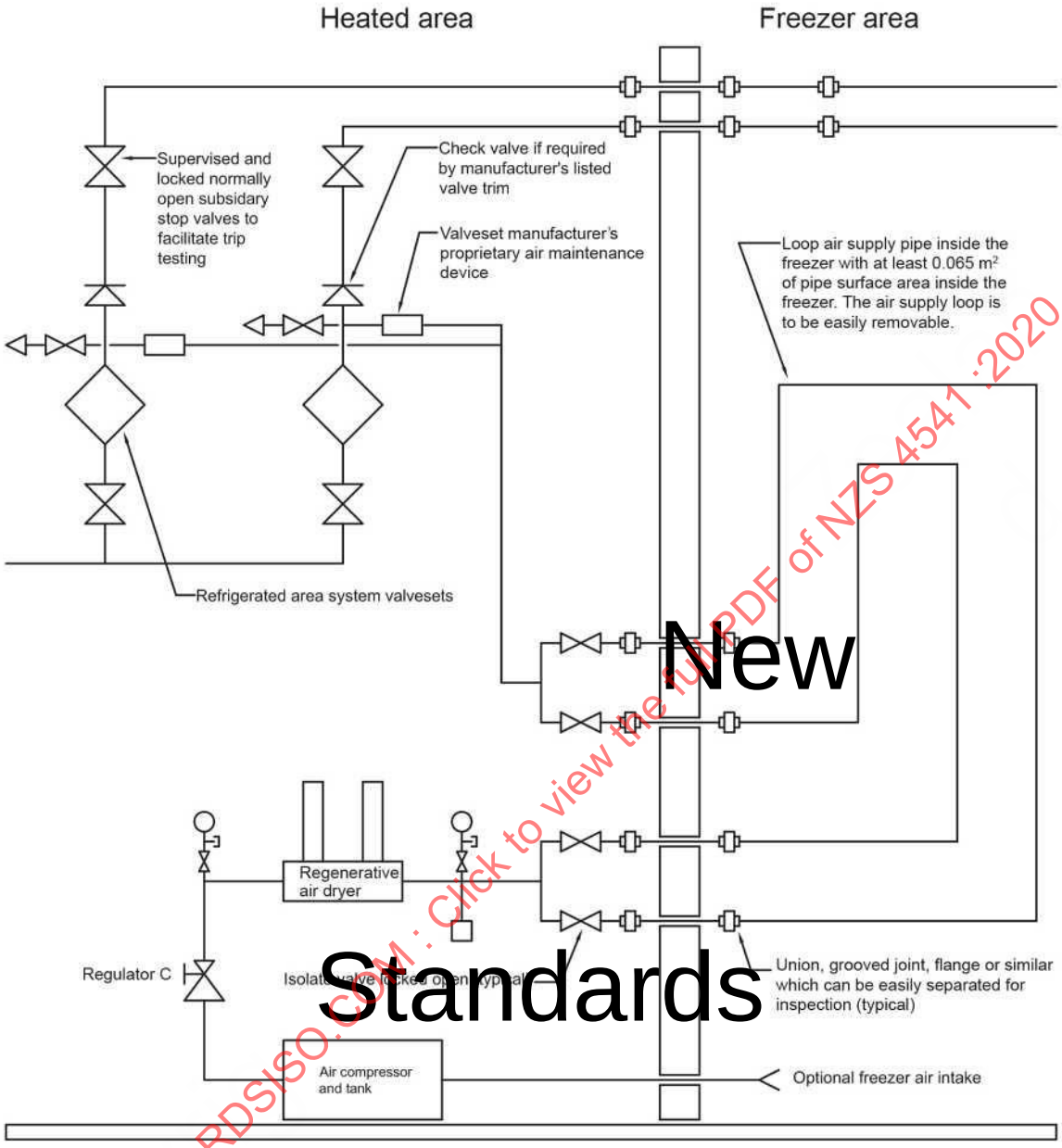


Figure 4.16 – Configuration of air supply for dry pipe systems in refrigerated areas

4.4.5.3 *Pipework*

4.4.5.3.1

Pipework shall be designed to allow easy inspection internally for ice plugs in accordance with 1202.5 (k) and to facilitate removal of ice build-up prior to the formation of ice plugs.

A label, clearly visible from ground level or suitable trafficable location, shall be attached at each inspection point stating:

ICE PLUG INSPECTION POINT

NOTE – The stretch of pipe likely to have ice plugs form, is the run of pipe just after entering the freezer.

In a system using an air compressor or site-supplied compressed air to provide the gas for the pipework, if the connection to the sprinkler pipe from the compressor is inside the freezer, then this section is also susceptible to build up of ice.

A tee in lieu of an elbow, at the top of the riser, external to the freezer, will permit easy access for visually inspecting the inside of the pipe with straight line of sight.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

New Standards

4.4.5.3.2

Rigid grooved couplings shall be used in freezer applications, except where flexible grooved couplings are required for seismic flexibility requirements. Gaskets used in freezer applications shall be recommended for such service by the coupling manufacturer.

NOTE – Gaskets used in freezers will have a special seal to close off the gap between the pipes, to minimise the possibility of moisture freezing inside the gasket surface and disrupting the seal. Care should be taken in the selection of gasket lubricants, as standard lubricants may freeze. Suitable gasket lubricants can include petroleum-free silicon based lubricants.

4.4.6 *Automatic pressure and flow regulating valves*

4.4.6.1 *General*

Automatic pressure/flow regulating valves shall be of a type listed for the task involved.

The trim on pilot operated valves shall be approved and be connected to the water supply to be controlled, through a suitable strainer, and piped in hard copper, steel or stainless steel tubing. The pilot valve strainer shall be in the automatic pressure or flow regulating valve's main water path, and be designed to be self-cleaning. Use of Y pattern strainers in the pilot operated valve trim tubing is not acceptable.

There shall be permanent facilities associated with all automatic pressure/flow regulating valves to enable the correct functioning of the valve to be verified on site.

When under test the delivery from the valve shall stabilise within 20 seconds of any change in the input without the output at any time rising more than 100 kPa above the required controlled pressure.

4.4.6.2 *Pressure reducing valves on water supplies*

Listed pressure reducing valves controlling sprinkler water supplies shall be equipped with a listed pressure relief valve set to relieve to waste any downstream pressure that rises above the intended controlled pressure. The relief valve shall be sized to vent not more than 5% of the design flow to waste.

The region from the pump to the pressure-reducing valve needs to be rated for the maximum pressures the pump will generate prior to the pressure being reduced. This includes the pump casing and pump flanges.

4.4.6.3 *Pressure sustaining valves*

Where listed pressure sustaining valves are used to control domestic or industrial draw-off from the sprinkler system water supply:

(a) The pressure sustaining valve shall be of a type, and installed in such a way, that failure of the valve operating device shall cause the valve to close;

(b) The pressure sustaining valve shall be configured to preserve the water supply pressure available to the sprinkler system by either:

  (i) Causing the pressure-sustaining valve to close on a drop in the installation pressure to the FIRE signal activation pressure, or

  (ii) Causing the pressure-sustaining valve to close on a drop in supply pressure to below 80% of the normal static supply pressure. This pressure setting is to be reviewed and agreed with an SSC;

(c) A clearly labelled device, interlocked with the FBA, may be provided within a FBA unit to permit the pilot operated devices on the pressure sustaining valve to be bypassed when the installation pressure has been lowered for servicing purposes. A notice in the FBA signalling unit shall clearly alert the need to restore the bypass device.

A valved bypass up to 40 mm, around the pressure sustaining valve is permitted, and shall be provided if hose reels are supplied by the domestic or industrial supply.

4.4.6.4 *Pressure relief valves*

Listed pressure relief valves may be used to automatically relieve pressure surges, in pump cooling lines, or to bypass excess pressure. On pump relief lines a strapped (not locked), normally open, gear operated stop valve shall be provided upstream. The stop valve shall be labelled 'PUMP RELIEF LINE VALVE' in letters of at least 12 mm and there shall be an associated sign with 25 mm lettering prominently displaying 'TO INCREASE PUMP SUPPLY PRESSURE IN EMERGENCY, SHUT THE PUMP RELIEF LINE VALVE'.

Where a pump draws water from a tank, it is preferred to return the pressure relief line to the tank with the outlet below the minimum water level and away from the vortex plate to avoid air entrainment. When this is not practicable then the pressure relief line shall enter the pump suction pipe at an angle of 90° at least10 pipe diameters upstream of the pump suction flange. There shall be an approved visual indicator of water flow in the pump relief line, or a valve position indicator on the pressure relief valve.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

4.4.6.5 *Other automatic control valves*

Listed automatic flow control valves shall be used for tasks on sprinkler systems where remote or automatic control of water is required. These tasks include the control of infill into supplementary tanks, quick discharge of installation pressure for remote hydraulic anti-interference devices, and so on.

4.4.7 *Deluge and pre-action valves*

4.4.7.1

Deluge valves which shall be of a listed type are employed to control the water supply to an array of open sprinklers or sprayers which are required to discharge simultaneously. The valve is normally held closed and is released automatically either by a loss of pressure from independent pipework carrying sprinkler heat detectors or initiated by the operation of an approved heat or smoke detection system. Alarm equipment is normally connected to the outlet pipework from the valve so that an alarm is given when water flows into the distribution pipework. See also 3.3.

4.4.7.2

Pre-action valves, which shall be of a listed type, are similar in use to a deluge valve except that the sprinkler pipework will be charged with gas under pressure and fitted with closed sprinklers. The normally closed valve is opened by the operation of a separate installation of detection sprinklers on small diameter, gas-filled pipework. See also 3.2.4.

4.4.8 *Drain valves*

4.4.8.1

Drain valves shall be fitted at the installation control valves to provide the functions of drainage, pressure switch testing where appropriate, comparative water supply testing.

4.4.8.2

A drain valve shall be fitted to the alarm valve, and shall terminate in a storm water sump or drain capable of disposing of the full open discharge of the drain valve without causing flooding in the building. Discharge of the drain test directly onto a sealed surface, such as a carpark, is permitted where the discharge will not cause damage or undue risk to the public

4.4.8.3

For installations from ELH up to and including OH3, the drain valve fitted to the alarm valve, and attached pipework shall be sized to allow the discharge of the highest design flow at the related design pressure. For OH3S, OH4, and EHH installations, the drain valve and attached pipework shall be 50 mm in diameter.

4.4.8.4

A drain valve shall be fitted downstream of the downstream main stop valve, and shall terminate in a foul water drain. The drain valve and associated pipework shall be sized to suit the system pipework it serves

4.4.8.5

The drain valves shall be clearly labelled and shall be locked or strapped shut.

4.4.8.6

The discharge pipe shall terminate in a sump or drain capable of disposing of the full open discharge of the drain valve without causing flooding in the building. Discharge of the drain test directly onto a sealed surface, such as a carpark, is permitted where the discharge will not cause damage or undue risk to the public.

4.4.9 *Air release valves*

For installations using wet pipe Type Y alarm valves, at least one air release valve shall be fitted to the installation, as required by the alarm valve manufacturer's installation, commissioning and servicing instructions

NOTE – A flow switch test valve or subsidiary stop valve drain valve may also serve this purpose, if so fitted.

4.4.10 *Water meters*

Water meters shall be listed. They shall be detector check valve style or of some other non-intrusive style.

4.4.11 *Town's main water supply strainer*

4.4.11.1

Where strainers are required on a town's main each strainer shall be listed, and shall be designed:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(a) To provide at least 25 mm^2 screen open area for each litre per minute of design flow, and not less than four times the cross sectional area of the supply pipe;
(b) With each orifice at least 1 mm smaller than the smallest sprinkler head or sprayer orifice used in the system which does not itself have a fitted strainer, but no smaller than 4 mm;
(c) To enable removal of the screen for cleaning;
(d) To be protected against corrosion;
(e) Marked with maximum working pressure, maximum rated flow, and direction of flow.

As part of the listing process, strainers shall be subjected to a pressure test to show that the strainer basket shall not deform when blocked. Strainers shall also be subjected to their maximum working pressure.

In addition, as part of the listing process, a flow test shall be carried out with the basket 50% blocked. The pressure loss characteristics shall be published and factored into the design calculations for the system.

4.4.11.2

Each strainer shall be installed on the connection from the town's main upstream of any combined main check valve and any backflow prevention unit. The strainer shall be upstream of fire pump and associated bypass and any fire pump preferably within, or directly adjacent to, the respective control valve or fire pump enclosure.

4.4.11.3

A pressure gauge shall be fitted immediately upstream of the strainer.

4.4.12 *Hazardous processes and explosion hazard – Special precautions concerning pipework, valves and the like*

In buildings or sections of premises in which particular hazardous processes are carried out or conditions exist which are liable to result in explosions:
(a) No sprinkler control valves shall be located within 6 m of such premises;
(b) There shall be arrangements whereby the sprinkler protection in the hazardous area may be quickly and independently shut down in the event that an explosion demolishes the mains within, or close by, the building. This shall be done in one of the following ways:
    (i) The hazardous area shall be protected by an installation that does not also protect a non-hazardous area
    (ii) The hazardous area shall be protected by an installation protecting non-hazardous buildings. In such cases, the sprinklers in the hazardous protected area shall be fed by a separate maindistribution pipe connected to the remainder of the installation immediately downstream of the alarm valve. A subsidiary stop valve located within the control valve enclosure shall be fitted to this main
    (iii) The hazardous area shall be protected by an installation that also protects non-hazardous areas. A separate connection to supply the hazardous area shall be made to a distribution pipe within the non-hazardous building at a point downstream of the last range supplied by that distribution pipe. Atfloor level, but within 3 m radially of the point of connection, there shall be an automatic pressure control valve and, immediately upstream of that, a subsidiary stop valve. All valves shall be readily accessible and in a well-lit position:
        (A) The pressure control valve shall be arranged to close down in the event that the flow through it exceeds 150% of the design flow in the hydraulically most favourably placed assumed area of operation in the hazardous building
        (B) Very careful attention is needed in setting the operating pressure of the automatic valve. The operating pressure shall be specifically approved. Adequate means of checking and testing its operation and pressure setting shall be provided
        (C) Prominent reference to the existence and location of the automatic valve and subsidiary stop valve shall be incorporated on the block plan;
(c) Sprinkler water supply pipes shall not be carried within these buildings or any locations subject to damage following collapse after an explosion;
(d) Water supplies, such as pressure tanks or gravity tanks shall not be housed therein.

4.4.13 *Check valves*

To facilitate maintenance the following check valves shall be an in-situ serviceable type (except where precluded by the need for a valve with anti-slam characteristics):
(a) All check valves greater than 50 mm;
(b) All check valves forming part of the floor isolate assembly on a safety enhanced valve set;
(c) Pump bypass;
(d) Pump deliver;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(e) Combined mains.

4.5 Enhanced safety valve set

Enhanced safety valve sets are designed to allow the alarm valve to be serviced without decommissioning the sprinkler system, or isolating the FBA. They also allow for increased floor areas per valve set, subject to conditions specified in 3.2.1.5. See 2.12.3.

An enhanced safety valve set shall consist of the following components:

(a) Normally open stop valves shall be fitted both upstream and downstream of the alarm valve. Both valves shall be locked and labelled and supervised in accordance with 4.4.2.4 and 4.4.2.5 as subsidiary stop valves, through the subsidiary stop valve isolation device, to allow authorised closing of the valves without isolation of the FBA. A durable label shall be fitted to the inside of the FBA cabinet door noting that the main stop valves are supervised through the subsidiary stop valve isolation switch;

(b) The FBA, installation pressure gauge, fire sprinkler inlet and any pump start lines shall be connected downstream of the second (downstream) stop valve;

(c) A bypass, of the same size as the main alarm valve, shall be fitted around the control valves. This shall incorporate:

  (i) A drip tight check valve in the case of Type X systems or a second alarm valve in the case of Type Y systems

  (ii) Locked and labelled, normally closed, supervised stop valves, both upstream and downstream of the check or alarm valve

  (iii) The supervised stop valves shall give a DEFECT signal when opened by more than two turns of the hand wheel

  (iv) For Type Y systems the hydraulic gong outlet shall be piped to the retard chamber, to give a rise in pressure alarm in accordance with 4.7.2.2.2. Check valves shall be installed on both gong outlets, to provide separation between alarm valves;

(d) The super-pressure pump or Type Y bypass shall be piped to downstream of the second (downstream) main stop valve;

(e) Clear testing, maintenance and isolation procedures, as agreed to by an SSC, shall be provided in a durable form and displayed in a conspicuous position adjacent to the control valves;

(f) A durable sign shall be mounted on the alarm valve as follows: ‘DO NOT CLOSE main stop valve. In the case of sprinkler activation or for service work use appropriate floor or sectional isolation valve – see block plan’.

A schematic diagram of this arrangement is shown in Figure 4.17.

NOTE –

(1) To maintain the enhanced safety features of these systems, it is important that service and maintenance personnel are familiar with this type of valve set when working on the installation. The water supplies and FBA functions should remain as fully operational as possible at all times.

(2) Refer to 3.2.1.5 for specific requirements when enhanced safety valve sets serve a floor area greater than 11 000 m^2.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

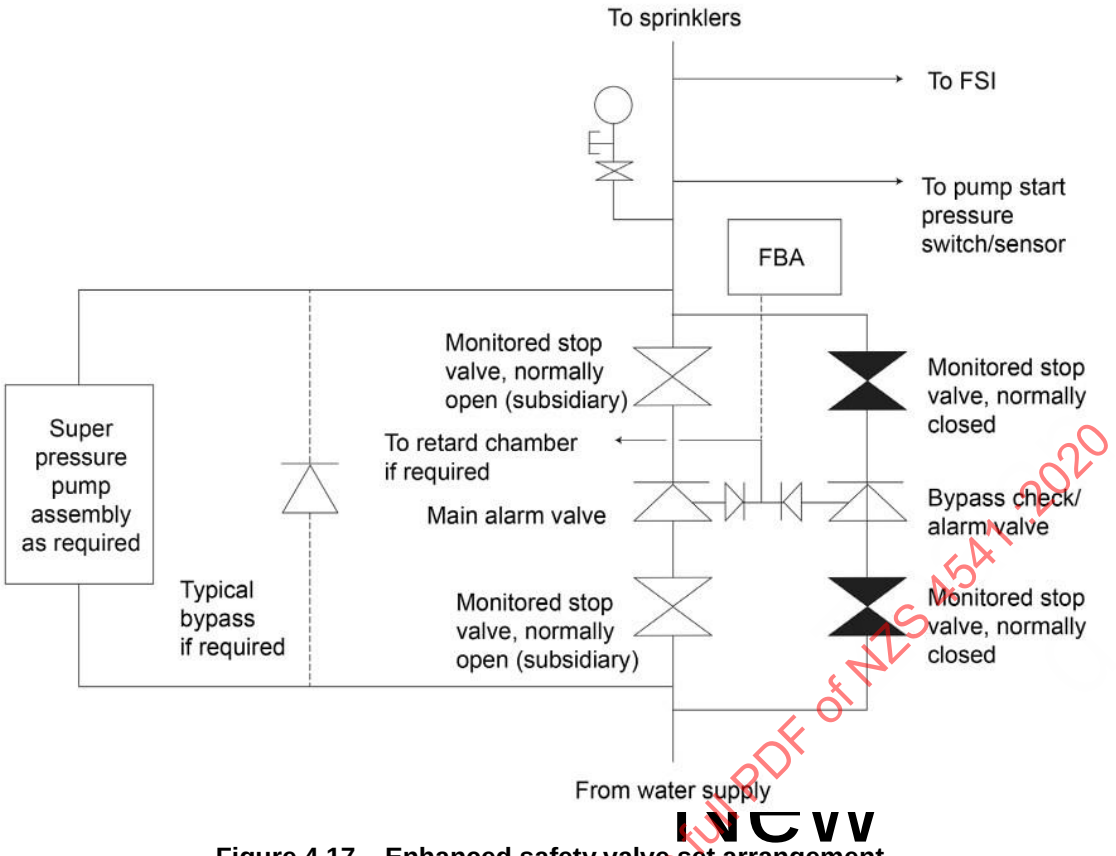


Figure 4.17 – Enhanced safety valve set arrangement

4.6 Pressure gauges

4.6.1

Each installation shall be fitted with an installation gauge which indicates the pressure above the alarm valves, and a FBA gauge which indicates the pressure on the FBA release mechanism.

4.6.2

Each system shall be fitted with a gauge indicating the pressure on the upstream side of each water supply back pressure valve or backflow prevention device.

4.6.3

The section of pipe immediately upstream of the main stop valve shall be fitted with a gauge indicating the single or combined main supply pressure.

4.6.4

Pressure gauges shall comply with the requirements of EN837, DIN 16005, or other equivalent Standard, shall be marked in kPa, and be not less than 90 mm nominal size.

4.6.5

The maximum scale value shall be of the order of 150% of the known maximum pressure. All gauges downstream of the alarm valve shall have the same calibration and maximum scale value. All water supply gauges shall have the same calibration and maximum scale value except pump suction gauges.

4.6.6

Pressure gauges shall be calibrated with divisions not exceeding:

(a) 20 kPa for maximum scale values ≤ 1000 kPa;
(b) 50 kPa for maximum scale values > 1000 ≤ 1600 kPa; and
(c) 100 kPa for maximum scale values > 1600 kPa.

4.6.7

The negative pressure section of compound suction gauges shall have divisions not exceeding 20 kPa.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

4.6.8

All pressure gauges shall be neatly and permanently labelled as to their purpose in such a manner that there is no possibility of the label fading, becoming detached from the gauge or fouling the operation of the gauge.

4.6.9

Special requirements for the location and marking of pressure gauges for fire sprinkler inlets are set out in 6.10.5.3.

4.6.10

A means of isolating a gauge shall be provided immediately below each gauge.

4.6.11

A permanent plugged fitting shall be provided between any normally pressurised gauge and the gauge isolation valve to allow the attachment of a test gauge.

4.7 Alarm devices

Every installation shall include, adjacent to the sprinkler valves, both an hydraulic water flow alarm and a FBA. An installation may also include a connection to an evacuation alarm and to flow switch indicators.

4.7.1 *Hydraulic water flow alarms*

4.7.1.1 *General*

The following requirements apply:

(a) The water flow alarm shall be a listed hydraulic gong, which detects and locally notifies water flow through the alarm valve;
(b) The gong shall be located outside the building as close as possible to the alarm valve. It shall be painted red and bear the words 'FIRE SPRINKLER ALARM' in contrasting letters;
(c) The water flow alarm shall not cause any signal to be transmitted to the fire brigade, except in the case of Type Y signalling.

4.7.1.2 *Hydraulic gong*

The following requirements apply:

(a) *Method of operation.* The device shall be actuated by the lifting of the alarm valve permitting water to flow to an hydraulic motor which directly operates the sounder;
(b) *Pipework.* The pipework shall comply with the listing requirements of the gong. The gong drain shall not be interconnected with the system drain except via an air gap;
(c) *Testing.* Means shall also be provided to permit testing of the gong without lifting the alarm valve;
(d) *Number.* Where there is more than one installation and the alarm valves are grouped together, one gong may serve two or more sets of control valves. Where there is more than one gong, each gong shall be numbered according to the installation it serves;
(e) A lockable isolation valve shall be fitted to permit isolation of the device. For a Type Y system, this isolation valve shall not isolate the rise-in-pressure alarm pressure device;
(f) Where any part of the of the pipework feeding this device is liable to exposure to sub-zero temperatures and can result in trapped water, a drain hole of not greater than 3 mm shall be located at a suitable point. The discharge from this drain shall be located as to not damage or stain the surrounding finishes.

4.7.2 *Fire brigade alarm*

4.7.2.1 *General*

This standard shall permit 2 types of fire brigade alarms (FBA.) The pressure rating of the sprinkler system components shall be compatible with the FBA type

The FBA shall comply with 4.7.2.2.1 (Type X) where the system is dry-pipe, pre-action or deluge;

The FBA shall be listed by the SSC as a complete assembly.

The FBA shall be mounted at between 1.4 m and 1.8 m to the top of the unit, above the finished floor level

NOTE –

(1) A diagram of a wet pipe control valve showing an acceptable arrangement for Type X signalling is given in Figure 4.18.

(2) A diagram of a wet pipe control valve showing an acceptable arrangement for Type Y signalling is given in Figure 4.19.

(3) A diagram of a dry pipe control valve showing an acceptable arrangement of signalling (see 4.7.2.2.1(b)) is given in Figure 4.20.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

4.7.2.2 *Types of fire brigade alarm*

4.7.2.2.1 Type X

FBA Type X shall be a listed device which interfaces to hydraulic connections to the sprinkler installation and to external alarm signal transport wiring and which:

(a) Detects, and is activated by, a drop in pressure in the installation and initiates an alarm signal. It shall be capable of detecting three different pressure states known as 'NORMAL', 'DEFECT', and 'FIRE';

NOTE – Where the brigade receiving equipment does not incorporate a facility to detect three different alarms states, or where the FBA is not connected to the fire brigade receiving equipment, the requirement in (a) above for a 'DEFECT' signal may be deleted.

(b) Generates, in the case of a dry pipe, pre-action or deluge system the various alarm states by either a drop in pressure or a rise in pressure or by a combination of the two and shall be subject to approval;

(c) Detects, and signals in the manner of a 'FIRE' call, unauthorised activation of supervisory devices on main and subsidiary stop valves. Authorised closure shall necessitate the transmission of a signal other than 'NORMAL' or 'FIRE' where the equipment has that capability;

(d) Consists of a lockable cabinet enclosing pressure switches/sensor(s), signal-generating devices and labelled isolation switches as required and, if no suitable alternative is provided, a space for the testing record book;

(e) Includes listed pressure switches/sensor(s) that:

(i) Are pressurised through a pipe incorporating a drilled check valve, pressure gauge and test valve (piped away to a suitable location) arranged to permit the operating pressures of the pressure switches/sensor(s) to be accurately set and subsequently checked

(ii) For wet installations are set and connected to the signal-generating device such that a 'FIRE' signal is generated at approximately 140 kPa above the highest supply pressure. A 'DEFECT' signal (if provided) shall be generated approximately 140 kPa above the fire pressure sensor setting and at pressures higher than that of a 'NORMAL' signal. The installation pressure shall be no less than 140 kPa above 'DEFECT' pressure. The actual settings shall be approved

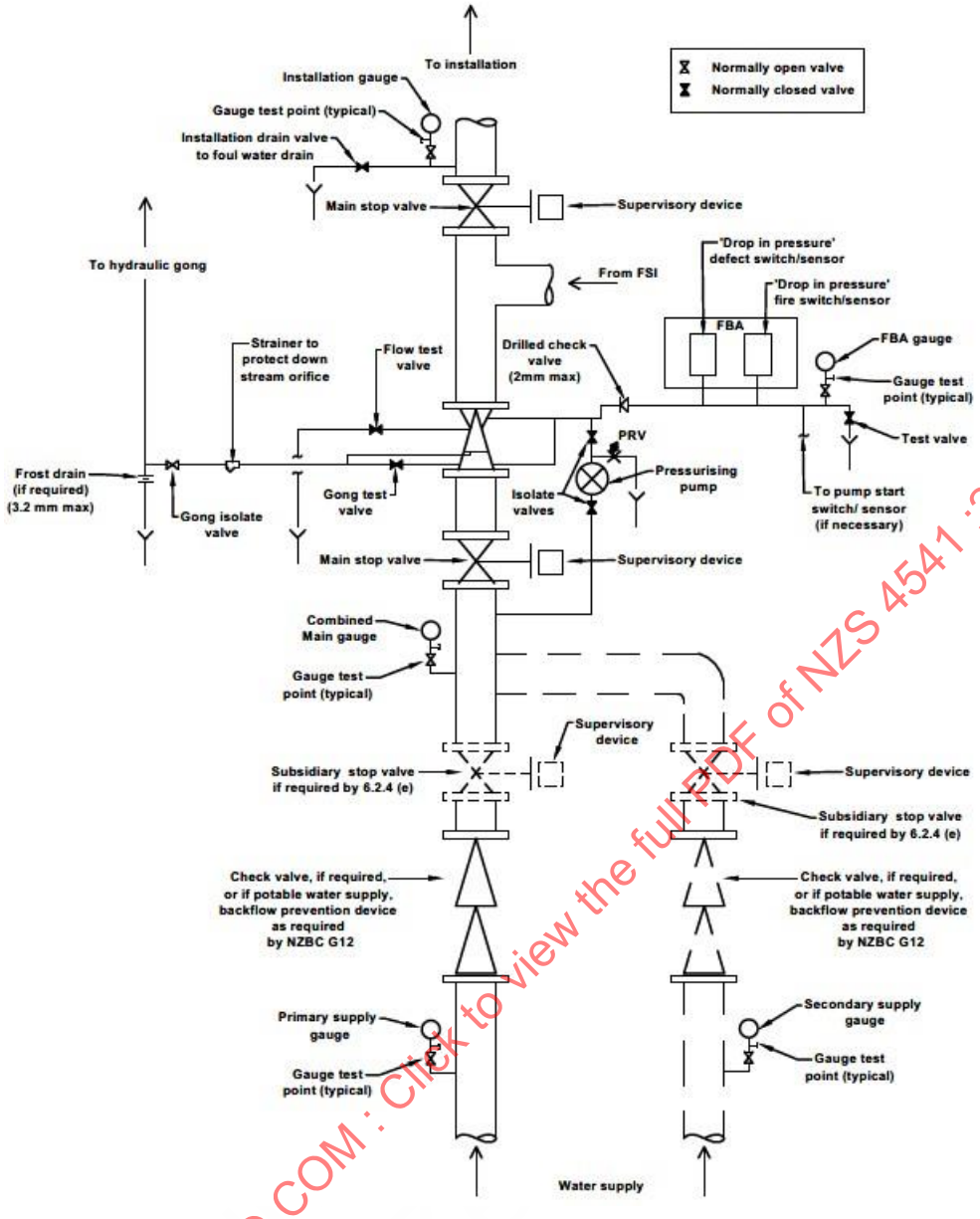
(iii) Have different differentials for dry pipe, pre-action, and deluge systems as may be appropriate. The settings shall also be approved;

(f) Includes a signal-generating device of a listed type and, where it is connected to the fire brigade receiving equipment, it is also authorised for use by the fire brigade. Stop valves are not permitted in pipes connected to pressure switches/sensor(s).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



NOTE –

(1) Backflow prevention devices require valves upstream and downstream for testing and maintenance purposes. If fit for purpose, the street valve and main stop valve may meet this need. Alternatively, additional supervised valves will need to be installed.

(2) This illustration is for guidance only. In the event of any disparity the requirements of this standard take precedence.

Figure 4.18 – Wet pipe control valve showing an acceptable arrangement for type 'X' signalling complying with 4.7.2.2.1

4.7.2.2.2 Type Y

FBA Type Y shall be a listed device which interfaces to hydraulic connections to the sprinkler installation and to external alarm signal transport wiring and which:

(a) Detects, and is activated by, a pressure rise in the hydraulic alarm gong line and also by a drop in pressure to 140 kPa above the highest installation design pressure required at the alarm valve. In the case of a rise in pressure in the gong line, the alarm shall be activated within 60 s of the lifting of the alarm valve seat. The equipment shall be capable of signalling two states known as 'FIRE' and'NORMAL';

(b) Detects and signals in the manner of a 'FIRE' call, unauthorised activation of supervisory devices on main and subsidiary stop valves. Authorised closure shall necessitate the transmission of a signal other than 'NORMAL' or 'FIRE' where the equipment has that capability;

(c) Is arranged as shown in Figure 4.19 and:

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

(i) Has a lockable cabinet housing pressure sensor(s), signal-generating devices, labelled isolation switches as required and, if no suitable alternative is provided, a space for the testing record book

(ii) Additionally, provides protection against false alarms being generated via transient pressure surges. This requirement shall be achieved by either:

(A) Providing a hydraulic retard system including the provision of one or more retard chambers installed in the gong line between the alarm valve and the gong valve, so sized and designed as to retard the rise in pressure as a consequence of transient openings of the alarm valve. The retard chamber shall incorporate a permanent drain and the drain, inlet pipe, and chamber shall be so sized and designed as not to retard the transmission of a FIRE signal more than 20 s after the alarm valve lifts in response to one sprinkler head opening and the satisfactory operation of the gong, or

(B) By providing an electronic retard system, including the installation of a listed pressure sensor, incorporated with an integral electronic time delay function, installed in the lockable cabinet described in (i). The gong line shall include a drain, complete with orifice to allow any trapped water to automatically drain

(iii) A piped connection shall be provided in parallel and bypass the alarm valve. This bypass trim shall be of a size specified by, and use a check valve supplied by, the alarm valve manufacturer for this purpose

(iv) Test devices (piped away to suitable locations) and pressure gauges shall be provided for both the rise in pressure and drop in pressure alarm functions and be labelled accordingly. These shall permit the operating pressures to be accurately set and subsequently checked. Generally, they shall be arranged as shown in Figure 4.19 including orifices and check valves. Stop valves are not permitted in pipes connected to pressure switches. An inspector's test valve complete with orifice equivalent to the smallest sprinkler shall be installed to prove that single head flow will generate a fire call

(v) Pressure sensors shall be of a listed type;

(d) Includes a signal-generating device of a listed type and, where it is connected to fire brigade receiving equipment, is also authorised for use by the fire brigade.

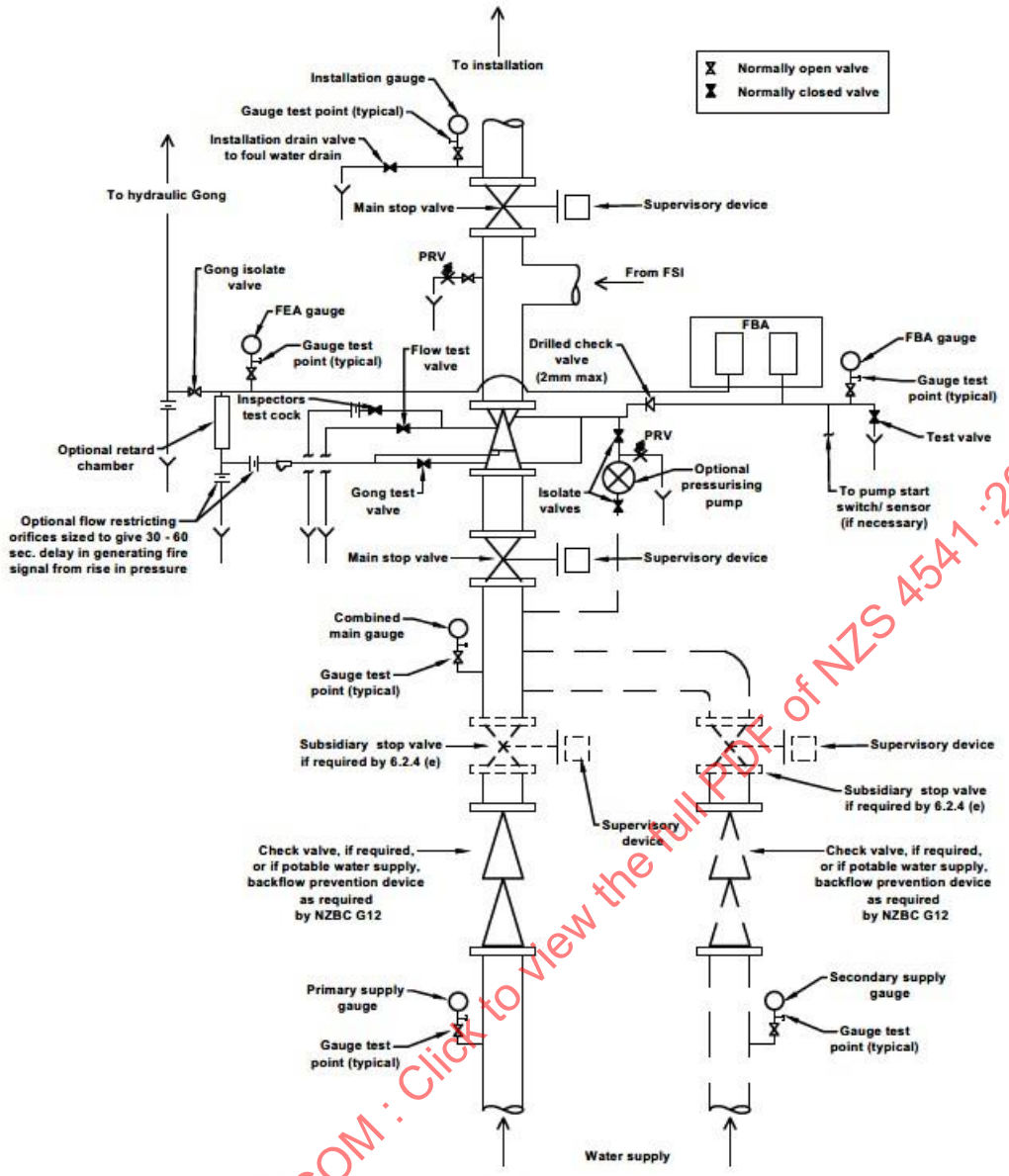
A super-pressure pump may be fitted to the valve set trim to allow the installation pressure to be raised as a means of reducing false alarms. Where this pump is automatically controlled its discharge rate shall be limited to ensure that single head flow generates a fire signal. The installation pressure shall not be raised above the pressure rating of the components installed in the sprinkler system.

NOTE – Type X systems generally provide better immunity to false alarm generation, when compared to Type Y systems. Most fire protection equipment has a maximum pressure rating of 1200 kPa. Some sprinkler heads, valves and pipe couplings are available with pressure ratings in excess of 1200 kPa. It is recommended that if the use of such equipment will avoid the use of Type Y alarms, that such equipment be used.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



NOTE –

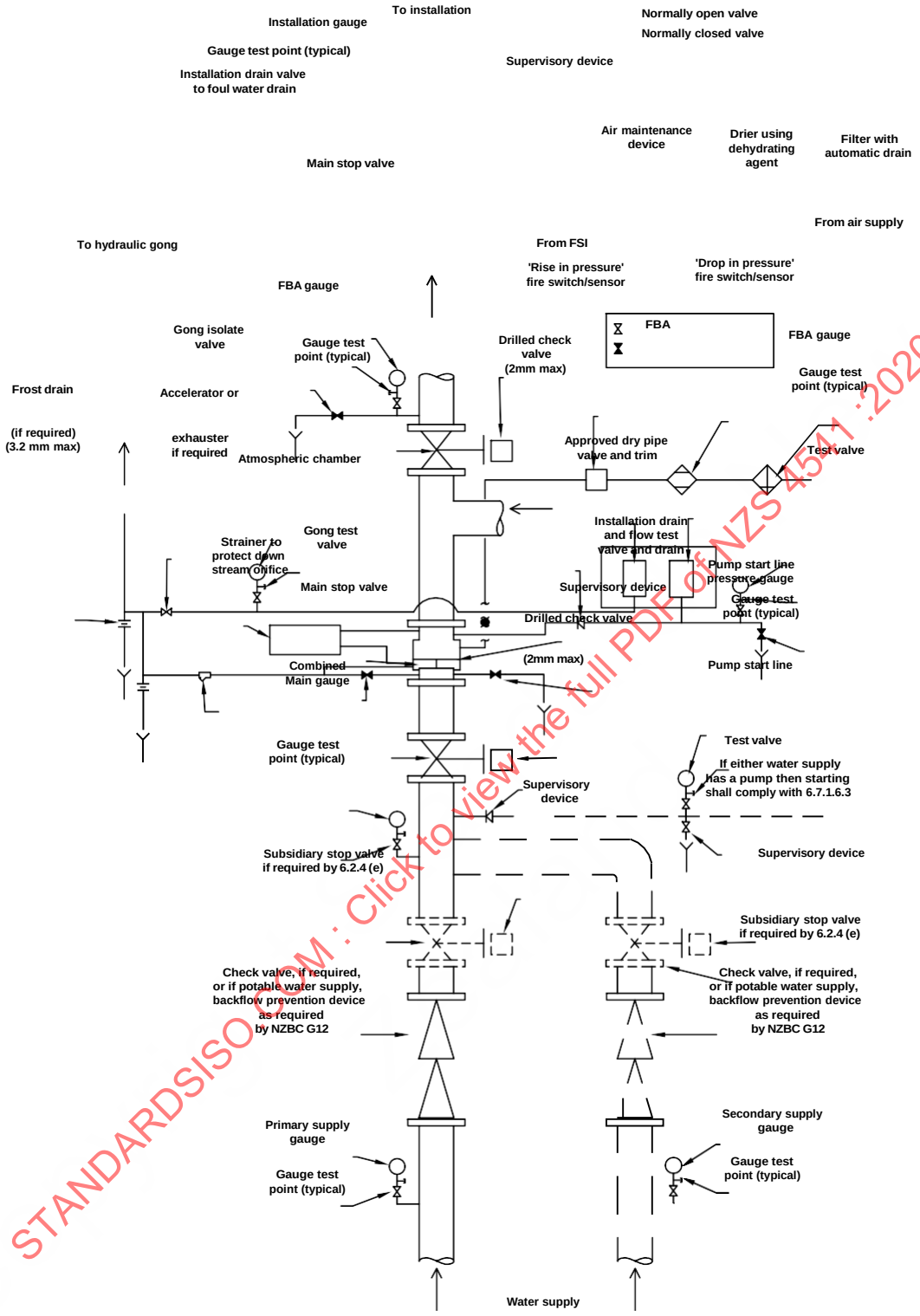
(1) Backflow prevention devices require valves upstream and downstream for testing and maintenance purposes. If fit for purpose, the street valve and main stop valve may meet this need. Alternatively, additional supervised valves will need to be installed.

(2) This illustration is for guidance only. In the event of any disparity the requirements of this standard take precedence.

Figure 4.19 – Wet pipe control valve showing an acceptable arrangement for type 'Y' signalling complying with 4.7.2.2.2

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



NOTE –

(1) Backflow prevention devices require valves upstream and downstream for testing and maintenance purposes. If fit-for purpose, the street valve and main stop valve may meet this need. Alternatively, additional supervised valves will need to be installed.

(2) This illustration is for guidance only. In the event of any disparity the requirements of this standard take precedence.

Figure 4.20 – Typical dry pipe control valve arrangement

4.7.2.2.34.7.2.2.3

It is permissible to utilise a fire alarm control panel compliant to NZS 4512, to provide the monitoring of devices as per clauses 4.4.2.4, 4.4.2.5, and 4.7.4. This panel shall be dedicated solely for fire sprinkler equipment, and

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

It is not permitted to perform functions undertaken by the building fire alarm.

If a fire control panel is utilised, it is also permissible to monitor the system pressure switches, provide brigade isolation features, and provide brigade monitoring features normally undertaken by a sprinkler FBA.

NOTE – The fire control panel is to enable easier monitoring and fault finding of monitored devices. It is expected that on installations where there are large quantities of devices to be monitored, an Analogue Addressable system will be utilised, so that identifying a faulty switch is easier due to the text features on LCD displays.

4.7.2.3 *Connection to the fire brigade*

The FBA shall be transmitted automatically to an alarm service monitoring provider contracted to the fire brigade to monitor private alarms. Transmission may be via dedicated data circuits (whether multiplexed or not) or via data-over voice circuits where digital packet networks facilities are available. ‘Fire’ signals shall be

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

annunciated automatically, either in a manned fire brigade control room, or cause automatic activation of mobilising alarms at an unmanned fire station. ‘Normal’, ‘defect’, ‘isolate’ and other supervisory alarms shall be annunciated either at the same place as the ‘fire’ signal or at some other location provided that procedures exist to promptly initiate appropriate action in response to such signals and provided that the fire brigade can exercise control over, and have means of monitoring the correct performance of such procedures.

4.7.2.4

An SSC may determine that due to such factors as distance, the absence of suitable receiving equipment, or an adequate signalling path, connection of the FBA to remote brigade receiving equipment is not practicable. In such situations alternative sustainable measures and a testing regime shall be provided, to the satisfaction of the SSC, to reliably annunciate and elicit an appropriate response to ‘Fire’ and ‘Defect’ conditions.

4.7.2.5 *Fire brigade alarm power supply*

The power supply for the FBA shall be via a listed device dedicated to or incorporated in the FBA and complying with the relevant requirements of NZS 4512.

4.7.3 *Evacuation alarms*

4.7.3.1 *General*

Where a sprinkler-protected building is fitted with a system of evacuation alarms, the sprinkler installation should be connected in such a way as to cause the evacuation alarms to operate on activation of the FBA fire signal. This connection shall not cause the system of evacuation alarms to transmit a signal to the fire brigade.

When staged evacuation is controlled via flow switches, the evacuation silence signal shall be controlled from the sprinkler FBA. There should be no need to isolate the fire panel to prevent evacuation signals from flow signals.

When the FBA can actuate the evacuation alarms, it shall incorporate on the FBA, an external evacuation sounders cut off key switch. This switch shall be ‘Bulgin 6083/C’ patterned, and clearly designated ‘SILENCE ALARMS. BRIGADE USE ONLY’. Operation of this switch shall generate a defect signal via the FBA, it shall not generate a defect warning via the fire alarm system.

While this standard does not mandate the interconnection of sprinkler installations with evacuation alarms, it is anticipated that normal practice would be to ensure that the building is partially or completely evacuated on sprinkler activation.

4.7.3.2 *Testing*

The connection to the evacuation alarm shall be made in such a way as to permit both the evacuation alarm alerting devices and the sprinkler system to be isolated or rendered inoperative without the need to isolate or render inoperative the other system. All alerting devices activated by the fire sprinkler system shall be isolated by a switch located in the cabinet described in 4.7.2.2.1(d) or 4.7.2.2.2(c)(i), as applicable.

4.7.4 *Flow switch indication*

In certain cases, this standard requires flow switches to provide indication of the section of the sprinkler installation which is operating (see 2.11.1). Flow switches shall be listed. Flow switches shall incorporate a test facility with orifice size not greater than the smallest nominal sprinkler or nozzle orifice used in that partof the sprinkler installation and this shall discharge via fixed pipework into a permanent drain. The valves controlling the test facility shall be labelled and strapped in the closed position.

NOTE – To ensure that the flow through this assembly will allow the flow switch to be tested, the drain pipework will require to be adequately sized.

Flow switches shall not be installed in series, in combination with Boolean logic to determine which section of a sprinkler installation has operated.

Flow switch indicators shall not be used to generate a signal to the fire brigade.

Flow switch test drains shall be installed such that they can be operated without need for access equipment.

4.7.5 *Pressurising pumps*

4.7.5.1 *Manual pressurising pumps*

In any sprinkler system that contains a Type X FBA (see 4.7.2.2.1) there shall be installed an electrically driven pressurising pump that is connected to each Type X installation so that the water pressure in the

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

installation can be raised to a minimum of 100 kPa above the system's designed standing pressure, without any fire pump running concurrently.

A sprinkler system that contains a Type Y FBA (see 4.7.2.2.2) may be fitted with a pressurising pump to minimise pressure surges and false alarms

The pressurising pump may be positive displacement or rotodynamic (centrifugal). The pump electric motor shall be fitted with a thermal overload switch. If not hard wired, a power outlet shall be installed adjacent to the pump.

The pressurising pump shall be connected to the sprinkler installation downstream from the alarm valve through a normally closed drip-tight isolation valve. This valve shall provide backflow prevention capability when open, or alternatively a non-return valve shall be fitted.

An isolation valve shall be fitted on the input side of the pump to enable the pump to be removed for service.

A pressure relief valve shall be fitted between the pump and the downstream isolation valve. It shall be set to limit the maximum pump output pressure to 100 kPa above the system's designed standing pressure.

NOTE –

(1) The pressurising pump should be sized to pump the sprinkler system from the highest no-flow delivery pressure of the water supply up to the installation standing pressure in a period not exceeding 1 hour.

(2) In the case of antifreeze and tail-end antifreeze systems the pressurising pump for the antifreeze component of the installation shall be sized to fill the installation and charge it up to its standing pressure in a period not exceeding 1 hour.

4.7.5.2 *Automatic pressurising pumps*

With the approval of the SSC, an automatic pressurising pump and pressure relief valve may be used as a means to overcome thermally induced pressure fluctuations in the sprinkler system. Automatic pressurising pumps shall not be used as a means of compensating for leaks.

The pressurising pump shall be of the rotodynamic (centrifugal) type. The pump electric motor shall be fitted with a thermal overload switch. If not hard wired, a power outlet shall be installed adjacent to the pump.

The pressurising pump shall be configured for automatic operation via a pressure switch and will have its discharge restricted by a 3 mm orifice to prevent flow through the pressurising pump masking the operation of a sprinkler.

A bypass shall be provided around the restricted orifice and shall be fitted with a closed and locked valve which shall be supervised to generate a defect call via the FBA when opened.

The automatic pressurising pump shall be configured as shown in Figure 4.21 where it is connected to a single sprinkler installation or Figure 4.22 where it is connected to multiple sprinkler installations.

NOTE – When considering an application for the installation of an automatic pressurising pump, the SSC may require a hydrostatic test to be carried out to confirm that the sprinkler system is free of leaks.

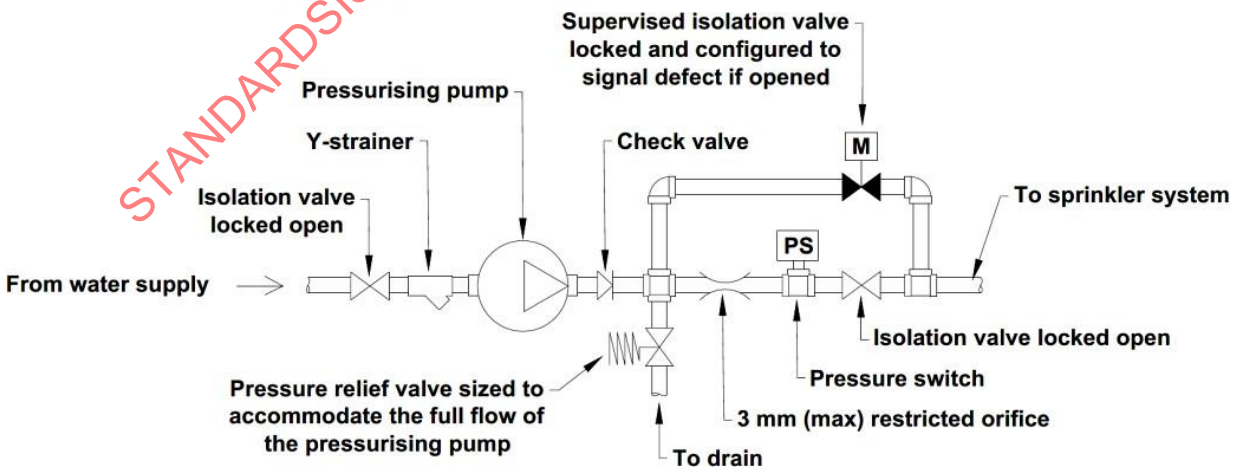


Figure 4.21 – Arrangement for single sprinkler system

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

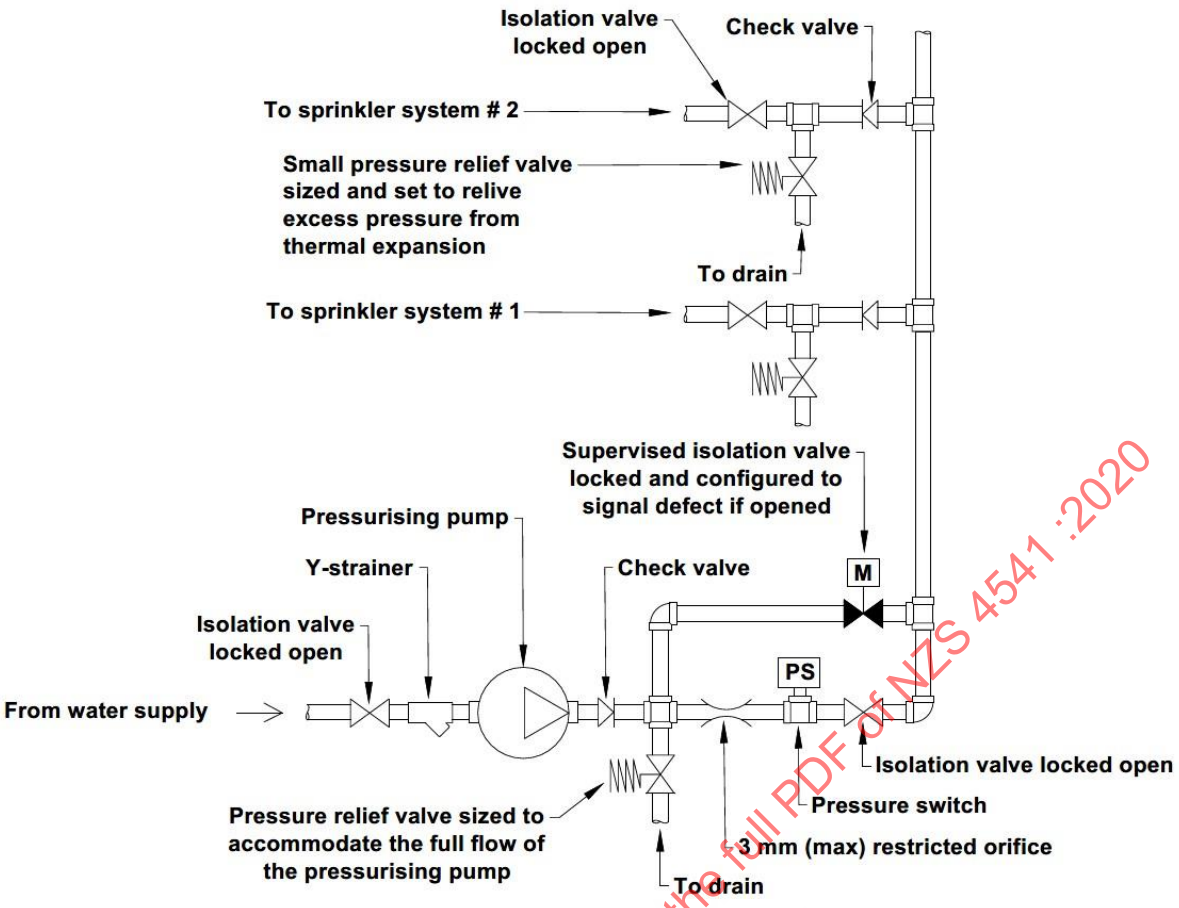


Figure 4.22 – Arrangement for multiple sprinkler systems

4.7.6 *Pressure switches and pressure sensors*

4.7.6.1 *Definitions*

A pressure sensor is a form of sensor that produces a scalable output (such as a change in resistance) in response to applied input pressure. The signal from a pressure sensor may be processed by other electronic devices and used to make electrical contact when a certain set pressure has been reached.

A pressure switch is a mechanical switch that makes electrical contact when a certain set pressure has been reached on its input.

4.7.6.2 *Types of pressure switch*

The following list describes the types of pressure switch:

(a) Single pole single throw (SPST): A simple on-off switch with a single set of contacts.
(b) Single pole double throw (SPDT): A simple change-over switch where a common terminal is connected to one of two alternative terminals dependent on the position of the switch.
(c) Double pole single throw (DPST): Equivalent to two SPST switches controlled by a single mechanism with the contacts closing together.
(d) Double pole double throw (DPDT): Equivalent to two SPDT switches controlled by a single mechanism with the contacts closing together.

4.7.6.3 *Listing*

All pressure switches and sensors shall be listed for their intended use. Where a combination of a pressure sensor and other electronic components are used to make an electrical contact for pump starting, supervision or alarm signalling then all parts shall be listed as a combined unit (for example, if a pressure sensor is used as part of a FBA or a fire pump controller, the sensor shall be listed as part of the entire assembly).

NOTE – NZS 4512 details tests used for fire alarm panels which could be used as guidance by an SSC in listing a pressure sensor as part of FBA or pump controller. Further guidance for listing can be found in FM Approval Standard 1321 and 1323 section 5.9.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

4.8 Storage height limitation indicators

4.8.1

Where there is a potential for storage to exceed the heights for which the system was designed, an SSC may require signs or other visual height indicators complying with 4.8.2 to be fitted which notify building occupants as to the maximum height of storage permitted and to warn against exceeding that height.

An SSC may approve alternative means of indicating storage heights, provided they give a clear and unambiguous indication of the maximum storage height permitted.

4.8.2

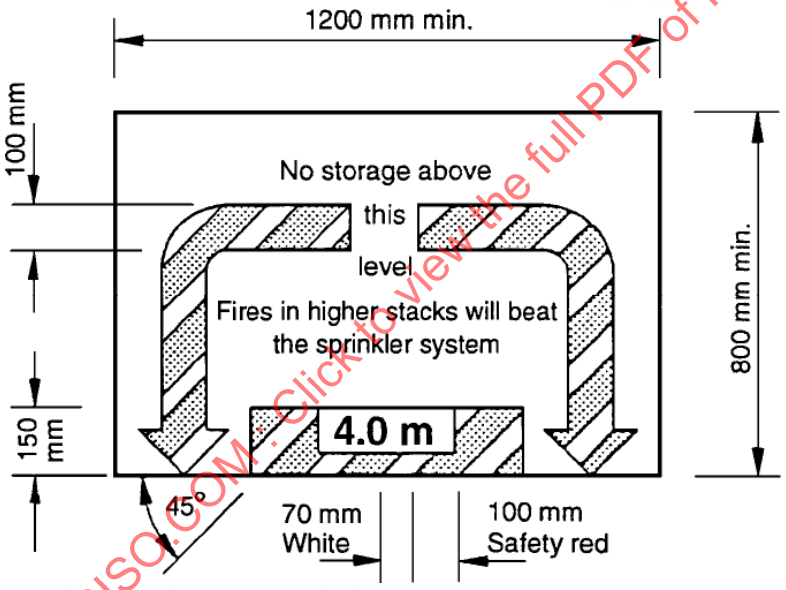
The bottom of signs or indicators shall be at the highest level to which the storage is permitted.

Such signs shall be installed to the satisfaction of an SSC at such spacing as to be readable from all points of the open floor and 90% of any aisleways formed.

4.8.3

In cases where there is a single category of storage involved or where the racks or stacks are known to contain a mixture of goods of different categories, the wording shown in Figure 4.23 shall be used based upon the most hazardous category.

Where there are, within one area, stacks or racks containing goods of a single category and other stacks or racks containing goods of another category, the wording and arrangement of signs shall be to the satisfaction of an SSC.



NOTE – The 4.0 m height limitation shown is an example only. In use the actual height limitation appropriate to the situation will be shown.

Figure 4.23 – Storage height limitation sign

4.9 Aerosol warning signs

4.9.1

Where levels 2 and 3 aerosol products, packaged in cartons, are stored or handled, an SSC may require signs to be fixed around areas of designated aerosol storage to notify building occupants that these products shall be kept within the areas that have been designed to cope with this fire load.

4.9.2

Such signs shall be metal or substantial sheet material and shall be painted in White with Black lettering and the Safety Red circle (and slash) shall be outlined in Black, as detailed in Appendix Q. Safety Red to be Shade No. 537 to NZS 7702 or 04 E 53 of BS 5252.

4.9.3

Such signs shall be installed to the satisfaction of an SSC at such spacing as to be readable from all points approaching the designated area and from 90% of any aisleway within the designated area. Prohibition signs

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

shall be positioned on all storage racks or storage areas immediately adjacent to the designated aerosol storage area.

4.10 Labelling

4.10.1

The function of the following sprinkler system components shall be labelled:

(a) Gauges;
(b) Switches;
(c) Valves;
(d) Other pump unit components intended to be operated;
(e) Components that are non-standard; and
(f) Other components as specified elsewhere in this standard as requiring labels.

Where the component is intended to be manually operated (either in the event of system operation or as part of testing), labelling shall indicate:

(g) The normal position (for example 'Normally closed');
(h) Any requirement for the component to be operated in certain conditions (for example 'Open before testing'); or
(i) The position that the component is to be returned to before recommissioning of the sprinkler system.

Labelling of gauges shall indicate any specified maximum or minimum values, set points (for example pressure switch settings) or permitted or normal ranges.

Where pressure reducing or press relief valves are used, a label shall be attached to the valve detailing its:

(j) Function;
(k) Set pressure (that is, pressure to open or close);
(l) Status (that is, normally open or normally closed); and
(m) Duty flow.

4.10.2

The form of all labelling shall comply with the following:

(a) Labelling (including related shading) shall be indelible, made of permanent materials, and permanently fixed in a readily viewable position that does not obscure information such as the scale or measurement units of a gauge, or impede the correct functioning of the component. Labels shall not have sharp edges;
(b) Subject to the foregoing, metal, thermoplastic, and semi-rigid plastic are suitable materials as are self-adhesive films, or similar products. Felt markers, ink pens, or similar shall not be used;
(c) Lettering or other markings shall be in a durable form such as engraving, be waterproof, oil and solvent resistant, resistant to fade, and letters and numbers be at least 4 mm high in bold, contrasting colours; and
(d) Fixing shall be by cable ties, metal screw/bolt, metal jubilee clip, twisted single strand wire, or crimped wire multi strand. Strong adhesives may be used subject to these being suitable for the environment.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

5 Location of sprinklers

5.1 General

5.1.1

This part provides guidance for the installation of sprinklers other than storage sprinklers. The installation requirements for storage sprinklers are provided in 9.4.

5.1.2

In addition to meeting the limitations specified for the maximum area coverage per sprinkler and the maximum distance between sprinklers, they shall be so located that there will be minimum interference to the discharge pattern by structural members, such as beams, columns, girders, and trusses, or any other obstructing feature. Also, sprinklers shall be located at the appropriate distance below ceiling and beams as required in 5.3.

NOTE – For further information on measurements converted to metric values see 1.2.

5.2 Walls and partitions

5.2.1

Except as provided for in 5.2.4, 5.4, and 5.9, the distance of sprinklers from walls and partitions shall not exceed half the maximum allowable distance between sprinklers or half the design spacing, whichever is the less

5.2.2

Where an external wall is omitted, the distance of sprinklers from the outer edge of the roof or ceiling structure shall not exceed half the design spacing

5.2.3

No sprinkler shall be placed with its axis closer than 100 mm from a window, wall, partition, or beam, except horizontal sidewall sprinklers mounted through the wall or beam.

5.2.4

The requirements of 5.2.1 shall not apply for spray sprinklers where the walls are angled or irregular. The maximum horizontal distance between the sprinkler and any part of the floor protected by the sprinkler shall not exceed 75% of the maximum spacing between sprinklers allowed, provided the maximum perpendicular distance is not exceeded (see Figure 5.1).

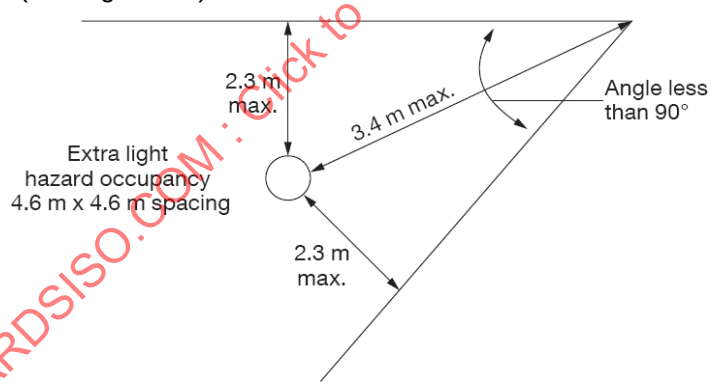


Figure 5.1 – Example of application of 5.2.4

5.2.5 *Shadowed areas*

The cumulative dry area of shadowed areas in the protection area of a sprinkler shall not exceed 1.5 m^2 per sprinkler.

NOTE – It is not intended or expected that water will fall on the entire floor space of any occupancy. When obstructions or architectural features interfere with the sprinkler's spray pattern, such as columns, angled walls, wing walls, slightly indented walls, and various soffit configurations, shadowed areas can occur. Note that small shadowed areas formed on the floor adjacent to their referenced architectural features are purely on paper and do not take into account the dynamic variables of sprinkler discharge. Examples of acceptable shadowed areas are shown in Figures 5.2(a) and (b).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

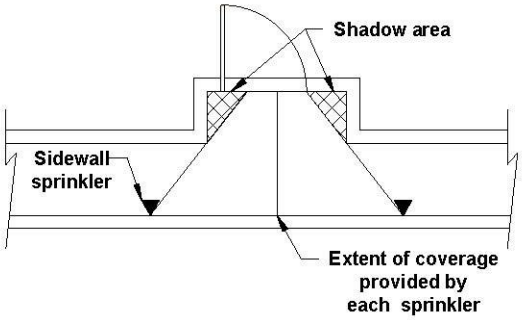


Figure 5.2(a) – Shadow area in corridor

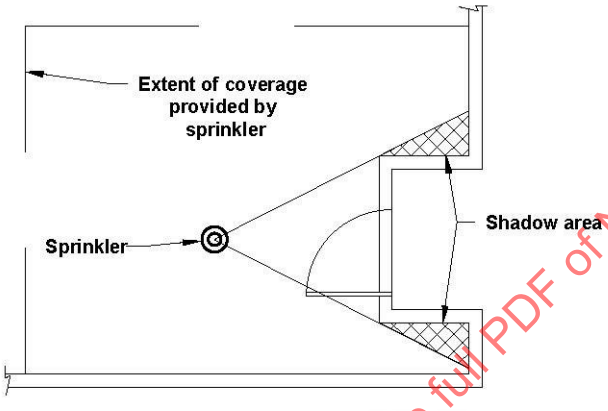


Figure 5.2(b) – Example of a shadow area

5.3 Ceilings and roofs

5.3.1

Sprinklers shall be positioned below the underside of ceilings, roofs, or equivalent surfaces in accordance with the listing details for the sprinkler.

If there are no specific limitations described within the listing, the centre line of the heat activated element shall be located not greater than 150 mm below the underside of any ceiling, roof, or equivalent surface. Under the following circumstances, this distance may be increased up to the maximums shown as follows:

(a) Continuous structural or architectural members contiguous with the ceiling, roof, or equivalent surface above, running in two directions, forming bays of area:
  (i) Not greater than 30 m^2 ..... 450 mm
  (ii) Greater than 30 m^2 but less than 100 m^2 ..... 350 mm;

(b) Continuous structural or architectural members contiguous with the ceiling above, running in onedirection only:
  (i) At spacing on centres not greater than 900 mm ..... 450 mm
  (ii) At spacing on centres greater than 900 mm but less than 2300 mm ..... 350 mm;

(c) Notwithstanding (a) and (b) above, 150 mm below the underside of any continuous structural or architectural members, contiguous with the ceiling, roof, or equivalent surface above (see Figure 5.3).

NOTE –

(1) The above requirements do not apply to residential, ECOH, suppression mode, and CMSA sprinklers.

(2) In this context, the intent of contiguous is to prevent the significant transfer of hot gases above the structural elements. It is acceptable to have small gaps, such as in tray deck construction on top of steel beams.

The placement of sprinklers below any ceilings, roofs, or equivalent surfaces that do not conform to the above criteria shall be assessed and approved by the SSC on a case-by-case basis. . In determining approval, an SSC shall consider whether the speed of detection is slower than would be the case with one ofthe options detailed above.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

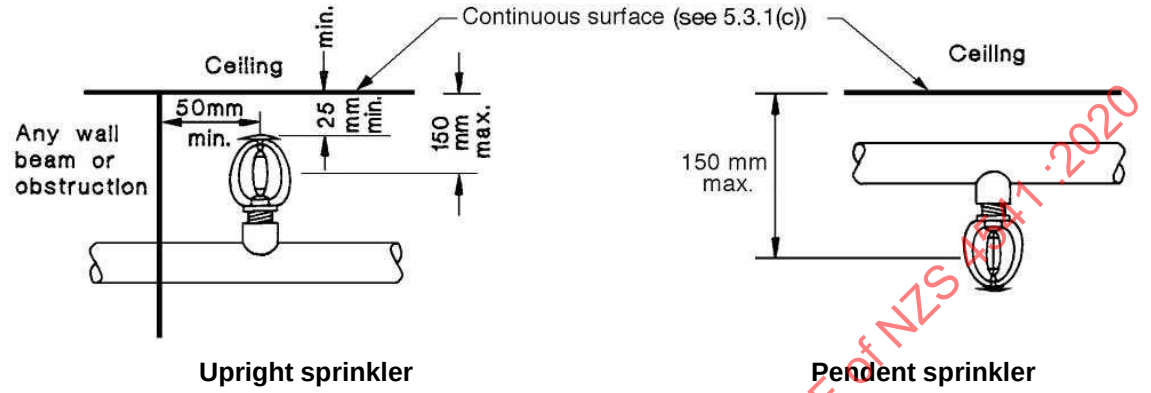
COPYRIGHT © Standards New Zealand

5.3.2 *Deflector orientation*

Deflectors of sprinklers shall be parallel to the slope of the ceiling, roof, or incline of stairs. Sprinklers installed upright shall have at least 25 mm clearance between their deflectors and any plane surface directly above them (see Figure 5.3).

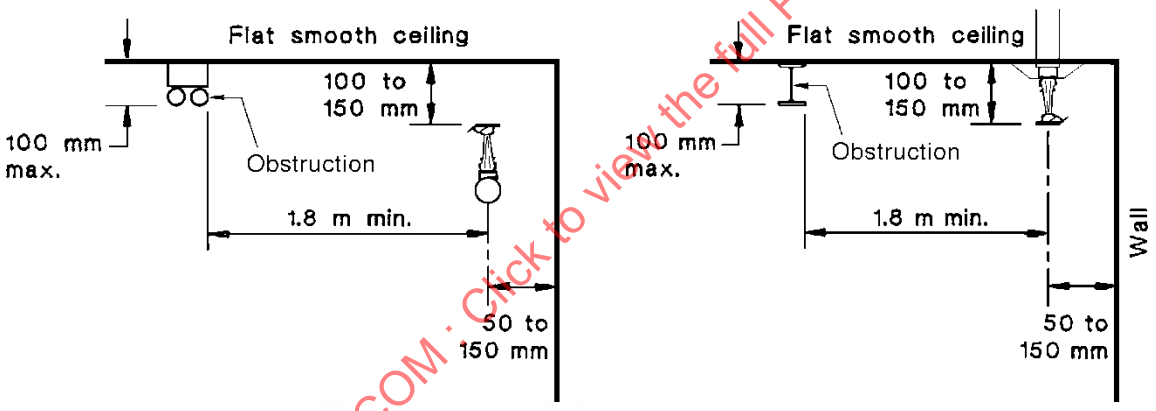
5.3.3 *Steeply sloped ceilings*

Where both the slopes are greater than one in three, a line of sprinklers shall be fixed at the apex unless there is a row of sprinklers not more than 750 mm distant radially from the apex. The valley at the intersect ofthe projection of such roof slopes shall be deemed to be the line of a wall for the purpose of 5.2.1 (see Figure 5.3).



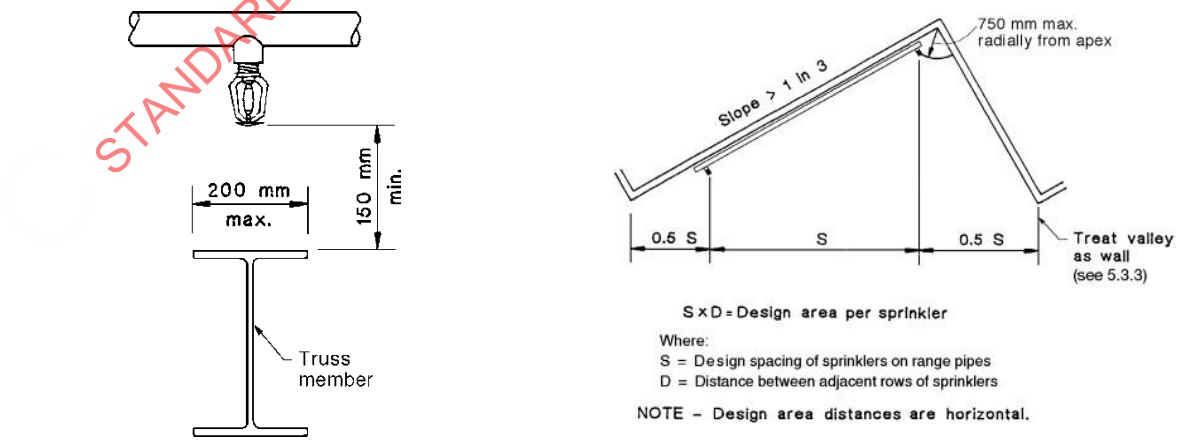
Upright sprinkler **Pendent sprinkler**

(a) Distance below ceiling – see 5.3.1



Standard sidewall upright **Standard sidewall pendent**

(b) Location of standard sidewall sprinklers – see 5.9.1.1



(c) Open roof trusses – see 5.8.2 **(d) Sloping ceilings – see 5.3.3 and 5.5.2**

Figure 5.3 – Positioning of sprinkler heads

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

5.3.4 *Ceiling pockets*

Sprinklers may be omitted in ceiling pockets where all of the following are met:

(a) The compartment is not a sleeping occupancy;
(b) The volume of the unprotected ceiling pocket does not exceed 30 m^3;
(c) The depth of the unprotected ceiling pocket does not exceed 900 mm;
(d) The entire floor under the unprotected ceiling pocket is protected by sprinklers at the lower ceiling elevation;
(e) The cumulative volume of all unprotected ceiling pockets in the same compartment within 3 m of each other does not exceed 30 m^3;
(f) The unprotected ceiling pocket has non-combustible or limited-combustible finishes; and
(g) Quick response sprinklers are used throughout the compartment.

NOTE – A painted gypsum plasterboard finish is deemed to be of limited combustibility.

Table 5.1 – Spacing arrangements

Hazard classification	***Maximum spacing*** (m)	***Maximum area*** (m^2)
Extra light	4.6	21
Ordinary, density ≤ 10 mm/min	4.6	12
Ordinary, density > 10 mm/min	3.7	9.3

5.4 Position of sprinklers

5.4.1

Unless otherwise listed, sprinklers shall not be spaced closer than 1.8 m apart, except where intervening constructional features provide a satisfactory baffle or where special baffles as described below are installed, to prevent the first sprinkler operating and wetting adjacent sprinklers.

Baffles should be 200 mm wide and 150 mm high and be of a strong rigid material. They should be located between the sprinklers and arranged to baffle the actuating elements. When placed on range pipes, the top of the baffles should extend above the deflectors by 50 mm to 75 mm.

5.4.2

Where sloping ceilings or roofs are concerned, the spacing measurements shall be taken horizontally (see Figure 5.3(d)).

5.5 Vertical obstructions to sprinkler discharge

5.5.1 *Obstruction to umbrella discharge pattern of non-storage sprinklers*

Where sprinkler deflectors are above the level of the bottom of beams, joists, light fittings, ducts, or other objects that could obstruct the umbrella pattern of the sprinkler, the sprinklers shall either be at a sufficient horizontal distance (as defined by Table 5.2), with regard to the relative levels of the deflector and base of the obstruction, or the obstruction treated as a wall or partition. Special requirements apply to residential sprinklers (see 5.5.5) and sidewall sprinklers (see 5.9).

NOTE – Attention is drawn to the need to comply with 5.3.1 and 5.5.1.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 5.2 – Sprinkler distances from obstructions

Minimum horizontal distance from sprinkler to side of obstruction (mm)	Maximum height of sprinkler deflector above bottom of obstruction		Minimum horizontal distance from sprinkler to side of obstruction (mm)	Maximum height of sprinkler deflector above bottom of obstruction	
	Conventional sprinklers installed upright (mm)	Spray sprinklers (upright and pendent types) and conventional sprinklers installed pendent (mm)		Conventional sprinklers installed upright (mm)	Spray sprinklers (upright and pendent types) and conventional sprinklers installed pendent (mm)
100	–	0	1000	90	300
200	17	0	1100	110	365
300	25	50	1200	135	425
400	34	70	1300	170	500
500	42	100	1400	200	565
600	51	125	1500	230	650
700	60	150	1600	265	725
800	68	200	1700	300	820
900	78	250	1800	340	900
(See Figures 5.4, 5.5, and 5.6.)					

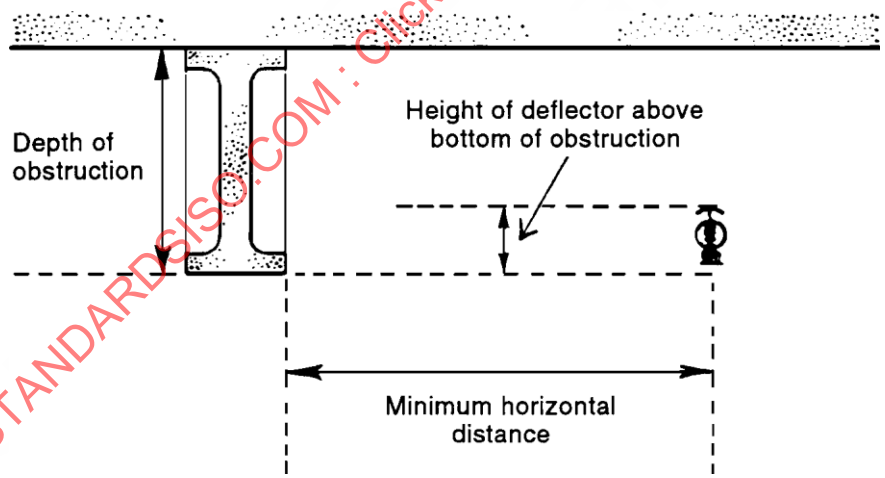


Figure 5.4 – Sprinkler distances from obstructions

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

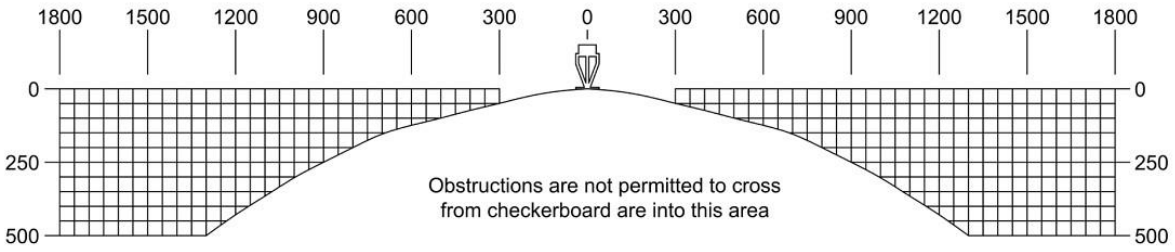


Figure 5.5 – Obstruction area to umbrella pattern of pendent and upright non-storage sprinklers (excluding extended-coverage sprinklers)

5.5.2

Where the depth of the obstruction exceeds 300 mm (combustible ceilings) or 450 mm (non-combustible ceilings) and it is impracticable to position sprinklers at the required distance from the side of the beam, the beam shall be treated as a wall in relationship to the sprinklers in the adjoining bay.

5.5.3

Where the depth of beams or joists is such that the dimensions specified in Table 5.2 cannot be complied with and the beams or joists are spaced closer than 1.8 m measured from centre-to-centre of the beam, special consideration may be given to a relaxation if full particulars are submitted to an SSC.

NOTE – Where beams of the above depth are spaced closer than 1.2 m, they should be underdrawn with substantial non-combustible material.

5.5.4

Where the top flange of a beam does not exceed 200 mm nominal width, sprinklers may be located directly over the beam, provided the sprinkler deflectors are at least 150 mm above the top of the beam (see Figure 5.3(c)).

5.5.5

Where residential sprinklers are installed, the listing data specified by the manufacturer shall be complied with. Where such data is not part of the listing, the requirements of Table 5.3 and Figure 5.6 shall apply.

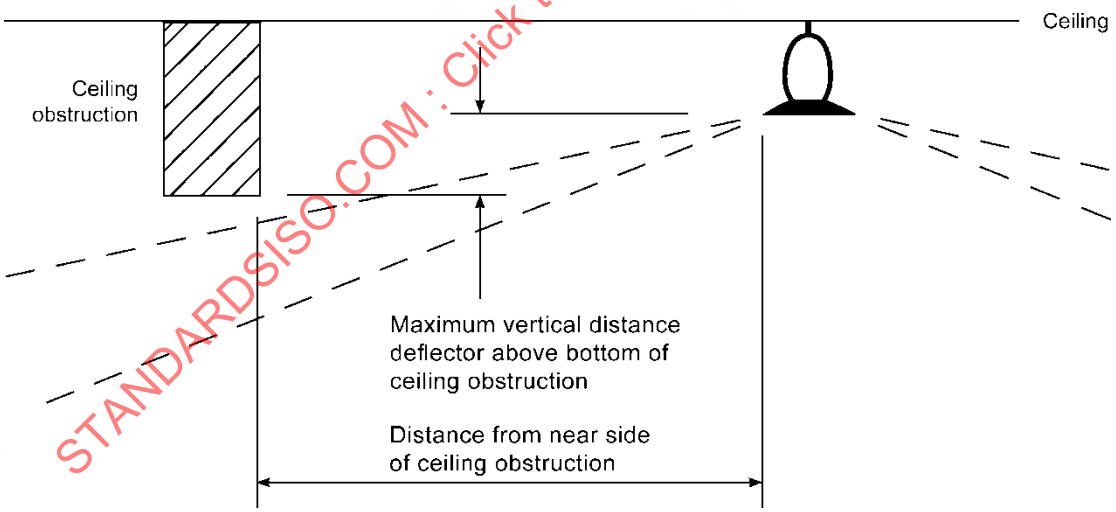


Figure 5.6 – Position of residential sprinkler deflector when located above the bottom of a ceiling obstruction

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 5.3 – Maximum distance of residential sprinklers above bottom of ceiling obstruction (where not specified by manufacturer)

Horizontal distance from sprinkler to near side of ceiling obstruction (mm)			Maximum vertical distance permitted (see Figure 5.6) (mm)
Up	to	150	Not permitted
151	to	300	0
301	to	600	25
601	to	750	50
751	to	900	75
901	to	1050	100
1051	to	1200	150
1201	to	1350	175
1351	to	1500	225
1501	to	1650	275
1651	to	1800	350

5.5.6

Unless otherwise listed, where upright sprinklers are installed directly attached to pipework 100 mm or larger, they shall be installed on sprigs of a distance three times greater than the nominal pipe diameter, up to a maximum distance of 600 mm.

Upright sprinklers shall be installed at least 150 mm away from rod hangers and similar obstructions. They shall be installed with the frame arms parallel to the direction of pipe to which they are fixed.

5.6 Columns

5.6.1

For obstructions such as columns, sprinklers shall be positioned away from obstructions a minimum distance of three times the maximum dimension of the obstruction. If the obstruction has a maximum dimension greater than 200 mm, sprinklers shall be located on opposite sides of the obstruction, with both sprinklers within half the design spacing from the obstruction.

5.7 Open roof trusses

5.7.1

Sprinklers shall be at least 300 mm laterally from truss members which are 100 mm nominal width or less. Where trusses exceed 100 mm nominal width, the sprinklers shall be at least 600 mm laterally distant.

5.7.2

Where range pipes pass above or through trusses the sprinklers may be located on the centre line of the truss if the truss members are not more than 200 mm nominal width and the sprinkler deflectors are at least 150 mm above the truss member. When sprinklers are located alongside truss members, the distance of the sprinkler deflectors from the truss shall be in accordance with Table 5.2, 5.3, or 5.4 as applicable (see Figure 5.3).

5.8 Clear space below sprinklers

5.8.1

A clear space of at least 500 mm shall be maintained below the level of the sprinkler deflectors throughout the room, except that in EHH and OH4 occupancies this clear space shall be at least 900 mm.

In ELH and OH1, 2, or 3 occupancies this clause shall not preclude full height shelving against the wall if not wider than 600 mm provided that the shelving is not directly below the sprinkler and the limit of Tables 2.2(a), (b), and (c) are not exceeded.

5.8.2

Where sloping ceilings or roofs are concerned, the storage of goods may follow the slope. Refer to 9.4.1.18 for specific requirements for storage sprinklers..

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

5.9 Spacing and location of sidewall sprinklers

5.9.1 *Standard pendent or upright sidewall sprinklers*

5.9.1.1 *Location*

Sidewall sprinklers are to be installed beneath smooth, horizontal, or sloped flat ceilings. The deflectors of standard sidewall sprinklers shall be located between 100 mm and 150 mm below the ceiling. The centre line of the sprinklers shall be between 50 mm and 150 mm from the face of the wall on which they are mounted. Deflectors shall be aligned parallel to ceilings and roofs (see Figure 5.3).

NOTE – Sidewall sprinklers may be used beneath overhead doors.

5.9.1.2 *Spacing*

Maximum spacing along wall:

ELH.....4.6 m
OH (combustible ceiling).....3.4 m
OH (non-combustible ceiling) .....3.7 m

Maximum spacing from end walls shall be half spacing along the wall.

Maximum spacing across the room, from wall to wall:

ELOH.....3.7 m

5.9.1.3 *Sloping ceilings*

Where installed under a sloped ceiling (slope of greater than 1 in 12) sprinklers shall be located at the high point of the slope and positioned to discharge downward along the slope.

In OH applications, the sidewall sprinkler shall be specifically listed for such use.

5.9.1.4 *Obstructions*

There shall be no obstruction at the ceiling within a rectangle extending along the wall 1 m on each side of the sprinkler and 1.8 m at right angles to the wall. Obstructions outside this rectangle shall meet the requirements of Table 5.4.

Table 5.4 – Obstructions to standard sidewall sprinkler discharge

Depth of obstruction not exceeding (mm)	**Minimum distance from sprinkler to obstruction**	
	At right angles to wall (m)	**Along wall** (m)
100	1.8	1.0
125	2.1	1.2
150	2.4	1.4
175	2.7	1.6
200	3.0	1.8

5.9.2 *Standard horizontal sidewall sprinklers*

The deflectors of horizontal sidewall sprinklers, unless otherwise listed, shall be located between 150 mm and 300 mm below the ceiling. The base of the sprinkler shall be no more than 200 mm from the face of the wall on which they are mounted. Where specifically listed, horizontal sidewall sprinklers may be located at greater depths below the ceiling.

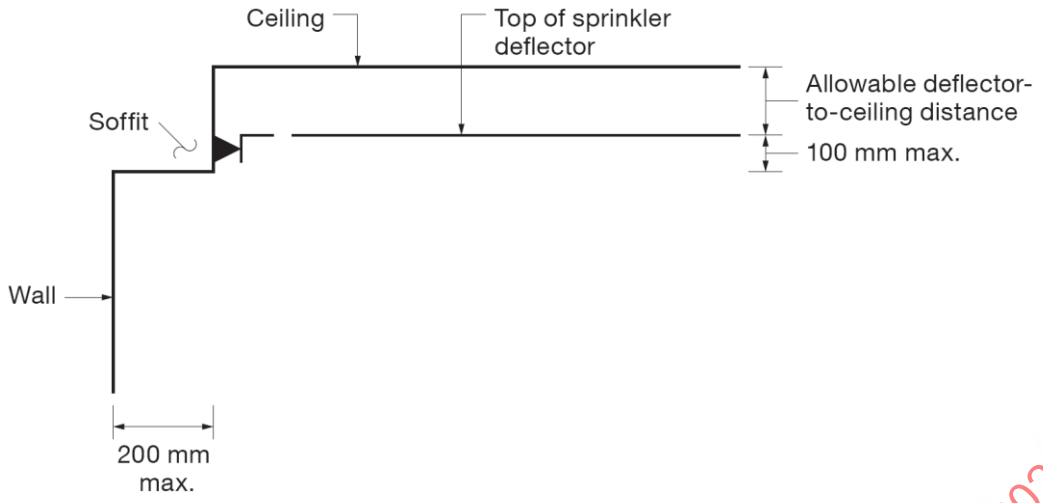
Where soffits are used for the installation of horizontal sidewall sprinklers, no sprinklers are required under them if they are less than 200 mm wide and the sprinkler is within 100 mm from the bottom of the soffit. See Figure 5.7.

The requirements for spacing, sloping ceilings, and obstructions of 5.9.1.2, 5.9.1.3, and 5.9.1.4 shall apply.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand



NOTE – Adapted with permission from NFPA 13-2010 *Installation of sprinkler systems*, Copyright © 2009, National Fire Protection Association, Quincy, MA. This material is not the complete and official position of the NFPA on the referenced subject, which is represented only by NFPA 13 in its entirety.

Figure 5.7 – Installation of horizontal sidewall sprinklers using soffits

5.9.3 *Extended coverage and residential horizontal sidewall sprinklers*

5.9.3.1 *Location and spacing*

Sprinklers shall be located and spaced as required by the specific approved sprinkler head data sheet.

5.9.3.2 *Sloping ceilings*

Where installed under a sloped ceiling (slope of greater than 1 in 12) sprinklers shall be located at the high point of the slope and positioned to discharge downward along the slope.

5.9.3.3

There shall be no obstruction at the ceiling within a rectangle extending along the wall 2.44 m on each side of the sprinkler and 2.44 m at right angles to the wall. Obstructions outside this rectangle shall meet the requirements of NFPA 13.

5.10 Locations or conditions requiring special consideration

5.10.1 *Concealed spaces*

5.10.1.1

Concealed spaces not exempted from sprinklering shall be sprinkler protected (see 2.8.1). The minimum design criteria shall be in accordance with the requirements for ELH occupancies, namely, six sprinklers flowing at a minimum flow rate of 57 L/min each.

5.10.1.2

Where any part of a space below a ground floor is not exempted from sprinkler protection under 2.8 such part of the space shall be protected in accordance with the hazard classification.

5.10.2 *Machinery pits and production lines*

Machinery pits and the undersides of production lines, where waste may collect, shall be protected by sprinklers.

5.10.3 *Hoists, lift shafts, and enclosed chutes through floors*

All hoists, lift shafts, and chutes inside, or in communication with, sprinklered buildings otherwise than as permitted in 2.8 shall be protected by sprinklers. Sprinklers installed at the head of lift shafts shall be protected by listed guards.

5.10.4 *Other vertical shafts*

In addition to those shafts described in 5.10.3, other vertical shafts containing sources of ignition, or a combustible material, such as switchboards and electrical cabling, shall be protected by a minimum of a single sprinkler at the top. Such shafts shall have a sprinkler at the top and not less than one additional sprinkler at every second level below.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Vertical shafts that do not contain any source of ignition or combustible material shall have at least one sprinkler at the head of the shaft.

NOTE– Paper-faced gypsum plasterboards in this context are deemed not to be combustible material.

5.10.5 *Conveyors, elevators, rope or strap races, gearing boxes, and dust receivers*

5.10.5.1

A sprinkler shall be fitted in the head of all seed and combustible product enclosed bucket elevators, so that it can discharge down both legs of the elevator. Such sprinklers may be omitted from elevators which are less than 8 m high, have an internal cross section of each leg of less than 0.1 m^2, and do not penetrate any floor other than service platforms.

5.10.5.2

Sprinklers shall be fitted internally in all rope or strap races, gearing boxes, and in all enclosed belt or shaft machine drives.

5.10.5.3

Sprinklers shall be fitted in dust cyclones, collection chambers, and boxes where these are:

(a) Housed within the protected building;
(b) Erected outside and directly above the protected building unless the roof is of non-combustible construction;
(c) External to, but adjacent to, the protected buildings.

Where dust cyclones, collection chambers, and boxes are erected above non-combustible roofs or are situated remote from the protected building at least one sprinkler shall be fitted inside the trunking where it leaves the protected building.

5.10.5.4

In corn, rice, provender, and oil mills:

(a) Sprinklers shall be fitted not more than 3 m apart inside all dust trunks which are more than 30° from the vertical and constructed of combustible materials;
(b) A sprinkler shall be fitted at the head of every dust trunk;
(c) When centrifuges or similar machines are placed one above another in tiers, and are less than 1 m from each other sprinklers shall be fitted in the spaces as shown in Figure 5.8.

5.10.5.5

Sprinklers shall be installed in all enclosed belt conveyors longer than 9 m within the protected building, other than conveyors with non-combustible belts transporting non-combustible materials.

Sprinklers shall also be installed in enclosed or partially enclosed conveyors transporting combustible materials into the building. Such sprinklers shall be installed at maximum 3.7 m centres and located so asnot to be obstructed by the conveyor structure and to ensure that the full width of the conveyor is protected.If there is a solid floor and the conveyor belt is wider than 1.2 m, the sprinkler shall be located beneath the return belt.

Sprinklers shall also be installed over any drive motors within or adjacent to combustible element of the building.

Where the installation of sprinklers is not practical the SSC may accept alternative solutions.

NOTE –

(1) FM Global Data Sheet 7-11 provides advice on best practice for belt conveyor protection.

(2) See 10.3.8 for hydraulic design requirements.

(3) It is recommended that conveyors shut down on detection of a fire. Suitable interlocks may be required to allow routine testing without impacting on the plant's operations, albeit, the interface will need to be tested annually.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

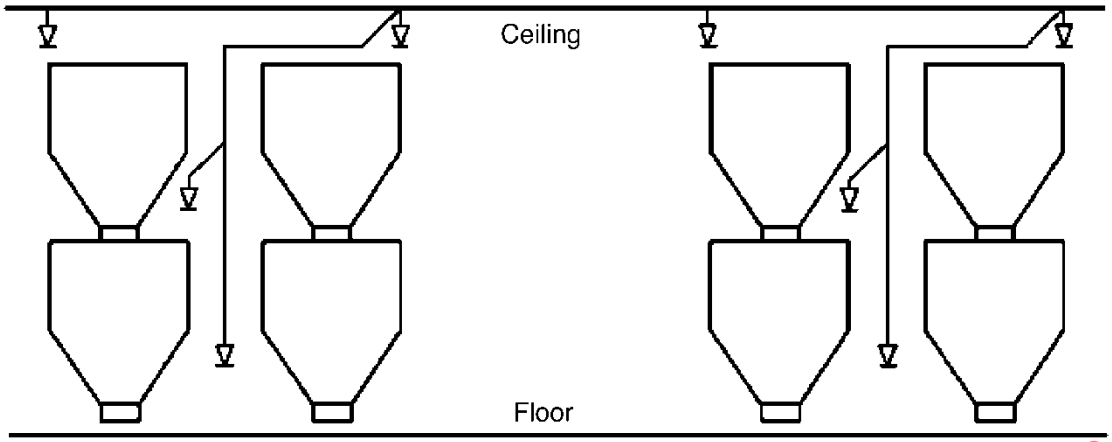


Figure 5.8 – Sprinkler positions for machines in tiers

5.10.6 *Spray dryers and their ancillary equipment*

All spray dryers producing combustible powders and their ancillary equipment (including cyclones, bag filters, and dust collectors) which have been provided with internal fire suppression deluge systems and rely on a water supply connected to the building sprinkler fire main shall have the following:

(a) The water supply to the powder dryer deluge system shall be controlled by a dedicated, monitored control valve connected directly to the fire main/combined main. All control valves shall be clearly and permanently marked with a conspicuous sign: WATER SUPPLY TO DRYER DELUGE SYSTEM – DO NOT CLOSE BEFORE CONTACTING THE PLANT OPERATORS. Instructions shall be provided on actions to be taken before operating the valve. The monitored control valve shall be locked in the open position.

NOTE – A number of dairy industry spray dryer systems have interlocks that will automatically shut-down the dryer process if the water supply for the deluge system is isolated or drops in pressure. Contractors working on the site fire main, building sprinkler systems, and deluge control valve must liaise with plant operators before operating the valves.

(b) The dryer deluge system manufacturers and installation contractors shall consult with sprinkler contractors and ensure that the simultaneous water demand calculations for the deluge systems and sprinkler system, balanced at the point of connection, are included in the sprinkler design parameters submitted to the SSC prior to installation. They shall be calculated for a 10-minute deluge discharge plusthe full sprinkler system discharge demand for the hydraulically most remote area of the building containing the dryer equipment.

NOTE – The SSC will only certify that the water supply is adequate for the building sprinkler system and the deluge demand. The specification, design, installation, commissioning, and periodic testing of the milk dryer fire suppression systems shall be the responsibility of the building owner, dryer manufacturers, and installation contractors. They should provide certification for the deluge system design and installation from a CPEng.

(c) Dryer deluge system manufacturers and installation contractors when calculating the deluge system water supply, demand flow and pressure shall consider the type and number of proprietary deluge nozzles being used, the number of heads designed to operate, the theoretical friction losses through pipework, and the height of the highest level of heads within the deluge system.

NOTE – It is recommended that the system is hydraulically designed by the sprinkler contractor/designer.

(d) The calculated maximum fire water supply pressure shall include all hydraulic losses downstream of the deluge valve including building height.

NOTE – Using a second booster pump, installed in series with the site fire pump(s) to provide water for the deluge system is considered poor design and should be avoided. Avoiding a second pump in series will prevent reliability issues with very high deluge-system pressures, the possibility of losing electrical supply to an electric motor-driven pump, as well as with the potential lack of ongoing testing, maintenance, and inspection of this second pump.

(e) The calculated fire water storage volume for the dryer cyclone shall be 10 minutes plus 60 minutes for the other simultaneous demands.

NOTE – This is assuming the deluge system is manually turned off after approximately 10 minutes, as is common practice in the dairy industry to prevent the volume of collected water in the dryer vessel from overburdening it structurally.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(f) Dryer manufacturers and installation contractors shall ensure that all pipework for the deluge system be designed to comply with the NZBC Seismic requirements and meet the Dairy Industry best practice requirements.

(g) The design and specifications for the dryer deluge system and pipework shall comply with NZ Dairy Industry hygiene best practice.

NOTE – It is advised that work on all dairy industry milk powder dryers deluge systems should comply with the current WORKSAFE ACOP – Prevention, detection, and control of fire and explosion in New Zealand dairy industry spray drying plant.

5.10.7 *Bins and silos*

All bins and silos having a plan area in excess of 9 m^2 for the storage of flour, bran, or other similar material which has undergone any process of reduction (in such premises as flour mills, granaries, oil mills, or distilleries), or for the storage of sawdust, wood flour, pulverised coal, and similar easily ignitable materials which can be extinguished by water, shall be internally protected by sprinklers on the basis of one sprinkler per 9 m^2 of the bin or silo area. If the bin or silo contains material which will swell if wet, and thereby incur the risk of bursting, exemption from this rule may be allowed if full particulars are submitted to an SSC.

5.10.8 *Escalators*

Sprinklers shall be fitted under the escalator and in the escalator boot and motor space. Where limited space prevents this, sprinklers shall be fitted in any surrounding ceiling space immediately adjacent to the escalator, to the satisfaction of an SSC. These sprinklers shall be fitted regardless of the depth of the ceiling space.

5.10.9 *Canopies, doorways and setback external walls*

5.10.9.1 *General*

Any omission of sprinklers permitted by the following subclauses shall not override any requirement of 2.5.

5.10.9.2 *Canopies*

Sprinklers shall be installed under all canopies where goods are stored or handled, and which communicate with the sprinkler-protected building.

In the case of verandahs and canopies covering walkways around the perimeter of a protected building, sprinklers will not be required over that portion of the walkway where:

(a) The walkway is constructed of concrete;

(b) There is no exposure created other than by any combustible elements of construction of the canopy; and

(c) The walkway is a footpath owned by the city corporation or is the subject of a lease requirement (which is observed) to the effect that the walkway has to be kept clear of any objects in the nature of storage, displays, or otherwise.

NOTE – Furniture of the nature typically found in outdoor seating areas and the like will not be deemed to be a significant fire load. However, where goods such as combustible furniture are stacked for storage or displays, sprinkler protection should be required.

5.10.9.3 *Canopies with mechanical louvres*

When a canopy has mechanical louvres over at least 25% of the roof area, the canopy will require sprinkler protection in accordance with the above clause, based on the louvres being in the closed position, unless the following conditions are met:

(a) The mechanical louvres shall open on automatic detection of fire underneath the canopy;

(b) The mechanical louvres have other automatic control systems, such as rain sensors, that the fire signal will override; and

(c) Testing of interlock appears on the compliance schedule.

5.10.9.4 *Fixed or furling fabric canopies*

Where a sprinkler-protected building has a fixed or furling fabric canopy or structure, it shall be sprinkler protected, or the requirements of 2.6 shall apply.

5.10.9.5 *Recessed doorways*

Where a building has recessed doorways where goods or refuse could be stored, such areas shall be sprinkler-protected unless:

(a) An SSC agrees to the omission of such protection; or

(b) The ceiling of the doorway has an FRR of –/30/30, and the doorway does not exceed 800 mm in depth and 2 m in width.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

5.10.9.6 *Setback external walls*

Where a part of an external wall is setback from the face of the building thereby forming a recess, sprinklers shall (except in the case of a doorway) be omitted from the exterior space thus formed with approval which should be granted only where:

(a) It is clear that there cannot be any combustibles in the recess; and
(b) The walls and ceilings of the recess have not less than the FRR required by the supporting documents to the NZBC Clause C Protection from fire.

5.10.9.7 *Residential decks and patios*

Sprinklers shall be provided over permanently covered patios, decks, balconies, verandahs, and the like where the cover exceeds 1.5 m in depth.

Sprinklers also need to be installed over permanently covered residential patios, decks, verandahs, and the like where sources of ignition, or significant fire loads, are located on them.

NOTE – Providing all walls, other than the ranch slider used for access, that communicate with the permanently covered residential patios, decks, balconies, verandahs, and the like comply with Sec 2.6.3 (a), (b), or (c). The following domestic items need not be considered: outdoor furniture, barbeques, gas heating appliances, and/or LPG bottles with a total quantity less than 20 kg.

5.10.10 *Exterior docks and platforms*

Sprinklers shall be installed under the floor of exterior docks and loading platforms of combustible construction unless such space is closed off against the accumulation of debris.

5.10.11 *Enclosed paint lines, drying ovens, and drying enclosures*

Sprinkler protection shall be provided inside the above structures and ducts in which combustible materials can accumulate unless an SSC considers that no benefit would accrue. Sidewall sprinklers may be used for this purpose.

NOTE – Ovens for the curing of powder-coating process do not require sprinkler protection.

5.10.12 *Extractor hoods and ducts*

5.10.12.1

Extractor hoods over deep fryers or other processes which produce flammable vapours or mists require sprinklers under the hood. These shall be located in the flow path of the extractant in sufficient numbers to cover the area beneath the hood. Where filter banks are provided, the sprinklers shall be located below the filters. Sidewall sprinklers shall not be used.

This clause is not intended to require sprinklers within or under domestic rangehoods.

The provisions of this clause may be met by the provision of a listed kitchen fire suppression system which complies with UL 300. Such systems will only be acceptable for listing if they include the continuous discharge of water spray or water mist spray to ensure that any fire does not re-ignite following the dischargeof any wet chemical fire suppressant agent.

5.10.12.2

Ducts where the perimeter is 1200 mm or greater and which are handling extractants that can lead to build-up in the duct of combustible material (including condensed flammable vapours and trapped fly) shall be fitted with sufficient sprinklers inside the duct to wet all interior surfaces and any electric motors therein. Permanent provision shall be made in the duct to allow annual inspection of the sprinkler, and the replacement of sprinklers, when required.

NOTE – This clause does not apply to ducts from domestic type kitchen range hoods.

Exhaust ducts shall have one sprinkler located at the top of any vertical riser and at the mid-point of any offset. The first sprinkler in a horizontal duct shall be installed at the duct entrance. Horizontal ducts shall have sprinklers located at 3 m centres, with the first sprinkler located no more than 1.5 m from the duct entrance. See Figure 5.9.

Sprinklers or automatic spray nozzles shall not be required in a vertical riser located outside of a building, provided the riser does not expose combustible material or provided the interior of the building and the horizontal distance between the hood outlet and the vertical riser is at least 8 m.

The design for sprinklers within a kitchen extraction hood shall allow for all sprinklers under the single largest hood plus all the in-duct sprinklers leading from this hood through to the exterior of the building to operate at a minimum pressure of 50 kPa.

NOTE – The use of small orifice sprinklers may reduce the hydraulic demand on the system.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

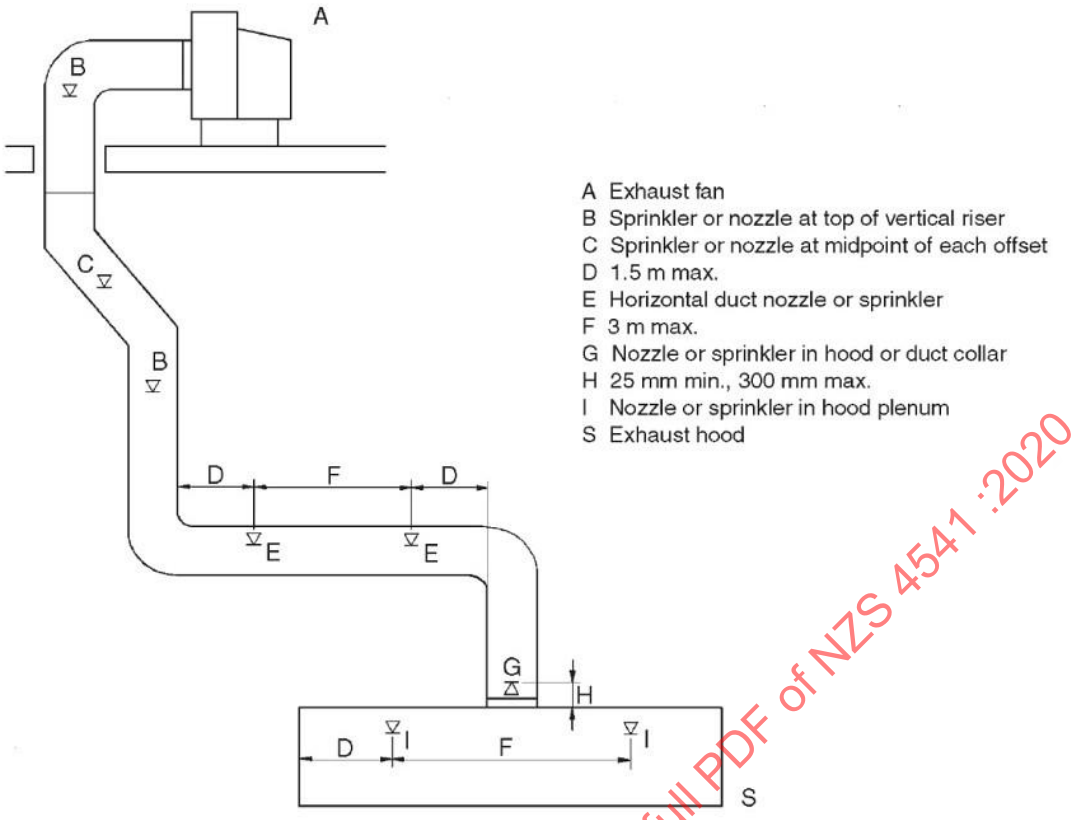


Figure 5.9 – Location of sprinklers in extraction ducts

In the case of commercial cooking hoods, a sprinkler shall be located between 25 mm to 300 mm above the point of the duct collar connection into the hood plenum. Hood exhaust plenums shall have one sprinkler in each chamber not exceeding 3 m in length.

Where a kitchen extraction hood is protected by a listed system as allowed by 5.10.12.1, and such a system is listed for the protection of ductwork, additional sprinkler protection is not required to be provided for sections of ductwork which provide extraction for a single kitchen hood only.

NOTE –

(1) Attention is drawn to 4.2.4 concerning the temperature rating of sprinklers.

(2) Sprinklers may require routine cleaning.

(3) Experience has shown that fires in fryers are effectively controlled by sprinklers without consequential risk of injury.

5.10.12.3

Bench type recirculating fume cupboards of less than 2 m^3 volume are not required to be sprinkler protected.

Bench type recirculating fume cupboards greater than 2 m^3 volume require sprinkler protection, unless a specific adverse reaction of the proposed contents with water is proven to the satisfaction of an SSC.

Bench type or walk-in vented fume cupboards require sprinkler protection regardless of volume. Where combustible ducting material is used, one sprinkler additional head is to be located between 25 mm to 300 mm above the point of duct collar connection into the cupboard plenum area.

NOTE – Automatic fire sprinkler operation without either a fire or mechanical interference is extremely unlikely. The likely effects of a fire in an unprotected fume cupboard containing combustible solvents and chemical reagents, combined with potential fire spread to concealed spaces and other areas through duct work, is considered a significantly greater hazard to life safety and property protection than a fire in a fume cupboard controlled by sprinkler discharge. It should also be noted that the hazards associated with water and/or other incompatible reagents are often already in the fume cupboards. Manual firefighting is seldom effective as automatic sprinkler protection and fume cupboards can be unattended. The proximity of a firefighter to the fire, the effects of extinguisher discharge, and any subsequent chemical reactions with the extinguishing agent are also considered to pose a greater life safety hazard than automatic fire sprinkler discharge.

Suitable anti-corrosion measures are required for all sprinkler hardware installed in fume cupboards or associated ducting.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

NOTE – The known adverse water reactions of high replacement series metals (potassium, lithium, sodium, barium, calcium, and magnesium) together with complex metal hydrides, metal carbides, metal phosphides, and metal nitrides should be duly noted. These substances should not be stored close to each other. Fire protection measures for areas where these substances are stored should not be water based.

5.10.12.4 *Air handling units*

Sprinkler protection shall be installed within air handling units when any of the following parameters are met:
(a) The enclosure is 2100 mm high or greater;
(b) The enclosure has an external plan area greater than 12 m^2;
(c) The enclosure is constructed of combustible materials in situ.

Sprinklers shall be installed in any associated ducting that contains combustible construction. Where sprinklers are installed in cooling towers, the design may require special consideration.

When installed, sprinkler protection shall provide adequate coverage, taking account of filter banks and other obstructions within the enclosure.

Sprinklers shall not be installed in fan/motor chambers that are designed in accordance with AS/NZS 1668.1, to enable spill air to pass through under fire conditions.

NOTE –

(1) The provisions of this clause do not apply to standalone fans, fan coil units, reheat coils (which are required to have multiple safeties) and other terminal units in the HVAC systems.

(2) it is the intent of this clause that prefabricated air-handling units meeting the above criterion do not require internal sprinkler protection.

5.10.13 *Electrical substations*

Where medium to high voltage (over 400 V) switchgear and associated equipment or high wattage equipment are within a sprinkler-protected building, the rooms containing such items shall be sprinkler protected. Hoods or shields may be installed to protect vulnerable electrical equipment from direct sprinkler discharge subject to SSC agreement. Where oil-filled equipment is used, consideration shall be given to the use of water spray systems. See 2.3.5.3.

Sprinklers may be omitted from these rooms if the room containing this equipment is an enclosure of FRR 120/120/120, including protection of any penetrations and access openings. Fire doors shall have an FRR of –/120/60.

NOTE – If a room containing oil-filled electrical equipment is not protected, it is recommended that the room be of masonry construction with suitable provisions for bunding and explosion venting, in accordance with Clause F3 of the NZBC. The effectiveness of sprinkler protection in controlling fires in such risks is well proven.

Consideration should be given to installing listed guards on sprinkler heads in substations to protect against mechanical damage.

5.10.14 *Other situations*

In any other situation where the meaning of ‘throughout’ in 2.4 is uncertain, the need for additional sprinklers shall be determined by having regard to whether the heat will reach the sprinklers sufficiently early and whether the discharge from other sprinklers will satisfactorily control the source of heat.

5.11 Obstructions below sprinklers

5.11.1 *General*

Where obstructions below sprinklers are such that the operation of sprinklers could be delayed, or effective distribution of water from the sprinklers could be impaired, sprinklers shall be mounted below such obstructions in accordance with the following requirements.

5.11.2 *Suspended or floor mounted vertical obstructions*

5.11.2.1

In light hazard occupancies only, the distance of all spray sprinklers (standard and extended coverage, vertical and sidewall) to privacy curtains, freestanding partitions, room dividers, and other similar obstructions shall comply with Table 5.5 and Figure 5.10.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 5.5 – Extra light hazard standard spray and extended coverage sprinklers distances from suspended or floor mounted obstructions (see Figure 5.10)

Horizontal distance from sprinkler to far side of obstruction Dimension (a) in mm	Minimum height of sprinkler deflector above top of obstruction Dimension (b) in mm
Less than 150	75
150 to less than 225	100
225 to less than 300	150
300 to less than 375	200
375 to less than 450	240
450 to less than 600	320
600 to less than 750	400
750 and greater	500

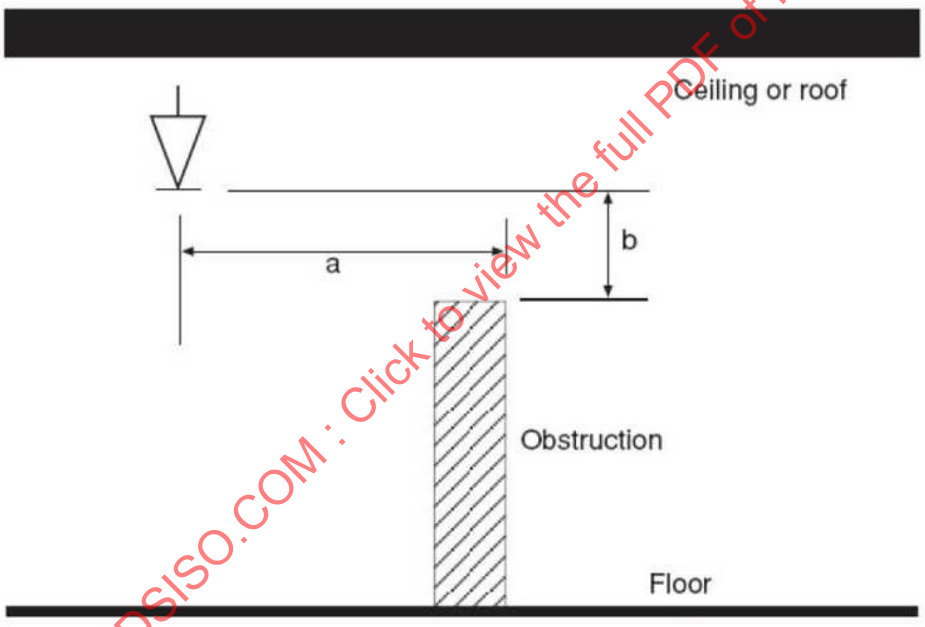


Figure 5.10 – Position of sprinkler head to avoid suspended or floor mounted obstruction to sprinkler discharge (extra light hazard standard spray and extended coverage sprinklers)

5.11.2.2

For OH and EHH occupancies these types of obstruction shall be treated as a wall unless the vertical clearance of the sprinkler obstruction is more than 500 mm for OH and 900 mm for EHH.

5.11.3 *Ducts, overhead platforms, open grid ceilings, and decks*

5.11.3.1 *Additional sprinklers for objects wider than 800 mm in least dimension that obstruct the distribution pattern of other than storage sprinklers*

For objects wider than 800 mm that obstruct a sprinkler's distribution pattern, sprinklers shall be installed in one of the following ways:

(a) Flat, continuous, solid objects that are between 0.8 m and 3.0 m wide shall have a single line of ceiling-level sprinklers centred under the object on a linear spacing not exceeding the maximum recommended for the sprinkler being used (see Figure 5.12);

(b) The underside of flat, continuous, solid objects over 3.0 m wide shall be treated as a ceiling and ceiling-level sprinklers for this area shall be installed in accordance with the occupancy design criteria; and

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(c) Non-flat, non-continuous, or non-solid type objects that are between 1.2 m and 3.0 m wide, shall have either:

(i) A flat, continuous, solid barrier installed under the object that equals the width of the object, and sprinklers installed as recommended in (a) or (b), depending on the width of the object (see Figure 5.13); or

(ii) Quick response ceiling-level sprinklers installed under the object at a maximum 1.2 m linearspacing and a maximum 1.5 m^2 area spacing (see Figure 5.14).

Additional sprinklers installed under the obstruction in accordance with (a) to (c) shall be supplied from the same pipework that supplies the related ceiling sprinklers provided that they are installed at a maximum linear spacing of 4.0 m and a maximum area spacing of 12 m^2.

The additional sprinklers installed under the obstruction as outlined do not need to be added to the hydraulic demand of the ceiling-level sprinklers.

Where required by this clause, any sprinkler located beneath an object shall be no more than 150 mm below the object and set back at least 150 mm from the outside face of the object.

5.11.3.2 *Open grid ceilings and decks*

Sprinklers shall be provided below open grid ceilings and decks according to the proportion of open areas as set out in Table 5.6 and shall be provided with the protection from above as set out in Table 5.7.

When omission of sprinklers beneath an open grid ceiling or deck is allowed by this clause, high-level sprinklers shall be designed for compliance with one of the following:

(a) The openings or perforations comprising an open grid area shall have no dimension less than 6.5 mm, the depth of the ceiling or deck shall be no greater than any dimension of the openings, and its top plane shall be at least 900 mm below the deflectors of the sprinklers above. Sprinkler design shall be suitable for the occupancy without further modification;

(b) The openings or perforations comprising an open grid area shall have no dimension less than 25 mm, the depth of the ceiling or deck shall be no greater than any dimension of the openings, and its top planeshall be at least 800 mm below the deflectors of the sprinklers above. Sprinkler design shall be suitable for the occupancy without further modification;

(c) The openings or perforations comprising an open grid area shall have no dimension less than 6.5 mm, the depth of the ceiling or deck shall be no greater than any dimension of the openings, and its top plane shall be at least 450 mm below the deflectors of the sprinklers above. Sprinkler design shall be suitable for the extra light hazard occupancy and spaced at no greater than 3.0 m x 3.0 m; or,

(d) The openings or perforations comprising an open grid area shall have no dimension less than 6.5 mm, the depth of the ceiling or deck shall be no greater than any dimension of the openings, and its top plane shall be at least 600 mm below the deflectors of the sprinklers above. Sprinkler design shall be suitable for the OH occupancy and spaced at no greater than 3.0 m x 3.0 m.

Table 5.6 – Sprinkler positioning above open grid or perforated ceilings and decks

Occupancy	Sprinkler spacing	'O' Opening minimum (mm)	Depth of ceiling maximum (mm)	Clearance minimum (mm)
ELH/OH	standard	> 6.5	≤'O'	900
ELH	3.0 x 3.0	> 6.5	≤'O''	450
ELH/OH	standard	> 25	≤'O'	800
OH	3.0 x 3.0	> 6.5	≤'O'	600

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

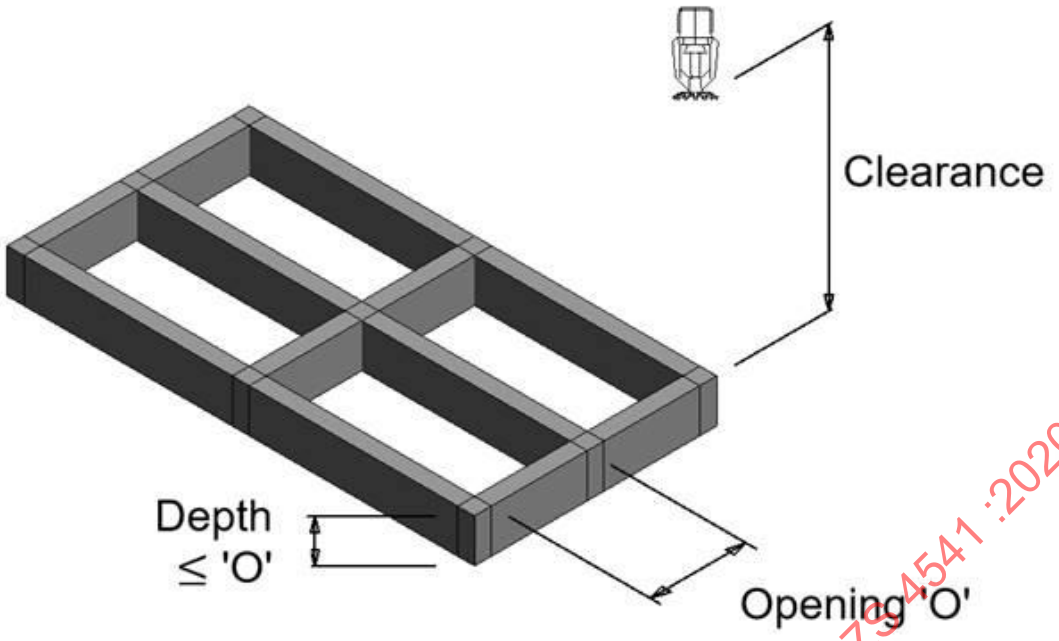


Figure 5.11 – Open grid ceilings dimension definitions

When there are ducts or other similar obstructions within the space above open grid or perforated ceilings and grids, the sprinkler positioning need to comply with Table 5.2 and 5.11.3.1.When there is inadequate clearance between the bottom of the obstruction and the perforated ceiling reference shall be made to the sprinkler head manufacturers' published spray patterns to determine the diameter of the spray pattern when it reaches the ceiling grid and reduce the spacing of the sprinklers beneath the duct to the corresponding value. When the clearance below a duct (over 800 mm wide) to the underside of grid or perforated ceiling is less than 300 mm then sprinklers shall be installed below the grid or perforated ceiling under the duct.

Table 5.7 – Sprinkler protection requirements below open grid or perforated ceilings and grids

Proportion of open area (%)	Protection required
0 – 25	Sprinklers beneath
26 – 50	Sprinklers beneath and a solid cover above each sprinkler at least 1 m^2 in area
51 – 70	Sprinklers beneath and a solid cover over the whole of the deck or ceiling
> 71	Sprinklers not required

5.11.3.3 *Ceiling clouds*

Ceiling clouds are suspended features that hang beneath the level of the main ceilings. They are manufactured normally from hard materials when used exclusively as a decorative feature or soft materials when used as a sound attenuation feature.

It is necessary to achieve both coverage across the whole floor and adequate detection. To meet both these requirements it may be necessary to install sprinklers beneath every cloud, although an element of designer's judgement is required. Where such judgement is applied it must be conservative.

In all cases of extensive cloud ceilings, the design requirements are for 50% of the design area at ceiling level to operate and 100% at the level of the cloud ceilings. Where cloud ceilings have been installed sporadically, the design requirement is 100% of the design area at the ceiling plus all sprinklers in the cloud ceilings within the footprint of the ceiling-level design.

Where the clouds are level and coplanar, it may not be necessary to install sprinklers beneath every cloud. Any clouds that are skipped must comply with rules in Table 5.8 below. Where clouds are of unequal size

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

and spacing, apply the spacing rule table based upon the combination of largest cloud size and maximum gap.

Table 5.8 – Sprinkler spacing rules for cloud skipping

Smallest cloud size (m)	Gap area fraction to ceiling height (= gap in mm between clouds/height of cloud ceiling in mm)		
	Sprinklers/m² required for each cloud	Sprinklers/m² required for every other cloud	Sprinklers required for every third cloud
Over 3 m	Up to 0.833	0	0
1.5 m to 3 m	> 0.0021	<0.0021	0
0.9 m to 1.5 m	> 0.0038	0.0025 ≤ gap ≤ 0.0038	< 0.0025
0.6 m to 0.9 m	> 0.0041	0.0029 ≤ gap ≤ 0.0041	< 0.0029
Under 0.6 m	> 0.005	0.0033 ≤ gap ≤ 0.0050	< 0.0033

5.11.3.4 *Tension fabric and membrane ceilings*

Where tension fabric ceilings are used, a layer of sprinklers shall be installed above and below the ceiling. Both levels of sprinklers shall be designed to independently control a fire below the ceiling. It shall not be necessary to allow both levels to operate simultaneously.

Tension fabric and membrane ceilings may be used in discrete areas provided that:
(a) The maximum area of the tension ceiling is that protected by four sprinklers;
(b) The tension fabric is at, or within, 350 mm of the ceiling lining.

Where extensive use of tensioned fabric or membrane ceilings has been used reference shall be made to FM Global Property Loss Prevention Data Sheet 1-59 or another recognised design standard.

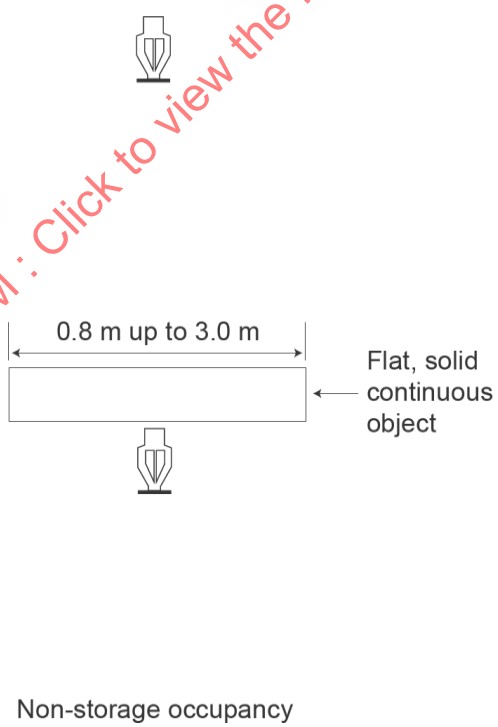


Figure 5.12 – Additional sprinklers installed below flat, continuous, solid obstructions between 0.8 m and 3.0 m wide

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

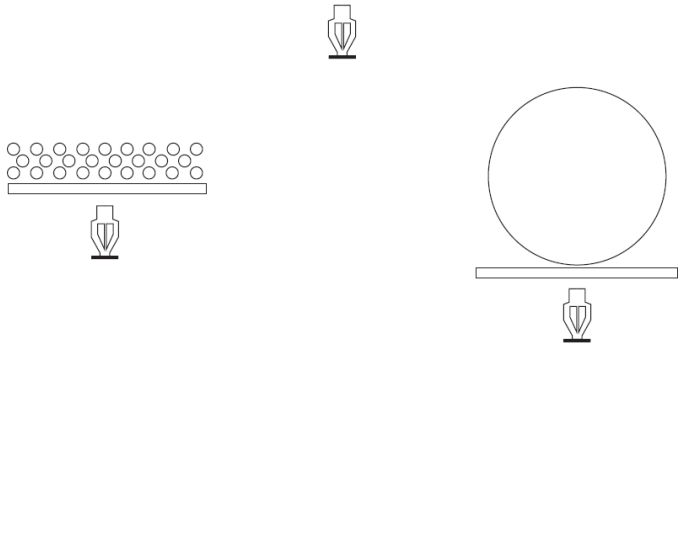


Figure 5.13 – Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 0.8 m and 3.0 m wide with flat, continuous, solid barrier provided

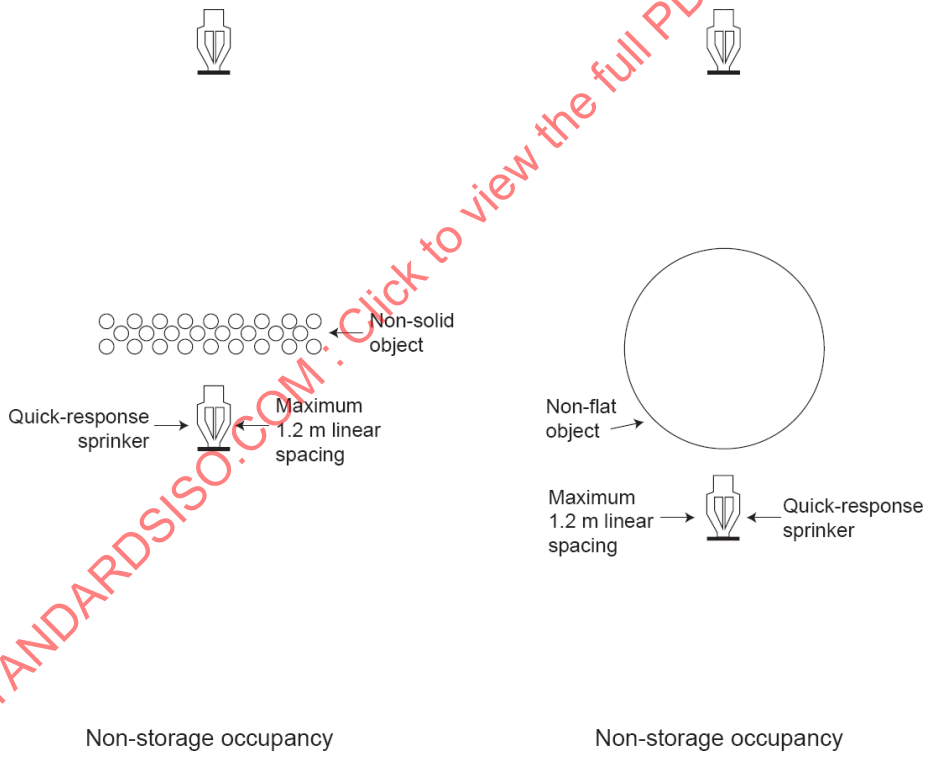


Figure 5.14 – Additional sprinklers installed below non-flat, non-continuous, or non-solid obstructions between 1.2 m and 3.0 m wide without a flat, continuous, solid barrier provided

5.11.3.5 *Suspended ceilings*

Sprinklers shall be installed below suspended ceilings (as, for example, in connection with diffused lighting) except where the ceiling construction has been shown to the satisfaction of an SSC not to impair detection and the effective water distribution from the sprinklers above.

5.11.4 *Hoods over papermaking machines*

The underside of hoods or shields over the dry ends of papermaking machines shall be sprinkler protected. Sidewall sprinklers may be used for this purpose.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

5.11.5 *Work tables*

Sprinkler protection shall be provided under any work table where the width exceeds 2.0 m, or the length exceeds 10 m, or both, if the table is of combustible construction or the area beneath is open sided, so as to permit the accumulation or storage of combustibles or rubbish.

Sprinklers may be omitted if the area beneath the table is subdivided by vertical partitions having a fire-resistant barrier, at intervals not exceeding 5 m in either direction, and the table is not used for storage ofcombustibles classified higher than Category 1.

5.11.6 *Sliding filing systems*

Where the total area occupied by the filing systems exceeds 4 m^2 the sprinkler head layout shall provide at least one head within 1000 mm of the centre line of sliding filing systems.

Where the clear space above these cabinets is less than 300 mm, the sprinkler head layout should be arranged so that sprinklers are located immediately above the cabinets.

5.11.7 *Tilting doors*

Tilting doors, overhead doors, and sectional roller doors are deemed obstructions to the sprinkler system unless in the fully closed position. To protect beneath the door when in the open position, sidewall sprinklers may be installed below the plane of the door. Adequate water shielding and mechanical protection may be required for the sprinkler head.

NOTE – This clause does not apply when the door is normally closed. For example, a security door for a sally dock of a prison or the forklift door of a freezer.

5.12 Film and television production studios

5.12.1

Overhead platforms or walkways including those for lighting or other equipment, whether slatted or not together with stairs thereto, shall be fitted with sprinklers on the underside if they exceed 800 mm width. (This does not apply to temporary platforms in connection with sets.)

5.12.2

Concealed spaces or cavities between walls and combustible linings which exceed 100 mm width and those between roofs and combustible linings which exceed 100 mm depth, shall be fitted with sprinklers. Electric cables are permitted provided the wiring is either in screwed steel conduit or in mineral-insulated metal-sheathed cable.

5.13 Theatres and music halls

5.13.1 *Proscenium openings*

Where drenchers are installed on a proscenium opening and the water supply for the drenchers is common to any water supply to the sprinkler system, the system of drenchers shall be deemed a part of the sprinkler system and the following requirements shall apply.

NOTE – For the purposes of determining the water supply requirements for the sprinkler system in terms of 6.2, the maximum flow and pressure requirements for the drenchers should be added to those required in Parts 7, 8, and 9 and any addition required by 2.6 in the case of external sprinklers.

All design and constructional details of the drencher system shall comply with the relevant provisions of this standard.

The flow requirement of the drenchers in the case of a system incorporating open-head drenchers shall be established by the sum of $Q = K\sqrt{P}$ for all drencher heads, where K is the K factor of the head and P is the highest pressure at which each head will operate when the least favourable design area of the sprinkler system is in operation.

NOTE – This clause should not be taken to impose any requirement or preference for the provision of drenchers on a proscenium opening in a sprinklered building.

5.14 Fixtures and fittings

5.14.1 *Cupboards and wardrobes*

5.14.1.1

The following types of cupboards and wardrobes shall be protected:

(a) Under stair cupboards;
(b) Cleaner's cupboards;
(c) Cupboards containing electrical switchboards;
(d) Cupboards containing laundry equipment;

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

(e) Hot water cupboards;
(f) Walk-in wardrobes;
(g) Cupboards and wardrobes deeper than 800 mm;
(h) Cupboards used for the storage of flammable liquids; and
(i) Cupboards containing electrical power points and/or USB charging points.

5.14.1.2

Unless sprinklers are required by 5.14.1.1, sprinklers are not required in cupboards and wardrobes up to 800 mm deep provided the sprinklers in the adjacent room are positioned to cover the floor area of the cupboard and wardrobe. The cupboard and wardrobe walls must be lined with non-combustible materials.

5.14.1.1, sprinklers are not required in under- or over-bench cupboards.

NOTE –

(1) This clause does not apply to furniture.

(2) Gypsum board is considered to be non-combustible in the context of this clause.

(3) This clause does not require internal protection of cabinet type cupboards fitted into a gypsum wall type enclosure.

5.14.2 *Furniture*

Furniture, such as portable wardrobe units, cabinets, trophy cases, and similar features not intended for occupancy, does not require sprinklers within. This type of feature is permitted to be attached to the finished structure.

5.14.3 *Car park storage lockers*

Car park storage lockers, of less than 3 m^3 in volume, do not require sprinkler protection, but protection may be required under the lockers. Flammable liquids, oil impregnated rags, and other potential hazardous materials shall not be stored in unprotected lockers.

5.15 Skylight shafts

Skylight shafts shall be protected except where:
(a) The skylight projects through a sprinkler-protected concealed space and is less than 1000 mm deep with a cross-sectional area of less than 1 m^2; or
(b) The volume of the skylight shaft is less than 1.5 m^3 and the internal linings within the skylight comply with NZBC Clause C3.4.

5.16 External sprinklers

5.16.1 *Extent of application*

Any part of an external wall of the sprinkler-protected building, including glazed openings and roof overhangs with an FRR less than –/30/30 that is required to be protected from an exposure hazard, shall be protected with external sprinklers.

For the purpose of this clause:
(a) ‘External wall’ shall include the façade of raised sections of the building, such as roof lanterns, set back from the perimeter of the sprinkler-protected building; and

‘Exposure hazard’ shall mean a source of radiant heat such as a non-sprinkler-protected building with an FRR less than –/30/30, or areas used for storage or handling of flammable or combustible materials.

5.16.2 *Sprinklers*

All sealed sprinklers used for exposure protection shall be rated as quick response and shall have a temperature rating of 68°C, with a discharge coefficient (*K* factor) of 8 L/min $(kPa)^{0.5}$. Sprinklers shall be of a type where the thermal element is visible (directly exposed) to the radiant heat source and not shielded by the body or arms of the sprinkler.

Sprinklers shall be any of the following types and orientation:
(a) Pendent sidewall or upright sidewall (WP) – mounted vertically and oriented to direct the spray towards the window or wall; or
(b) Sprinklers specifically designed for the purpose that are located and spaced in accordance with their listing.

Conventional sprinklers (C/UP) shall not be used, except in the case of protection beneath roof overhangs. Sprinklers beneath roof overhangs shall not be considered a substitute for protection of walls.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

5.16.3 *Shielding*

Where building features do not shield sprinklers to prevent cooling from sprinklers operating above, such sprinklers shall be fitted with flat metal shields not less than 80 mm diameter or greater than 100 mm in diameter.

5.16.4 *Sprinkler spacing and location*

Unless specifically listed otherwise, external sprinklers shall be located in accordance with Table 5.9.

In addition to the requirements contained in Table 5.9, a sprinkler shall be positioned not more than half the design spacing horizontally from:

(a) Vertical extremities of the protected surface;
(b) Vertical extremities of each glazed opening, with the sprinkler located within the opening; and the

Centre of any building feature, such as downpipes, glazing bars, or mullions, which project more than 40 mm from the protected surface.

Where vertical glazing bars or mullions project more than 40 mm from the glazed surface and are spaced not more than 1660 mm centre to centre, every alternate sprinkler may be positioned on the centre line of a mullion or glazing bar, except that sprinklers shall be positioned within half the design spacing of each sideof any vertical glazing bar or mullion that exceeds 40 mm in width.

Where windowsills or horizontal mullions result in recesses or projections exceeding 25 mm in depth, separate sprinklers shall be provided for each window on each level.

Table 5.9 – External sprinkler spacing and location

External sprinkler location				
Spacing	**Measured**	**Measurement** (m)		**Point of measurement**
		Max.	**Min.**	
Horizontal	Horizontally	2.5 for windows 3.0 for walls	1.8 (see Note)	Centre of sprinkler
Vertical	Vertically	4.6	N/A	Deflector to deflector
NOTE – The 1.8 m minimum distance may be reduced where sprinklers are separated by a baffle or a building feature that will prevent cooling from an adjacent operating sprinkler.				
External sprinkler location				
Orientation	**Measured**	**Measurement** (mm)		**Point of measurement**
		Max.	**Min.**	
Vertical	Vertically below top of eave or overhang	200	150	Sensing element
WP pendent (Spray towards wall)	Horizontal from wall	300	150	Centre of sprinkler

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

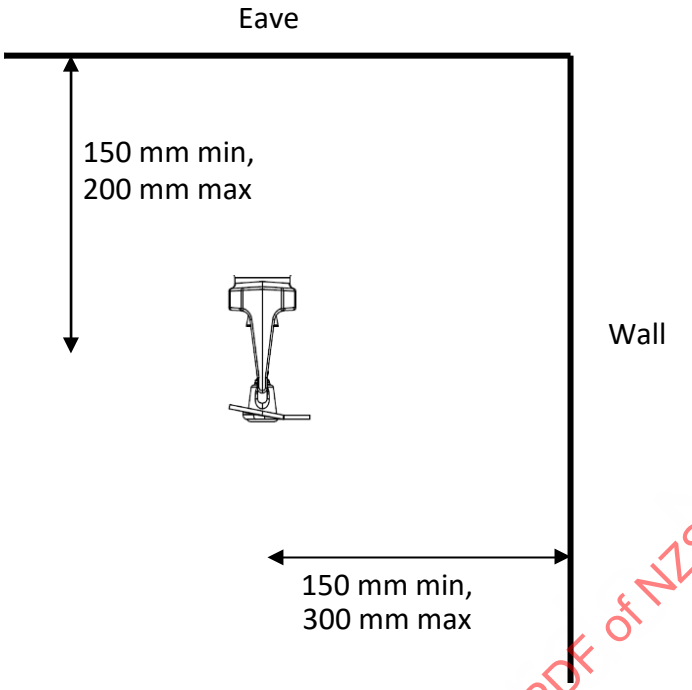


Figure 5.15 – Sprinkler positioning under eaves

5.16.5 *Performance*

The performance requirements for external sprinklers are set out in 2.7.3.2 and 2.7.3.3.

5.17 Extended coverage ordinary hazard and extended coverage light hazard sprinklers – Special requirements

5.17.1 *Location*

5.17.1.1

Any specific requirements detailed within the listing for an ECOH and ECLH sprinkler shall be applied in preference to 5.17.1.2 to 5.17.1.6.

5.17.1.2

ECOH and ECLH sprinklers shall not be installed under ceilings with continuous structural or architectural projections exceeding 150 mm in depth unless the sprinkler is not required to spray beyond such a projection or unless specific approval is obtained from an SSC.

5.17.1.3

The slope of the ceiling shall not exceed 10°. Deflectors shall be installed parallel to ceilings or roofs.

5.17.1.4

The deflector of the sprinkler shall not be more than 300 mm below the ceiling and, in sleeping occupancies, not more than 150 mm below the ceiling.

5.17.1.5

If the deflectors of ECOH and ECLH sprinklers are located at the same level or above ceiling mounted obstructions, then the sprinkler shall be positioned in accordance with the dimensions shown in Table 5.10.

5.17.1.6

Where vertical obstructions exist with a clear space of less than 500 mm above them (for example, suspended fittings or floor-mounted vertical obstructions which do not exceed 100 mm in width), the sprinklershall be positioned in accordance with dimensions shown in Table 5.10.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Table 5.10 – ECOH and ECLH sprinkler distances from ceiling mounted obstructions (see Figure 5.16)

Minimum horizontal distance from sprinkler to side of obstruction Dimension (a) in mm	**Maximum height of sprinkler deflector above bottom of obstruction** Dimension (b) in mm
Less than 500	0
500 to less than 900	25
900 to less than 1200	75
1200 to less than 1300	125
1300 to less than 1800	175
1800 to less than 2000	225
2000 to less than 2100	275
2100 or more	350

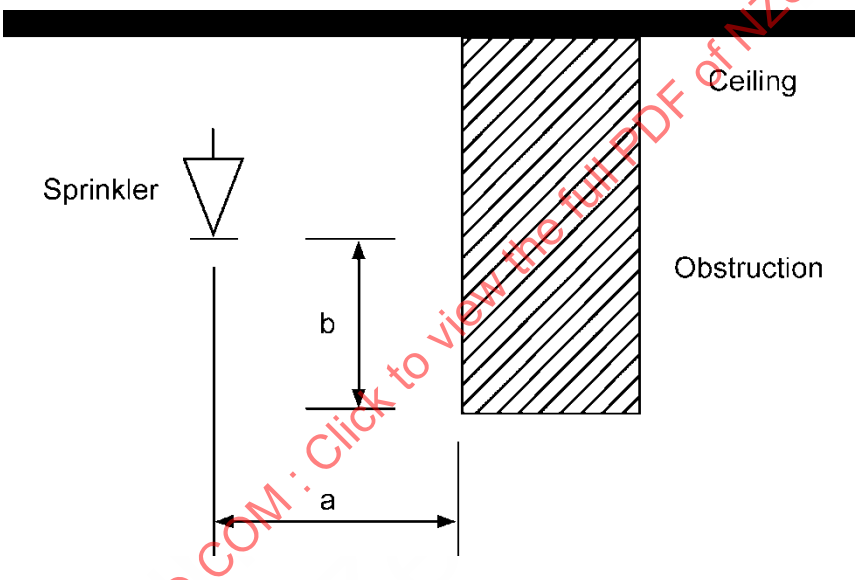


Figure 5.16 – Position of sprinkler head to avoid obstruction to sprinkler discharge (extended coverage upright and pendent spray sprinklers)

5.17.1.7 *Four times rule*

Unless the conditions of 5.17.1.7(a) and (b) are met, ECOH and ECLH sprinklers shall be positioned away from obstructions at a minimum distance of four times the maximum dimension of the obstruction (for example, truss webs and chords, pipe, columns, and fixtures). The maximum clear distance required shall be 900 mm in accordance with Figure 5.17.

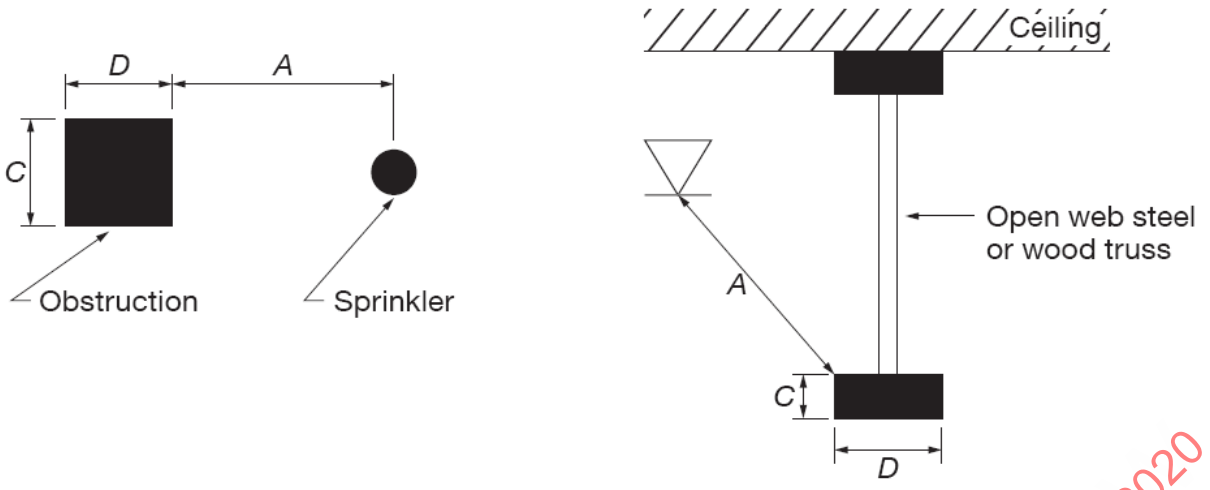
Sprinklers shall be permitted to be:

(a) Spaced on opposite sides of the obstruction where the distance from the centre line of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers;
(b) Installed on the centre line of a truss or bar joist, or directly above a beam, provided that the truss chord or beam dimension is not more than 200 mm and the sprinkler deflector is located at least 150 mm above the structural member, and where the sprinkler is positioned at a distance four times greater than the maximum dimension of the web members away from the web members.

These requirements shall not apply to sprinkler system piping less than 80 mm in diameter.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution



Plan view of column **Elevation view of truss**

NOTE –

(1) A ≥ 4C or 4D.

(2) A ≤ 900 mm.

(3) Use dimension C or D, whichever is greater.

(4) Adapted with permission from NFPA 13-2010 *Installation of sprinkler systems*. Copyright © 2009, National Fire Protection Association, Quincy, MA. This material is not the complete and official position of the NFPA on the referenced subject, which is represented only by NFPA 13 in its entirety.

Figure 5.17 – Minimum distance from obstruction (extended coverage upright and pendent spray sprinklers)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

6 Water supply

6.1 General

To ensure reliability, every sprinkler system shall have at least one water supply that meets the requirements for a 'primary' supply as specified in this part.

In some cases, one or more additional reliable water supplies also complying with this standard, may be required or warranted. Such cases may include or relate to:

(a) The level of risk relating to the nature and number of occupants, critical functions of the building, or the protection of the assets of the owner;
(b) Operational or safety limitations to fire brigade firefighting due to the size, height, or location of the building; or
(c) Specific requirements of the NZBC.

NOTE –

(1) A town's main fire sprinkler system water supplies may fail during (and for some time after) significant earthquakes as a result of damage to water mains, or as a result of water supply authority control features activating to prevent a town's main water storage supply losses (such as reservoir valves closing). Building owners should, therefore, consider each of the issues listed above (including the 'importance level' of their building) and the need for the sprinkler system to remain operational after a significant earthquake event. This may warrant the installation of an additional water supply, independent of the town main (such as an automatically starting diesel engine driven pump taking water from a tank). Any such additional supply is to comply with the relevant requirements of this standard.

(2) The supporting documents to the NZBC Clause C Protection from fire may define the requirements of a building's water supply.

6.2 Classes of water supply

6.2.1 *Classification*

The water supply of a sprinkler system shall be classified according to its reliability and number of supplies as follows:

(a) Class A1 – Dual superior supply
Two approved supplies, both of which shall be carried independently to a combined main within each control valve enclosure, at least one of which shall be a primary supply and independent of the town's main;

(b) Class A2 – Dual superior supply
Two water supplies consisting of two 50% capacity water storage tanks manifolded to two 100% duty (each) capacity pumps. At least one of the pumps shall be diesel driven. The water storage tanks shall be topped up by a full duty flow infill from an inexhaustible water source, such as a town main, bore, or other approved supply. Where the Class A2 supply is used as part of a Combined Sprinkler and HydrantSystem the water storage capacity of the tanks shall include both the full water storage capacity requiredfor the sprinklers plus 45 m^3 of water for hydrants. The infill shall only be required to meet the duty flowof the sprinkler system;

(c) Class B2 – Private site fire main
A private reticulation system which complies with 6.12 and is reserved solely for fire purposes, being charged with water and normally pressurised, comprised of at least one approved ring and supplied by two approved supplies, at least one of which shall be a primary supply, but only one of which may be dependent on a town's main. The sprinkler system(s) water supply connection pipes shall be independently connected to the fire main. Two connections shall be carried independently to a combined main within each valve enclosure. Isolation valves shall be provided at each connection with the fire main so as to ensure that there are at least two isolation valves between any two connections;

(d) Class C2 – Single superior supply
A single approved primary supply. Where the supply is reliant on the use of fire pumps, two pumps shall be provided in parallel. Each pump shall be individually capable of meeting the highest design flow and pressure. At least one pump shall be driven by a diesel engine; or

(e) Class C1– Single supply
One approved primary supply.

NOTE – See Figure 6.1.

6.2.2 *Primary supply*

A primary supply shall be only one of the following:

(a) A town's main, boosted town's main, or supplemented town's main provided that any pump is driven by a diesel engine;
(b) A diesel engine driven pump taking water from an approved source other than a town's main; or
(c) An elevated tank.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSSO.COM : Click to view the full PDF of NZS 4541:2020

6.2.3 *Secondary supply*

A secondary supply shall be one of the following:

(a) A town's main, boosted town's main, or supplemented town's main where any pump is either diesel engine or electric motor driven;
(b) A diesel engine or electric motor driven pump taking water from an approved source other than a town's main; or
(c) An elevated tank.

6.2.4 *General requirements*

Every water supply shall:

(a) Automatically provide water at least at the design flows and pressures specified in 6.3;
(b) In cases other than a town's main, boosted town's main, or supplemented town's main, have a storage capacity of at least that specified in 6.6;
(c) Meet the requirements of 6.4, 6.5, 6.6, 6.7, 6.8, or 6.9 as they relate to the particular water supply (see Figure 6.2);
(d) Except in the case of a town's main, be under the direct control of the owner of the protected building. Where this is not practical, approval may be given to a legally binding arrangement which suitably guarantees the building owner's right to use the water supply;
(e) In the case of a Class A1, A2, and B2 dual supply there shall be sufficient isolate valves installed such that it is possible to carry out routine maintenance, including the servicing of check valves on one water supply without the other water supply being in any way impaired.

NOTE –

(1) The use of salt or brackish water is not normally allowed. In special circumstances where there is no suitable fresh water source available, consideration may be given to the use of salt or brackish water, provided the installation is normally charged with fresh water.

(2) Attention is drawn to the need to comply with the requirements of the NZBC Clause G12.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

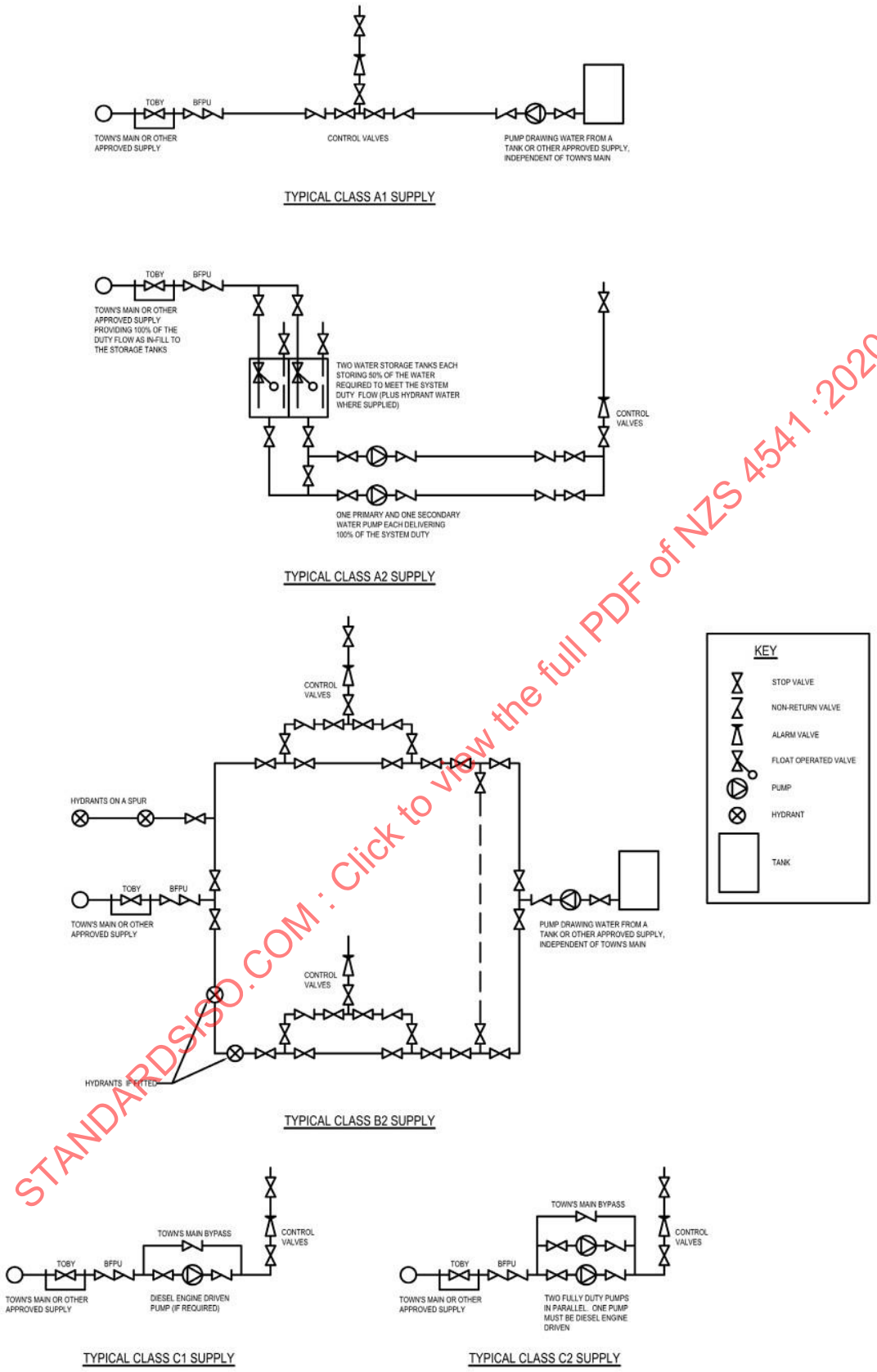


Figure 6.1 – Water supply classes – Typical diagrammatic layouts

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

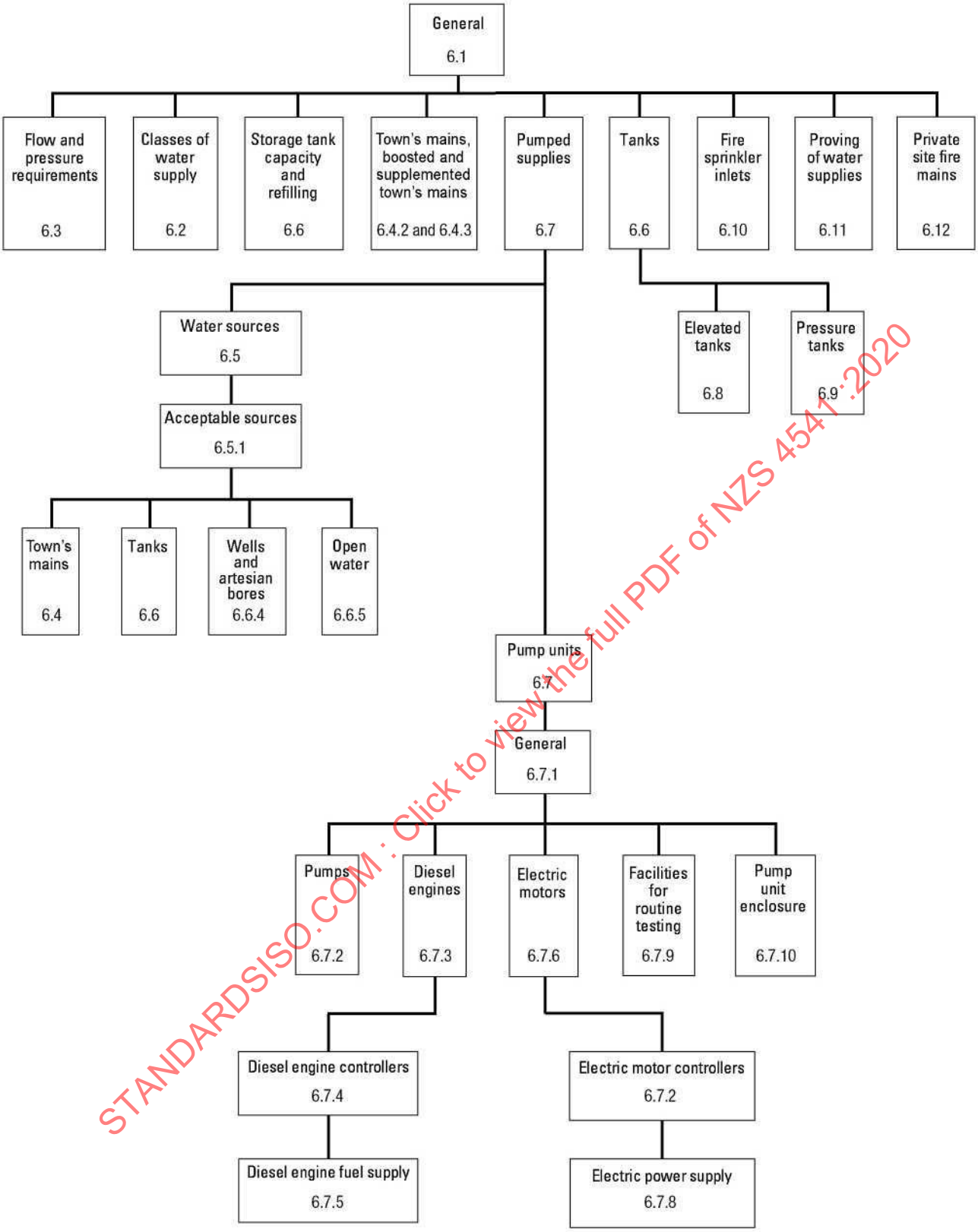


Figure 6.2 – Diagrammatic key to water supply requirements

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6.2.5 *Minimum water supply requirements*

6.2.5.1 *Class A1, A2, and B2 water supplies*

A Class A1, A2, or B2 water supply, as defined in 6.2.1, with the primary supply independent of a town's main, is required for the following buildings:

(a) Buildings greater than 45 m high, measured from the point of lowest entry to the floor level of the highest normally occupied floor; or
(b) Buildings with a total floor area greater than 11 000 m^2 that have managed evacuation strategies.

6.2.5.2 *Class C2 water supply*

A Class C2 water supply, as defined in 6.2.1, is the minimum required for buildings greater than 25 m high, measured from the point of the lowest entry to the floor level of the highest normally occupied floor.

6.2.5.3 *Class C1 water supply*

A Class C1 water supply, as defined in 6.2.1, is the minimum requirement for all buildings not described in 6.2.5.1 or 6.2.5.2.

NOTE – The above requirements are a minimum only. In some cases, it may be desirable to provide a higher level of water supply than the required minimum to address items such as business continuity and maintenance.

6.3 Flow and pressure requirements

The flow and pressure requirements for each installation shall be defined at a point immediately above the alarm valve and shall be those specified in Parts 7, 8, and 9 as appropriate to the hazard class.

Where additional systems, such as drenchers, deluge systems or external sprinklers impose a greater demand on the water supply than this standard requires, this shall be allowed for in system's water supply.

Except for internal drenchers installed for building consent purposes and proscenium opening drenchers, systems shall not be required to be designed to deal with internal and external concurrent demands.

6.4 Town's main, boosted town's main, and supplemented town's main

6.4.1 *Town's main*

A water supply may be obtained by means of a piped connection from a town's main which meets the following requirements.

The town's main shall be part of a reticulation system under the control of the network utility operator and has been approved by an SSC after first determining that the system:

(a) Is in good order with a record of reliable drought-free operation;
(b) Is supplied by an inexhaustible source of water or has sufficient stored capacity to meet the normal needs of the area served for a 24-hour period during peak demand;
(c) Has, where pumps are used to provide or supplement pressure, at least 50% of the pumping capacity independent of the local network utility operator for its electrical power supply.

NOTE – A town's main is likely to be significantly impaired following a maximum credible earthquake event. The building owner may wish to consider a more reliable water supply to cater for such an event.

The flow and pressure characteristics of a town's main shall be determined by method 1 or method 2 of Appendix R. Based on past history, an SSC may nominate the need to use of method 2 at design parameter review.

If the static pressure of the main exceeds 1000 kPa, full particulars shall be submitted to an SSC including any proposed use of automatic pressure control valves.

6.4.1.1 *Privately owned sections of water mains supplied by a town's main*

Notwithstanding the requirements of 6.4.1, the SSC may accept sections of privately owned water mains supplied from a town's main as compliant, if it can be demonstrated that these sections of privately owned water mains have equivalent reliability to that required by 6.4.1, and that suitable procedures are in place for maintaining and controlling isolations of the section of privately owned water mains. Such procedures shall be documented in accordance with Part 11.

Where a section of privately owned water main is accepted as compliant, the main and any connections to it shall be treated as if the main were a town's main as per 6.4.1.

A suitably sized legible plan showing the water reticulation and associated valving shall be provided within the sprinkler valve enclosure.

NOTE – It is recognised that it there may be limits on the correctness of such plans on existing sites.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.4.1.2 *Rules for two connections used to produce a complying single supply*

On a Class C1 or C2 system (see 6.2), two such connections may be made to the reticulation network and combined to produce a complying single supply provided that:

(a) A prominent sign warning of the two connections is affixed to the block plan and both connections are shown;
(b) An engraved metal sign is affixed to the underside of the toby box lid of both street valves drawing attention to the existence and location of the other valve; and
(c) The network utility operator consents.

Where it is proposed to make two connections to a private site fire main to provide a Class B2 supply (see 6.2.1), the flow and pressure available at each point of connection shall meet the design requirements and there shall not be any one section or component of the reticulation on which both points of connection depend. Hence, the mains shall be part of different reticulation systems or shall form part of an interconnected reticulation system that is supplied from at least two reservoirs or pumped source and is fittedwith sufficient stop valves so that in the event of a breakdown anywhere in the system, selective closing of these valves will ensure that at least one of the mains can remain operational. In addition, an interconnected reticulation system shall require that:

(d) The branch connections to an interconnected reticulation system shall comply with 6.4.1.7.1(c) and have at least two other valves between them. The location of such valves shall comply with 6.4.1.7.1(d);
(e) Each branch connection shall be capable of supplying the design flow and pressure; and
(f) The reticulation network shall be tested with sufficient valves closed to simulate the hydraulically worst condition of breakdown or repair. The particular configurations of closed valves shall be approved.

6.4.1.3 *Strainer rules for town's main water supply*

Except in the case of a supplemented town's main, a listed strainer, complying with 4.4.10, shall be installed on every town's main water supply in the following cases:

(a) Where the design flow is 2300 L/min or greater; or
(b) Where the design flow is less than 2300 L/min and previous experience or test results indicate a need for a strainer to eliminate particulate matter, which could block a sprinkler or other system orifice.

In such cases, the contractor may obtain an early ruling regarding the need for a strainer, by the submission of appropriate information to, or by facilitating demonstrative tests for, an SSC.

Ordinarily, it will not be necessary to require a strainer for an ELH occupancy design flow if the town's main is 100 mm or larger.

6.4.1.4 *Pipework*

The pipework of a connection to a town's main shall comply with 4.3.11.2.

6.4.1.5 *Connections for hose reels and other low-demand uses*

Provided the town's main and the branch connection are not less than 100 mm nominal diameter:

(a) A single pipe not larger than a 40 mm ID may be taken off the branch connection from the town's main for low-demand purposes only; or
(b) A single pipe not larger than a 40 mm ID may be taken off the branch connection from the town's main for supplying hydraulic hose reels for firefighting purposes. A single pipe not larger than a 40 mm ID maybe taken off this 40 mm pipe for low-demand purposes, in which case there shall be stop valves suitably labelled on each of the supply pipes for hydraulic hose reels and for low-demand purposes fixed in close proximity to their common connecting point;
(c) Where the water supplies comprise connections taken from more than one town's main, a pipe or pipes not larger than a 40 mm diameter to supply hydraulic hose reels for firefighting purposes only may be taken from the main which conveys the combined supplies from the point at which they are joined together up to the installation control valves. A stop valve suitably labelled shall be fitted on the pipe taken off for hose reel purposes close to the point of its connection with the combined main;
(d) Such connections shall be fitted with a labelled stop valve in close proximity to the point of connection; and
(e) Where required by the building consent authority (BCA), such connections are fitted with an approved backflow prevention device.

6.4.1.6 *Connections for industrial and/or high-demand use*

Water for industrial, large domestic demands or other purposes requiring a supply greater than 40 mm, may only be taken from the branch connection from a town's main with approval and if all the following conditions are complied with:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(a) All industrial uses are supplied from a single spur from the branch connection;
(b) The spur is provided with a stop valve, complying with 6.4.1.7.1(d), within the boundary of the protected premises so that the spur may be independently closed;
(c) There is no intrusive pattern water meter on the branch connection to the town's main although there may be a meter on the spur and downstream of the valve in (b);

NOTE – This clause is not intended to exclude the installation of non-intrusive water meters, such as magflow meters.

(d) Apart from the street stop valve, there is no other stop valve in the waterway to the sprinkler installation unless it is fitted with a listed supervisory device and its location is specifically approved by an SSC;
(e) The position of all valves and the industrial uses spur shall be shown on the block plan; and
(f) Where required by the BCA, such connections are fitted with an approved backflow prevention device.

6.4.1.7 Connection of hydrants

6.4.1.7.1 Hydrant connections to branch connections from town's main supply

No hydrant shall be supplied from any combined main. Hydrants, including those on risers in multistoreyed buildings, may only be connected to a branch connection from the town's main, provided they comply with the following conditions:

(a) The branch connection is at least 100 mm diameter;
(b) For private potable water site reticulations complying with 6.4.1.1 and 6.4.1.10, hydrants do not need to be on separate spurs if they are on or alongside formed roadways subject to above-ground hydrants having impact protection;

NOTE – This is intended to apply to campus reticulations typical of hospitals, universities and other large educational sites, large retirement complexes, and the like, where the site reticulation has all the characteristics of a public town main and where hydrants are located as if it were a public main. Where it is unclear whether a particular site falls within this clause, the SSC approval should be sought before installation begins.

(c) Industrial and commercial sites hydrants are to be located on a spur or spurs fitted with valves from the branch connection, and which may be in the form of a ring and/or may be supplied by more than one connection to a town's main (see Figure 6.4). An SSC may accept a single hydrant outlet supplied from an unvalved spur, or a single inline hydrant, provided it is satisfied the reliability of the water supply will not be adversely affected by its location;
(d) Alternatively, the hydrants and the sprinkler connection are taken directly from a ring main supplied by the branch connection. In this case, normally open valves shall be located on the ring, immediately on either side of the junction with the branch connection, and also immediately on either side of anunvalved connection to each sprinkler installation. No other valves may be located in the ring or the respective branch connections unless approved by the SSC. The ring main may be supplied by more than one connection to a town's main (Figure 6.4);
(e) All valves, other than the street valve on each branch connection at the junction with the town's main, shall be listed post indicator valves; or stop valves and toby boxes complying with 604.1.9; or listed stop valves located beneath a suitably sized manhole cover, service duct or accessible part of the building, and shall be locked in the open position and the above-ground portions painted red. The hydraulic position of valves shall be as indicated in Figure 6.4;
(f) The location of all street stop valves, ring mains, hydrant spur mains, and associated stop valves shall be shown on the block plan.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

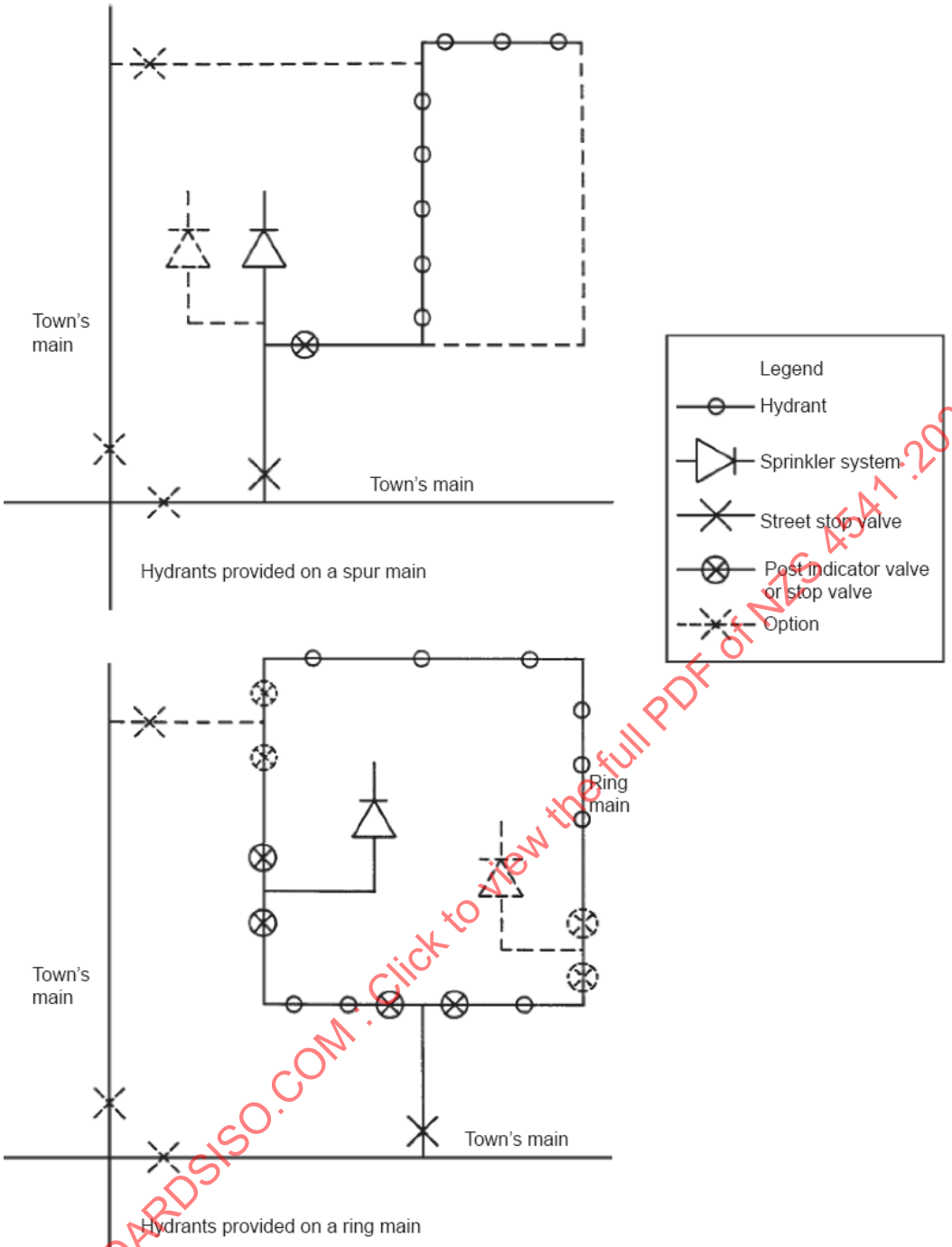


Figure 6.4 – Permissible supply to hydrants from town's main sprinkler connections – Diagrammatic layout (Class C1 supply)

6.4.1.7.2 Hydraulic design allowances for sprinkler systems supplied by a town's main with fire hydrants

Where the fire sprinkler system is supplied from a town's main, which has fire hydrants located on that town's main supply, hydraulic design allowances will be made in accordance with SNZ/PAS 4509.

(a) The hydrant demand shall be available at the closest two hydrants to the sprinkler valve set when the main is supplying the sprinkler system design demand;

(b) Where the sprinkler system and the hydrants are supplied by an internal ring main (Figure 6.4), the pressure availability at the sprinkler valves shall be determined by closing the hydraulically mostfavourable arm of the ring;

(c) Where the sprinkler system(s) and the hydrant(s) are fed by a ring main that is a Class B2 system, the pressure availability at the sprinkler valves shall be determined by closing the hydraulically mostfavourable arm of the ring, or by the impairment of either of the water supplies.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

The hydrant allowance shall be in addition to the sprinkler demand. It is not necessary to provide the demand at the highest design pressure, but merely to be able to demonstrate that the demand is available ata residual pressure of 100 kPa, within 100% of the sprinkler water supply. See Figure 6.5.

In certain cases, the provision of hydrant demand will impose an additional burden on the building owner, where the town's main is not able to provide for both the sprinkler demand plus the hydrant demand. If in such cases, the provision of the hydrant demand would necessitate the provision of a fire water storage tank,the requirement for hydrant demands may be waived if notification is provided in writing to the fire brigade with a copy to an SSC. The notification shall give an indication of what the shortfall will be.

NOTE – For most buildings the notification will be to the National Commander of Fire and Emergency New Zealand.

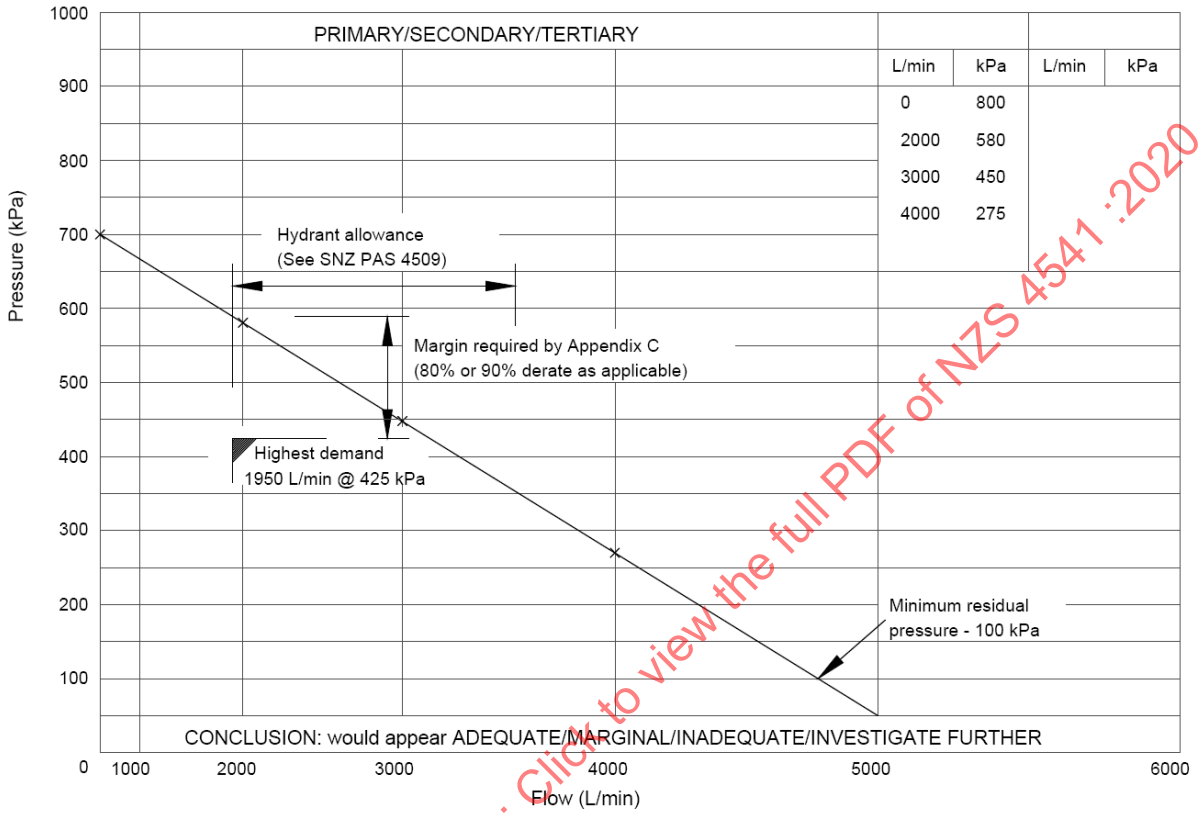


Figure 6.5 – Illustrative example of hydrant allowance (see 6.4.1.7.2)

6.4.1.8 *Stop valves and toby boxes*

A left-handed closing stop valve enclosed in a toby box shall be provided at the point of connection to the town's main.

NOTE – With the agreement of the network utility operator, the underside of the toby box lid should be painted with a colour distinctive to fire sprinkler connections.

Other than valves installed to allow the isolation of pumps, no other valves may be fitted to the water supply of any sprinkler installation, between this valve and the main stop valve, unless supervised. Underground stop valves on private site ring mains are not required to be supervised.

6.4.1.9 *Water meters*

Where required by the network utility operator, listed water meters may be installed on the connection to the town's main.

6.4.1.10 *Private potable water mains to multiple buildings*

Private potable water reticulation mains serving multiple buildings and/or sprinkler systems shall be deemed to comply provided all of the following conditions are met:

(a) The reticulation main shall be supplied by at least one approved primary supply;
(b) The reticulation main can be demonstrated to have a similar level of reliability to a town's main; and
(c) Where multiple buildings are served by the reticulation main the connections to each building, for other purposes, shall be required to comply with 6.4.1.6 and 6.4.1.7 except that one connection shall be permitted per building, or in the case of residential units, one connection per unit.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

6.4.2 *Boosted town's main*

6.4.2.1 *General*

In any situation where a town's main, which otherwise complies, cannot meet the necessary pressure requirements, an automatic starting diesel pump unit or, in the case of a secondary supply, an automatic starting electric pump unit, may be used to boost the pressure to meet the relevant design pressure requirements. (See Figures 6.6, 6.7, or 6.8 for typical layouts.)

6.4.2.2 *Pump unit*

The combined output of the town's main (when measured in accordance with method 1 or 2 of Appendix R) and pump shall meet the pressure and flow requirements of the system. The pump unit shall comply with 6.7.

6.4.2.3 *Town's main pressure*

The residual pressure in the main when meeting the highest design flow shall not fall below 100 kPa at the point of connection to the town's main and shall be positive pressure between that point and the suction point of the pump. This value is not subject to derating in terms of Appendix R.

6.4.2.4 *Bypass*

A bypass shall be provided around the pump of the same diameter as the town's main connection and shall be fitted with a non-return valve to prevent recirculation.

6.4.2.5 *Pump test return*

A pump test return pipe shall be taken from the pump delivery (downstream of the flexible coupling) to the pump suction (upstream of the flexible coupling). This pipe shall be fitted with a normally closed, locked and labelled indicating stop valve fitted with a supervisory device. A normally closed pump cooling drain may be required in accordance with 6.7.2.4, and Figures 6.6, 6.7, and 6.8. An orifice plate, sized to induce approximately 110% of the design flow, shall be fitted in the pump test return unless the hydraulic characteristic of the pipework is such as to cause 110% of the design flow to be induced. The pump test return valve shall be supervised to signal defect when more than 5% open (see also 6.7.9).

6.4.2.6 *Pump discharge pressure control*

Where the boosted discharge pressure from a pump will exceed the rating of the system components or cause difficulties with operation of the system, then listed pressure relief or listed pressure reducing valves may be fitted. Typical arrangements are shown in Figures 6.7 and 6.8.

6.4.3 *Supplemented town's main (using infill tank)*

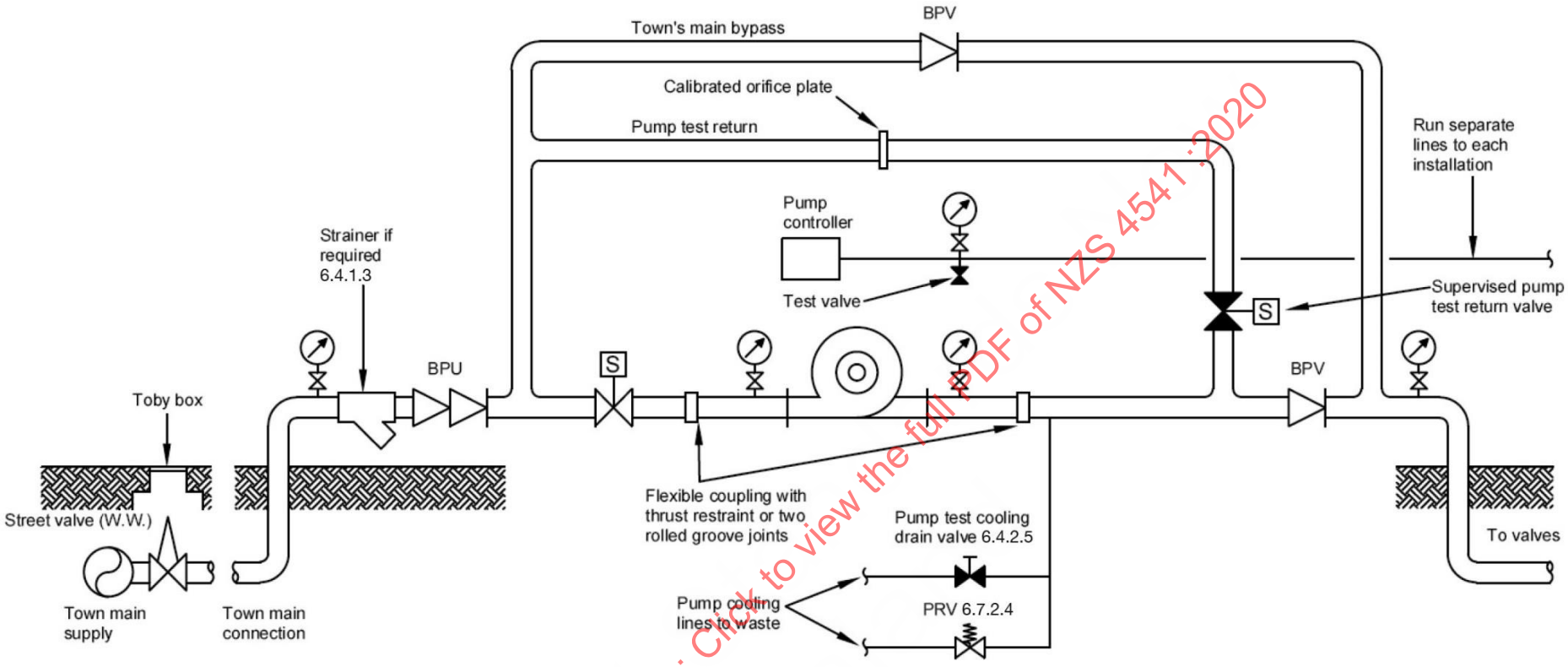
6.4.3.1 *General*

In any situation where a town's main, which otherwise complies, cannot meet the necessary flow requirements, an infill tank and automatic starting diesel engine driven pump unit or, in the case of a secondary supply, an automatic starting electric pump unit, may be used to provide the relevant design flow requirements for the required period of discharge. See Figure 6.9.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



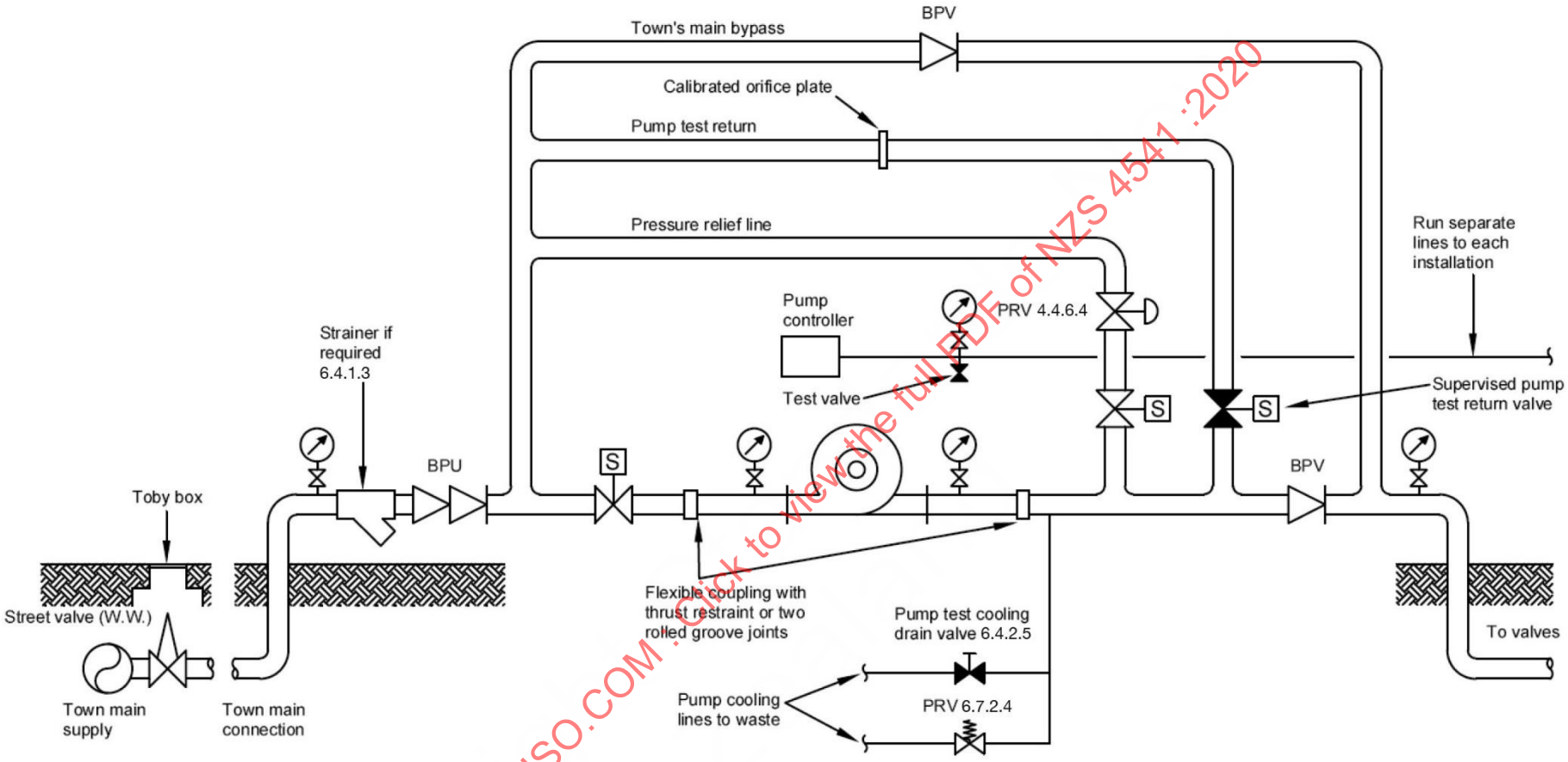
Legend:

PRV	Pressure relief valve
BPV	Back pressure valve
BPU	Backflow prevention unit
W.W.	Water works pattern stop valve

Figure 6.6 – Typical arrangement for boosted town's main without pressure relief line

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



Legend:

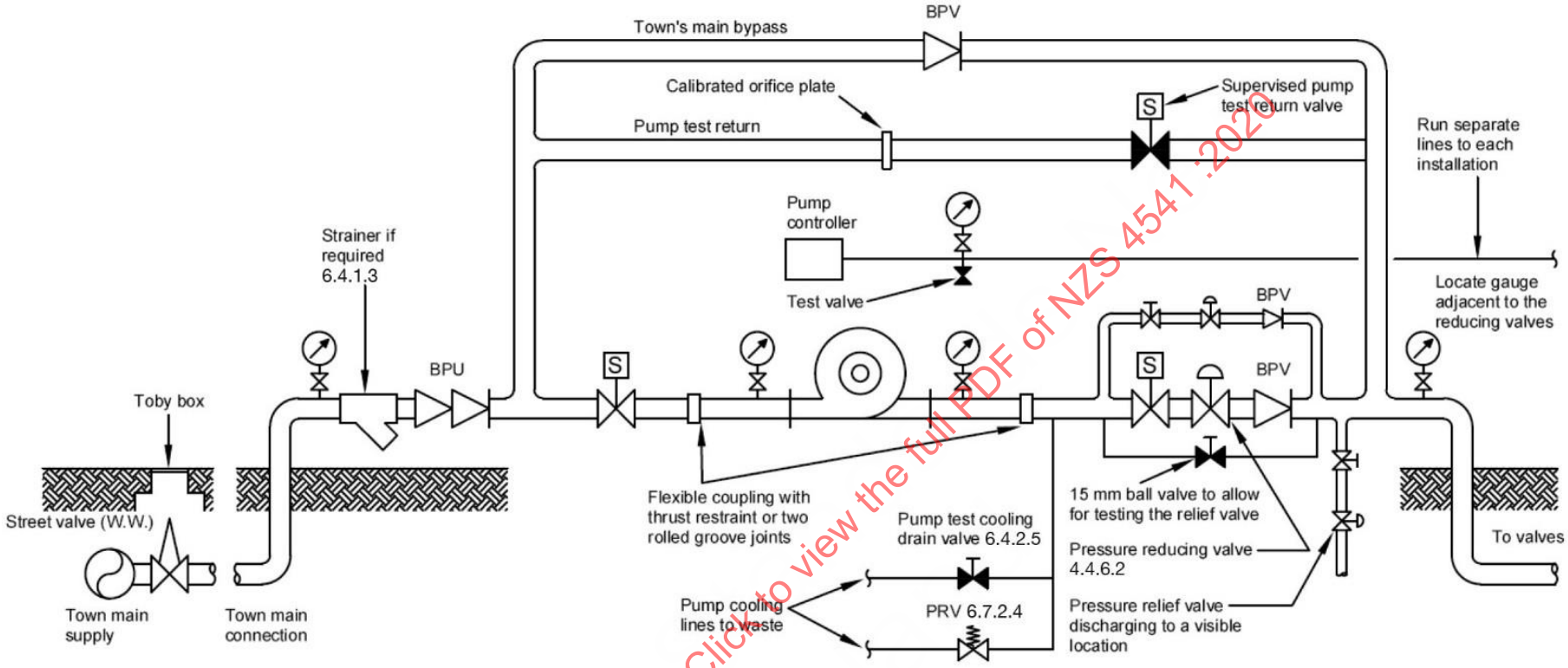
PRV	Pressure relief valve
BPV	Back pressure valve
BPU	Backflow prevention unit
W.W.	Water works pattern stop valve

Figure 6.7 – Typical arrangement for boosted town's main with pressure relief line

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand



Legend:

PRV	Pressure relief valve
BPV	Back pressure valve
BPU	Backflow prevention unit
W.W.	Water works pattern stop valve

NOTE –

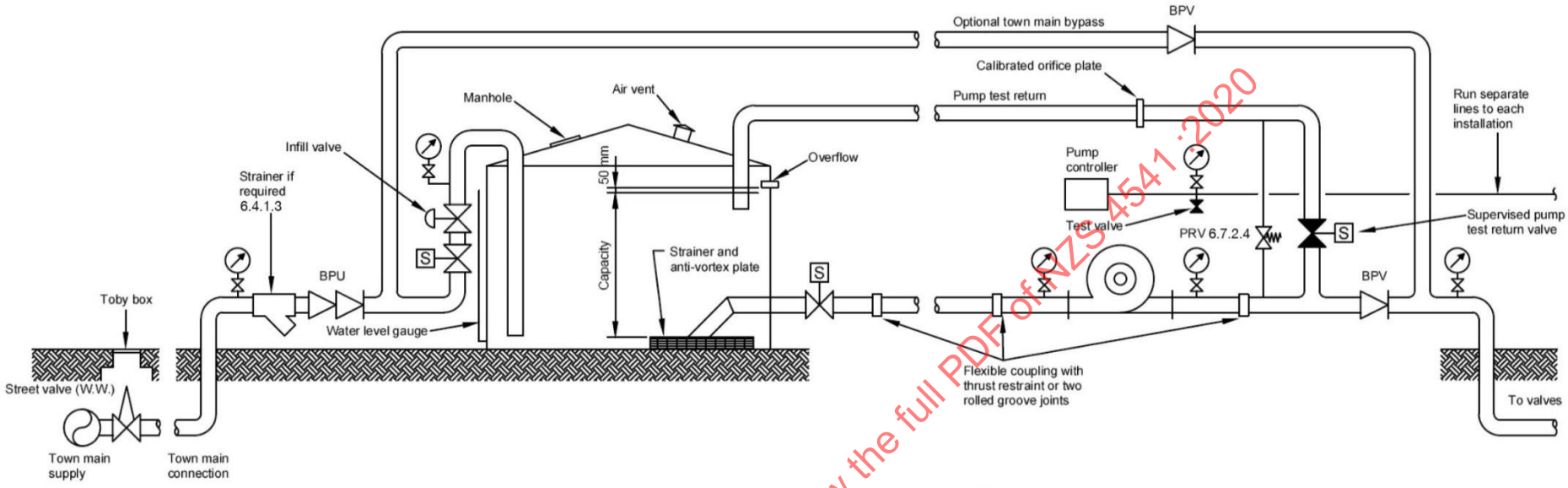
(1) A low-flow pressure reducing bypass may be required to allow stable pressure control at single head flow. This valve is typically set a minimum of 100 kPa above the main reducing valve set pressure. Consult with valve manufacturer to correctly engineer this valve.

(2) A pressure relief valve is required downstream of the pressure reducing valve to cater for transient surges. The pressure relief valve is to be piped to waste. The use of a pilot-operated relief valve is recommended.

Figure 6.8 – Typical arrangement for boosted town's main with pressure reducing valve system

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



Legend:

PRV	Pressure relief valve
BPV	Back pressure valve
BPU	Backflow prevention unit
W.W.	Water works pattern stop valve

Figure 6.9 – Typical arrangement for supplemented town's main (using infill tank)

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6.4.3.2 *Tank*

The following requirements apply:

(a) The tank shall comply with the requirements of 6.6.1 to 6.6.3 other than those of 6.6.2.3;

(b) The tank shall be filled by the town's main. The filling pipe shall terminate below the level of the anti- vortex plate. Adequate arrangements shall be made to prevent inflow turbulence creating air entrainment in the pump suction at all tank levels within the design capacity;

(c) The inflow shall be controlled by a listed automatic valve operated by an approved pilot control arrangement so that a lowering of the water level more than 75 mm below the overflow will fully open the inflow. The automatic valve shall close before the tank overflows. The arrangement shall have regard to wave action and the need to be tested, and the overflow pipe shall have a cross-sectional area at least twice that of the infill pipe and be capable of preventing the water level rising above the overflow pipe;

(d) A 15 mm nominal diameter connection controlled by a ball valve and float in parallel to the main inflow valve may be provided to facilitate topping up;

(e) The tank shall have a capacity which is the greater of:

(i) 20 minutes stored water at the highest design flow rate, or

(ii) sufficient stored water capacity and the automatic infill flow rate sufficiently large that, taken together, the pump can deliver the design flow for the times specified below, without the town's main residual pressure falling below 100 kPa at the inlet to the automatic control valve;

Supply	**Extra light and ordinary hazard**	**Extra high hazard**
Primary supply	60 minutes	Storage occupancies – see Table 6.1 Process occupancies – 90 minutes
Secondary supply	40 minutes	

(f) The flow and pressure characteristics of a town's main shall be determined by method 1 or method 2 of Appendix R. Based on past history, an SSC may nominate the need to use of method 2 at design parameter review.

(g) Where the flow requirement for external sprinklers exceeds that for the hazard classification within the protected area, the tank and main capacity combined shall also be capable of meeting the specified minimum operating times (see also 6.6.1.3);

(h) The capacity shall be measured as the depth of water contained between a horizontal plane 50 mm below the overflow, and the level below which air entrainment due to in-flow turbulence may occur or thelevel of the anti-vortex plate, whichever is the higher;

(i) Where the water storage tank provides water supply to fire hydrants, the tank capacity shall allow for 45 m^3 for the hydrant demand required by 6.4.1.7.2 and

(j) Where hydrants are connected to the town's main supply to the infill valve, the tank capacity shall allow for 45 m^3 for the hydrant demand required by 6.4.1.7.2.

NOTE – In certain circumstances consideration should be given to increasing the volume for hydrants where external fires may occur.

Table 6.1 – Duration of water supplies for EHH occupancies

Sprinkler type by spacing	**Number of sprinklers in ceiling design**	**Primary supply duration (minutes)**
Standard spacing	Up to 12	60
	13 to 19	90
	20 or more	120
Extended spacing	Up to 6[a]	60
	7 to 9	90
	10 or more	120
[a] The number of sprinklers in the ceiling design can be up to eight (instead of up to six) for extended coverage sprinklers having a maximum area spacing of 13.4 m^2 as outlined in Table 9.5.		
The secondary supply shall be 50% of the primary supply, but not less than 60 minutes.		

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.4.3.3 *Pump unit*

The pump unit shall comply with 6.7.

6.4.3.4 *Town's main infill testing*

The town's main infill rate shall be determined by timing the rate of rise of water level in the tank over a measured increase in depth. The volumetric infill rate is then calculated from the net increase in tank volume over time.

6.4.3.5 *Bypass*

A bypass of the same diameter as the town's main connection and fitted with a non-return valve to prevent recirculation may be provided to supply water to the underside of the sprinkler control valves, downstream of the booster pump. See Figure 6.9.

NOTE – Whether the town's main's flow and pressure characteristics offer sufficient benefit to justify the additional cost and complexity of installing a bypass should be considered.

6.5 Pumped supplies – Water sources

6.5.1 *Acceptable sources*

The following are acceptable sources of water for pump units, provided they satisfy the detailed requirements set out in this standard:

(a) Town's main (see 6.4);
(b) Tanks (see 6.6.1 to 6.6.3);
(c) Wells and artesian bores (see 6.6.4); and
(d) Open water (see 6.6.5).

In each case, the water shall be clean and free from sediment and debris.

6.5.2 *Town's main*

A town's main supplying water for a pump shall meet the requirements for a boosted or supplemented town's main.

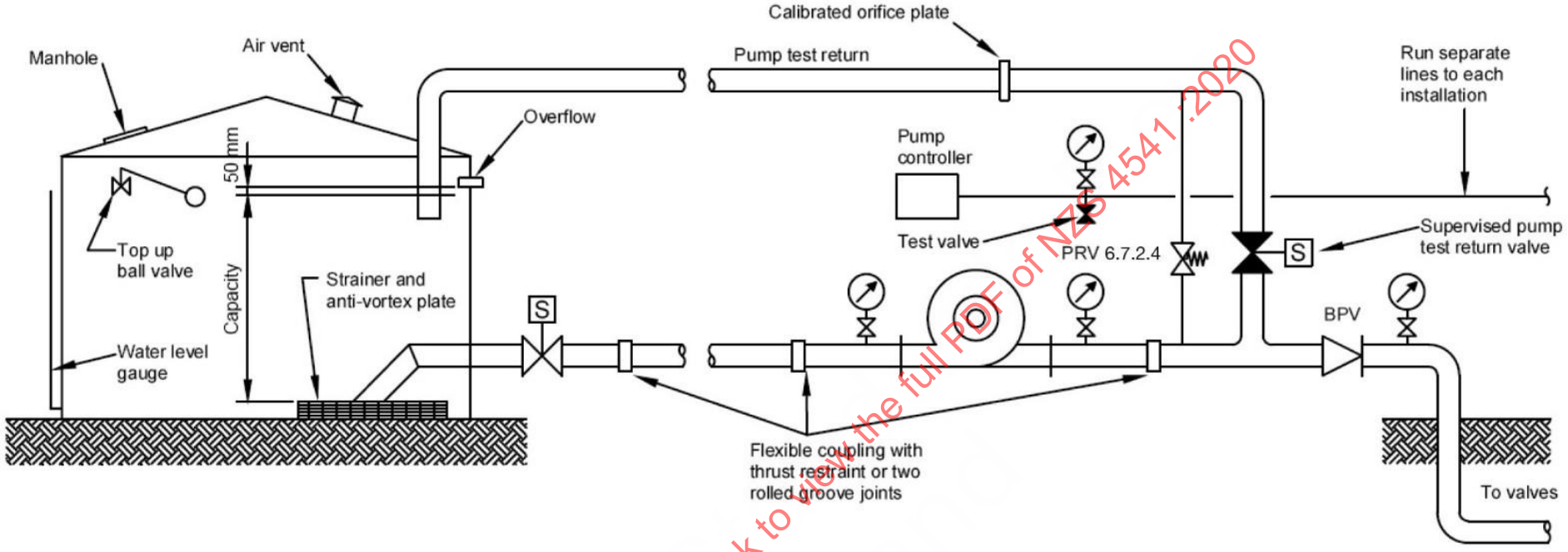
6.5.3 *Tanks*

Figure 6.10 shows a typical arrangement for a water supply consisting of a pump drawing from a storage tank.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



Legend:

PRV	Pressure relief valve
BPV	Back pressure valve
BPU	Backflow prevention unit
W.W.	Water works pattern stop valve

Figure 6.10 – Typical arrangement for pump and tank supply

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.5.4 *Class A2 water supply*

Figure 6.11 shows a typical arrangement for a Class A2 water supply.

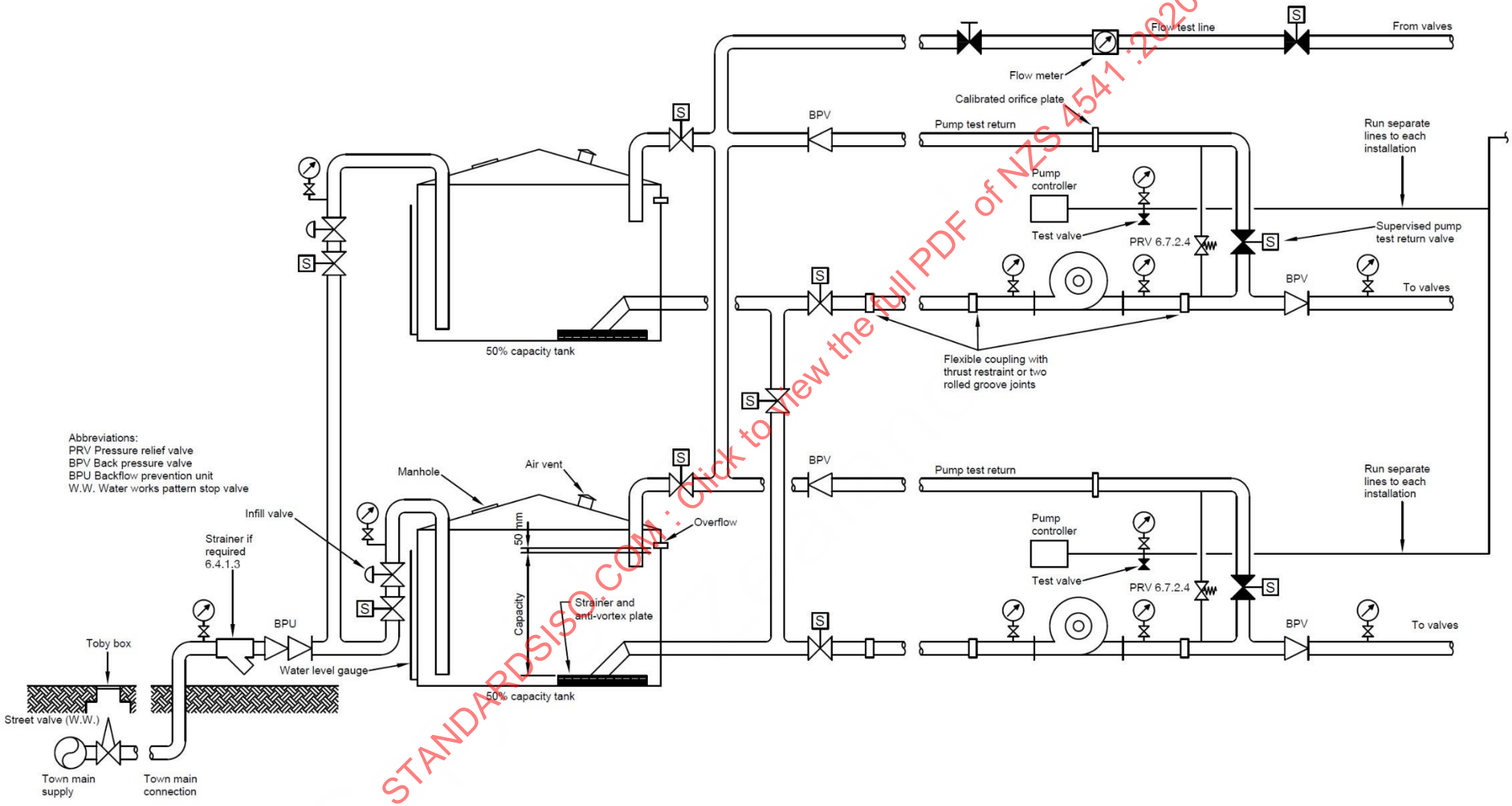


Figure 6.11 – Typical arrangement for Class A2 water supply

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

6.6 Water storage

6.6.1 *Storage tank capacity*

6.6.1.1

Where a water supply incorporates a storage tank, the minimum effective capacity shall be the product of the greatest design flow and the time (as specified below) during which that flow shall be delivered. Where the water storage tank provides water supply to fire hydrants the tank capacity shall be increased by 45 m^3.

Hazard classification	Primary supply	Secondary supply
Extra light	60 min	40 min
Ordinary	60 min	40 min
Extra high – Storage	Table 6.1	Table 6.1
Extra high- Process	Table 6.1	Table 6.1

NOTE –

(1) For infill tanks associated with supplemented town's main, see 6.4.3.

(2) Where external sprinklers are provided see also 6.6.1.3.

(3) In certain circumstances, consideration should be given to increasing the volume for hydrants where external fires may occur. An example of such a situation is when an external fire is expected to expose the protection of a building for a duration greater than the minimum design duration of the water supply.

The water supply duration for deluge and water spray systems shall be subject to specific approval by the SSC.

6.6.1.2

The effective capacity shall be measured as follows:

(a) Where the storage tank or elevated tank is used exclusively as a water source for the sprinkler supply, the effective capacity shall be measured between a horizontal plane 50 mm below the overflow and the top of the anti-vortex plate; and

(b) The effective capacity of a storage tank or elevated tank that also provides water for purposes other than firefighting, is the volume contained in the depth by which the sprinkler anti-vortex plate is below the other purposes outlet.

NOTE – See also 6.6.3.11.

6.6.1.3

In the case where the design number of external sprinklers creates a flow requirement in excess of the hazard classification within the building, the capacity of any storage tank shall be increased, where necessary, as follows:

(a) Where the exposure consists of a private dwelling or other structure of similar size, there shall be sufficient storage for 30 minutes discharge at the highest design flow imposed by the design number of external sprinklers; and

(b) In other cases, so that there is sufficient storage for 60 minutes discharge at the highest density flow imposed by the design number of external sprinklers.

6.6.2 *Refilling and topping up*

6.6.2.1

Provision shall be made on all storage tanks and elevated tanks to:

(a) Automatically keep the tank topped up; and

(b) Manually refill the tank after emptying.

6.6.2.2 *Topping up*

The top-up system shall be arranged to maintain the water level at 50 mm (± 25 mm) below the overflow level, or, when tanks are shared for other purposes, within 25 mm of the other purposes tank outlet.

Topping up may be by either:

(a) A float operated valve or other suitable device controlling a 15 mm NB pipe connected to a town's main; or

(b) An electrically driven 20 L/min pump taking suction from a reliable source, automatically switched by a level controlled switch.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Where (a) or (b) cannot be achieved, topping up may be provided by a continuous overflow controlled supply from rainwater or other less reliable source.

6.6.2.3 *Refilling*

The following requirements apply:

(a) Refilling may be provided by a connection to a town's main, provided that this will not deplete a town's main supply to the system in the event of the system operating, or from some other reliable source of water;

(b) Refilling shall be achieved within the following times:

Tanks up to 500 m^3 ..... 6 h;

Tanks of larger capacity ..... 12 h.

(c) If the refilling time specified above cannot be met alternative contingency plans shall be submitted for consideration to an SSC.

6.6.2.4 *Rainwater*

Where rainwater or other unfiltered water is used to provide topping up or refill, it shall first pass through a debris and sludge trap.

6.6.2.5 *Float operated valves*

Float operated valves shall be accessible for maintenance without requiring significant water storage depletion.

6.6.3 *Construction*

6.6.3.1 *Design and manufacture*

6.6.3.1.1

Tanks shall be designed to take into account seismic and other geotechnical hazards, and shall remain serviceable after a design event.

Roofed storage tanks and supporting elements on which the tank rests shall comply with 1.7.2, and shall be specifically designed and reviewed by a CPEng with competence in the area of seismic design of water storage tanks and supporting elements, irrespective of whether the tank is of a standard design. If the tank material is included in the scope of the New Zealand Society for Earthquake Engineering (NZSEE): *Seismic design of storage tanks*, the design shall comply with that design recommendation document.

NOTE –

(1) NZS 1170.5 states that the design of tanks containing liquids is beyond its scope because some critical seismic characteristic of tanks are different from buildings on which the standard is based. However, some provisions from NZS 1170.5 are relevant and applicable. As an example (for concrete tanks), provisions relating to: subsoil type, various factors including seismic zone hazard, return period (limit state and building importance level), near fault, damping, and ductility correction are relevant to tanks containing liquids. The same applies to structural analysis methods. For more detail, see Appendix A of NZS 3106.

(2) The requirement for each installation to be specifically designed is to provide appropriate consideration to the seismic zone and soil type relevant for the particular situation of the tank. Designers are also required to consider the same site-specific factors for tanks manufactured to a standard specification or design.

(3) The SSC should require producer statements for the design, construction, and construction review of the tank and its supporting elements to ensure that this clause is met.

6.6.3.1.2

Swimming pools are an acceptable form of water storage capacity provided that:

(a) The drain valve is chained, padlocked shut, and labelled in 12 mm high white letters on a red background 'FIRE SPRINKLER PUMP WATER SUPPLY. DO NOT DRAIN BEFORE NOTIFYING SPRINKLER CONTRACTOR';

(b) Unless it is an indoor pool a grating additional to the suction inlet strainer is installed to prevent foreign matter reaching the strainer;

(c) The water is kept clean at all times by an effective filtration unit; and

(d) The purification system does not use sodium chloride or other corrosive materials.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6.6.3.1.3

The water storage capacity of the tank or pool shall be calculated to allow for slosh so that the design quantity of water remains available after an earthquake. The following are acceptable:

(a) Freeboard;
(b) Containment;
(c) Additional volume; or
(d) Other measures to minimise slosh.

6.6.3.1.4

Whether or not the roof or cover forms part of containment, it shall be designed not to fail in a way that could fall into the tank and block the outlet.

6.6.3.1.5

Tanks shall be designed to provide structural integrity for a minimum life of 50 years. The minimum durability is to be 15 years.

6.6.3.1.6 *Lined tanks*

Tanks of the type using tank liners shall comply with AS 2304:2019 clause 3.6, noting that:

(a) All liners shall use scrim reinforced material; and
(b) The selected tank liners shall meet the durability requirement of the NZ Building Code.

NOTE – The durability requirement for a tank liner to comply with the NZBC will normally be 15 years.

6.6.3.2 *Access*

Access, secured against unauthorised entry, shall be provided to inspect and maintain the fittings and fixtures of every tank.

6.6.3.3 *Indicator*

The tank shall be fitted with an indicator showing the contents above the level of the vortex plate.

6.6.3.4 *Overflow pipe and air vent*

A tank overflow pipe of suitable size shall be provided which discharges in an observable place. An air vent of suitable size shall be fitted.

6.6.3.5 *Freezing protection*

In situations where freezing of water is likely, the tank, together with the inlet and suction pipes, pumps test return and level indicator shall be protected against freezing.

6.6.3.6 *Suction pipe inlet*

All suction pipes shall commence with:

(a) A screen having a net cross-section open area of four times the cross-sectional area of the suction pipe and openings in the screen shall not have a major dimension larger than 8 mm; and
(b) An anti-vortex plate having a minimum dimension, measured from the centre of the outlet pipe to the outside edge of the plate, of 0.4 m for design flows up to 2000 L/min and 0.6 m for greater design flows; or
(c) An anti-vortex plate complying with (b), and a strainer complying with 6.4.1.3, installed immediately downstream of the stop valve identified in 6.6.3.7(b).

6.6.3.7 *Suction pipe*

The following requirements apply:

(a) The size and position of the suction pipe shall be such that, at the highest design flow, the water velocity does not exceed 4.0 m/s and the total pressure loss between the entry to the suction pipe and the inlet of the pump (including any permissible static lift) does not exceed the net positive suction head required minus 20 kPa when the water is at the level of the anti-vortex plate;

NOTE – The velocity limitation specified here does not apply to the five pipe diameter length of pipe attached directly to the pump casing, as specified in 6.7.2.3(d).

(b) A supervised stop valve fitted with an open and shut indicator and chained and padlocked open shall be located in the suction pipe upstream of any flexible coupling;
(c) Gate valves shall be used on pump suctions. Valves which protrude into the waterway when in the fully open position shall not be permitted on pump suctions;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(d) The suction pipe should be laid such that no air may be trapped in it. Where this is impracticable, provision shall be made for the automatic release of trapped air; and
(e) Provision shall be made to accommodate differential settlement and seismic movement between the tank and pump, and between tanks where multiple tanks are interconnected.

See also 6.7.2.3 and Figure 6.12.

6.6.3.8 *Flooded suction*

The location of the tank and suction pipe for the pump shall be such that the centre line of the suction inlet of the pump is below 60% of the required stored water capacity in the tank and at least 650 mm below the overflow and any other-purposes outlet on the tank.

6.6.3.9 *Priming devices and foot valves*

Automatic priming devices and foot valves are not permitted.

6.6.3.10 *Pump test return*

A pump test return shall be taken from the pump delivery (downstream of the flexible coupling) to the tank. This pipe shall terminate below the normal water level in the tank, so no air entrainment will take place during the pump testing.

When it is not practicable to pipe the test return back to the tank then, with specific approval, the test line shall be piped back into the pump suction pipe such that it enters the suction pipe at an angle of 90° at least 10 pipe diameters upstream of the pump suction flange.

The test return pipe shall be fitted with a normally closed, locked, and labelled stop valve fitted with a supervisory device. An orifice plate, sized to induce approximately 110% of the design flow, shall be fitted in the pump test return unless the hydraulic characteristic of the pipework is such as to cause approximately 110% of the design flow to be induced. The pump test return valve shall be supervised to signal defect when more than 5% open (see Figure 6.10 and 6.7.9).

Where butterfly valves are used as the pump test return, they shall be installed with no disturbances five pipe diameters upstream and two pipe diameters downstream.

If the pump test return pipe is also used to return the discharge from pressure relief valves back to the tank, then it should terminate below the anti-vortex plate or minimum water level.

NOTE – The provisions of 4.3.10.4 apply to orifice plates installed in pump test returns

6.6.3.11 *Connections for other purposes*

A water storage tank may be used to supply water for purposes other than for fire-fighting purposes. In such cases, the supply connection for these purposes shall be arranged above the level dedicated for fire-fighting water supply. Pipework between the tank and the other purposes connection shall meet the seismic flexibility requirements of this standard, to ensure that failure of this pipework shall not compromise the tank.

6.6.3.12 *Suction connection for FENZ*

Where there is on-grade access to the tank a suction connection shall be provided at the same level as the anti-vortex plate to allow FENZ to draw water from the tank. The suction connection shall be minimum Ø100 mm and shall be fitted with a normally closed and chained valve and a Ø100 mm female suction hose coupling conforming with SNZ PAS 4504.

6.6.4 *Wells and artesian bores*

6.6.4.1 *SSC approval requirements*

Wells and artesian bores may be used as a source of water for a pump unit only with SSC approval. Any application for approval shall set out full details of the hydrological history of the proposed aquifer or one close to it and provide details of the water quality and well design.

Due allowance shall be made for seasonal variations, with ongoing biennial flow testing of water supplies undertaken at the time the lowest water table occurs. To this end:
(a) Static bore head pressures need to be recorded for up to 2 years after initial system certification, at intervals not less than 3 months apart during autumn and winter, and every month during spring and summer;
(b) Results shall be progressively furnished to the original approving SSC; and

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(c) The first re-inspection and associated flow testing to then be timed to fall between 18 and 28 months from the date of initial certification, at the time of lowest indicated bore head pressure.

6.6.4.2 *Well development*

The well development flow shall be at least 150% of the highest design flow. At completion of development at such flow, the number of sand grains lifted shall not exceed 50 per litre.

6.6.4.3 *Well construction and accessories*

The following requirements apply:

(a) The well shall have a screen with a sealed bottom;
(b) The velocity of water through the screen shall not exceed 50 mm/s;
(c) Foot valves are not permitted;
(d) The top of the inlet to the pump or dip pipe shall be submerged at least 2 m at all conditions of flow up to and including the highest design flow;
(e) An approved device to measure draw down level under all flow conditions shall be permanently fitted; and
(f) Adequate facilities shall be available for withdrawal of the dip pipe and, where needed, submersible pump.

6.6.4.4 *Pumps*

Where submersible pumps are used, attention is drawn to the need to comply with the requirements for vertical shaft pumps and submersible electric pumps.

Where an artesian well provides the highest design flow at the surface, above-ground pumps may be used provided that such flow is delivered to the pump at a pressure of at least 10 kPa.

6.6.4.5 *Pump test line*

A pump test line as described in 6.6.3.11 shall be installed. Where permitted by the local authorities, the test return may be piped back to the well head. Alternatively, other arrangements for the safe disposal of water utilised during testing will be required to be agreed to by the SSC.

6.6.5 *Open water*

6.6.5.1 *Approval required*

With approval by the SCC and local authorities, and subject to any conditions imposed, water for a pumping unit may be taken from a river, lake, pond or reservoir for which an appropriate water right is held.

NOTE – Approval may be required under the Resource Management Act.

6.6.5.2 *Design details*

Full details shall be submitted to an SSC concerning:

(a) Quality of the water;
(b) Design of the suction pit, settlement chamber and water entry;
(c) Capacity and available flow at all times;
(d) Flood protection arrangements; and
(e) Lowest and highest known water levels.

6.6.5.3 *Flooded suction*

The lowest known water level of the water source shall be at least 650 mm above the pump centre line.

6.6.5.4 *Pump test return*

A pump test return similar to that described in 6.6.3.11 shall be installed. The point of discharge should be back to the water source.

Should the water source be a considerable distance away from the pump then, with an SCC approval, a pump test return similar to that described in 6.4.2.5 may be used (see also 6.7.9).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.7 Pumped supplies – Pump units

6.7.1 *General*

6.7.1.1 *Pump selection*

The published manufacturer's curve of the selected pump shall demonstrate that:

(a) At the design flow of every installation supplied, the pump will produce 110% of the additional pressure needed, at the point of connection to the water supply of the pump inlet flange, to meet the highest design pressure of each installation at the control valves, plus the pressure losses (or gains) due to difference in height and due to friction between the pump delivery and each alarm valve.
In determining the pressure available at the pump suction, the following shall be allowed for:

(i) On tanked or open water supplies, the pressure loss due to friction at the highest design flow in the suction pipe between the tank and the pump suction, plus allowance for the difference in elevation of the pump suction and the level of water (in tanks, when both full and empty);

(ii) For boosted towns' mains, the pressure differences due to friction loss (at the highest design flow) and due to static height, between the point at which the pressure measurement is taken to determinethe characteristics of the town's main and the suction inlet of the pump;

(b) The 'Net positive suction head (NPSH) required' at the highest design flow is not more than the 'NPSH available' minus 20 kPa at the suction inlet, measured or calculated as an absolute pressure having regard to the water temperature;

(c) At 150% of the highest design flow, the pump will produce at least 65% of the pressure available (on the manufacturer's curve) at the design flow and, when driven by the selected driver the pressure will fall progressively with the rate of flow;

(d) For centrifugal pumps installed in parallel, it is preferable that the discharge head shall fall consistently from the highest pressure at zero flow to the full flow shown on the manufacturer's curve. Where this is not practicable, then:

(i) An instability is only allowable as follows. The delivery head at zero delivery flow or minimumbypass flow may be up to 5% (however no more than 5 m) below the maximum delivery head, or

(ii) For diesel driven pumps, an unstable curve may be permitted where it can be demonstrated that, in practice, the governed engine speed delivers demonstrates a stable pump curve on test due to the change in engine speed across the performance curve; and

(e) Where a pump is required to boost the pressure for a low-flow duty, but not required to boost the pressure for a higher flow duty for a system, the pump may be sized for the lower flow duty as required by (a), (b) and (c), however, the pump shall also be capable of providing at least 110% of the flow required by the higher duty within the manufacture's published performance curve.

NOTE –

(1) An alternative to sizing the pump for the larger flow in 6.7.1.1(d) would be to install a separate system (control valve set) for the higher flow duty and individual start switches for all systems to ensure that the pump was only automatically started by the systems with the lower flow duties for which the pump was sized.

(2) In this context, the expression 'design flow' means whichever is the larger of:

(a) The flow rate required to supply all sprinklers discharging over the assumed area of operation to provide the design density or otherwise provide the flow required for CMSA or suppression mode sprinklers; or

(b) The flow rate required to operate any water spray or deluge system forming part of the sprinkler system; or

(c) If the pump also provides water for a fire hydrant system (as permitted by the standard), the flow rate required to supply the sprinklers or water spray or deluge system plus hydrant demand.

(3) Any flow rate discharged or recirculated to control pump discharge pressure should be added to the flow rates required in note 2(a), (b), or (c).

6.7.1.2 *Extensions to existing systems*

When existing systems are being altered or extended, the pump selection shall be able to demonstrate on the manufacturer's curve:

(a) For diesel driven engines, the power absorbed at the highest duty is not more than 90% of the engine manufacturer's published intermittent rating;

(b) That the pump curve demonstrates 110% of the required boost;

(c) On commissioning, the pump demonstrates 105% of the required boost;

(d) That the pump manufacturer's curve shows 110% of the highest design flow.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6.7.1.3 *Component parts*

A pump unit consists of a listed pump, listed motor, listed controller, and a unit frame.

6.7.1.4 *Unit manufacture*

Pump units shall be manufactured by a manufacturer or contractor listed for that purpose and:

(a) When ordering a pump unit, a schedule of relevant information, including the data specified in Appendix S, shall be advised to the unit manufacturer; and

(b) Before dispatch from the manufacturer's premises, every pump unit shall be inspected for compliance, including operation of control functions, and for units up to 100 kW a flow test (for larger units see 6.7.2.2).

6.7.1.5 *Pump coupling and mounting*

The pump unit and driver shall be assembled so that:

(a) The mounting on the frame shall allow either driver or pump to be removed without disturbing the other and the impeller to be withdrawn without removing the driver or pump body;

(b) There shall be ready access for checking the alignment of resilient couplings when the installation is complete;

(c) Cement grout or oil resistant flexible pads shall be provided under the frame unless the manufacturer's instructions state otherwise. Care shall be taken not to distort the frame when bolting it down;

(d) The alignment shall be checked to be in accordance with the manufacturer's specification after the pump frame is installed, bolted down, and pipework connected;

(e) The pump and driver shall be in line direct or close coupled, and the coupling shall be rated for the maximum torque of the driver under all conditions, and of a design such that if any elastomeric element used in the coupling to absorb vibration should fail, that the pump shall continue to be driven under all operating conditions, except that a right-angle gear drive may be used for vertical shaft pumps; and

(f) Guards shall be fitted to protect against injury from moving parts. Guards shall be designed in accordance with AS/NZS 4024.1601:2014.

The installation of anti-vibration spring mounts under pump set base frames (or inertia base frames) is not permitted.

6.7.1.6 *Automatic starting*

6.7.1.6.1 General

Automatic starting shall be provided so that:

(a) It shall be initiated by a listed pressure switch of one of:

  (i) A double pole double throw (DPDT) type with contacts that close on a drop in pressure, or

  (ii) Two single pole double throw (SPDT) type in parallel with contacts that close on a drop in pressure, or

  (iii) A listed pressure transducer;

(b) Start pressure switches and sensors shall be located on the controller;

(c) Every time a drop in pressure closes the contacts of a start pressure switch, or generates a start signal via a start pressure sensor, the pump, if it is not already running, shall start; and

(d) The pump start arrangement shall comply with the requirements of either 6.7.1.6.2 or 6.7.1.6.3.

Where a pressure sensor is used the sensor and associate electronics shall be listed as part of the controller assembly (see 4.7.6.3).

6.7.1.6.2 Individual installation start arrangement

This form of start arrangement has each sprinkler installation connected separately to the water supply pump(s) controller by a hydraulic pipe to sense a drop in pressure in that installation. The followingrequirements apply:

(a) A start pressure switch shall be provided for each sprinkler installation supplied by the pump;

(b) The start pressure switch shall be pressurised through a hydraulic line with a check valve (opening away from the pressure switch) in which a 2 mm orifice or equivalent score across the valve seat has been made. The hydraulic line shall also incorporate a test valve piped to drain and pressure gauge arranged to permit accurate setting and testing of the pressure switch, unless, within easy reading distance, other test apparatus will serve the same purpose. Where a distant pump enclosure necessitates long hydraulic connections, such connections may be run in high density polyethylene pipe provided that the check valve is located close to the control valves;

(c) The start pressure switch shall close before the pressure drops below that required to provide the most hydraulically remote six sprinkler heads operating;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTE – In most cases it will not be necessary to calculate the start pressure if it is possible to set the pump start pressure switch above the highest design pressure.

(d) Where there are both electric motor and diesel engine driven pumps then:

(i) Where there are two storage tanks, the electric motor driven pump is to start first
(ii) If there is a storage tank plus one other type of water source of unlimited capacity (such as a town's main) the pump on the unlimited capacity source is to start first; and

(e) This method of starting shall not be used for dry pipe, deluge or pre-action installations.

6.7.1.6.3 Water supply manifold start arrangement

This form of start arrangement senses a drop in pressure of the sprinkler system water supply main to initiate the pump(s) starting. It shall be used for dry pipe, pre-action, or deluge installations. The following requirements apply:

(a) A start pressure switch shall be provided with connection downstream of the pump discharge check valve;
(b) The start pressure switch shall be pressurised through a hydraulic line with a check valve (opening away from the pressure switch) in which a 2 mm orifice or equivalent score across the valve seat has been made. The hydraulic line shall also incorporate a test valve piped to drain and pressure gauge arranged to permit setting and testing of the pressure switch;
(c) The start pressure switch shall close before the pressure drops below that required to provide the most hydraulically remote six sprinkler heads operating;

NOTE – In most cases it will not be necessary to calculate the start pressure if it is possible to set the pump start pressure switch above the highest design pressure.

(d) The pressure downstream of the pump discharge check valve shall be maintained at a pressure above the pump start pressure switch setting, but below the lowest FIRE pressure switch setting for any installation served by the pump. If this requires the use of an automatic jockey pump, it is recommended that this be served by an essential service switchboard serving the site;

NOTE – For B2 supplies, 6.12.3 requires the pressurisation to be maintained for 24 hours without the standard power supply.

(e) Where there are two storage tanks, the electric motor driven pump is to start first; and
(f) Where there is a storage tank plus one other type of water source of unlimited capacity (such as a town's main) the pump on the unlimited capacity source is to start first.

6.7.1.7 *Manual starting*

A labelled green manual start button shall be provided on the controller to energise the starter relays. This function shall not be able to be interrupted by isolation of the pump start pressure switches or controller.

6.7.1.8 *Stopping and isolation*

Once started, every pump unit shall run until manually stopped at the pump unit. The use of a failsafe device such as an 'energised to stop' solenoid is accepted as meeting these requirements providing it meets the other requirements of this clause. Automatic or remotely operated stopping is not permitted. The following facilities shall be provided:

(a) A red, clearly labelled, easily accessible stopping device that automatically resets or returns to its normal position; and
(b) Manual means of individually isolating each start pressure switch. Only pressure switches that are closed may be isolated. Reopening the pressure switch shall automatically cancel the isolation.

6.7.1.9 *Gauges*

The following gauges shall be provided:

(a) A pressure gauge complete with gauge cock connected to the suction of every pump far enough from the pump not to be influenced by pump entry turbulence; and
(b) A pressure gauge complete with gauge cock connected to the pump delivery.

Gauges shall comply with 4.6. Gauges shall be mounted independent of the system pipework and piped in such a manner that pump set vibration is not transmitted to the gauge.

6.7.1.10 *Pump running indicator*

(a) Every pump unit shall be provided with a device which indicates at an approved location that the pump is running.
(b) On diesel engine driven pumps, an SSC may agree to the omission of this alarm if the noise of the engine will serve the same purpose.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(c) A self-resetting device may be incorporated to suppress an electrically operated alarm for up to 60 minutes.
(d) Where the indication is made at a location which is not manned at all times, a defect signal shall be generated through the FBA. The FBA control box used to generate the defect signal shall be clearly marked 'Pump running alarm connected to this unit.' In such situations, there is no need for a separate pump running alarm, such as a bell.

6.7.1.11 *Pressure relief valves*

Pressure relief valves may be used to limit pump discharge pressure where excessive pressures may be generated. If fitted to boosted town's main or tank supplies, these valves shall not discharge to waste. See 4.4.6.4.

6.7.1.12 *Acceptance of load*

The design flow of the pump unit shall be provided automatically (at the pressure designated on the pump curve) within 30 seconds of the pump start signal when tested under open discharge conditions.

Starting of a pump shall not cause water hammer or surges that over-pressurise the installation or trigger spurious fire alarms from the FBA's of connected sprinkler installations, when the FBA is in its normal state.

6.7.2 *Pumps*

6.7.2.1 *Listing of pumps*

Only listed rotodynamic pumps shall be used. Factors that shall be considered for any listing are:
(a) Materials and construction;
(b) Performance range and accuracy against the manufacturer's curve;
(c) Availability of documentation;
(d) Every application for listing of a pump shall be accompanied by the following:

(i) Details of construction

(ii) The discharge versus power absorbed at duty speed

(iii) The net positive suction head required (NPSHR) versus discharge at duty speed

(iv) The total head versus discharge at various speeds and impeller diameters; and

(v) The maximum impeller width and diameter.

6.7.2.2 *Measured performance of pump*

Every pump shall demonstrate, by means of one of the methods specified below, that it is able to provide on test any flow (up to and including 110% of the highest design flow) at not less than 95% of the pressure available on the manufacturer's curve at that flow. The methods are:
(a) Production of a certificate, duly identified with the pump serial number, of a test conducted in accordance with AS 2417 or other approved equivalent;
(b) A bench test conducted in accordance with AS 2417, or other approved equivalent, witnessed by an SSC; or
(c) An *in situ* test of the installed pump unit using a certified test device (whether installed or portable) witnessed by an SSC;

Additionally, every pump forming part of an installed pump unit shall demonstrate on test when the design flow is induced through the alarm valve of every sprinkler installation supplied by the pump unit that:

(d) On newly installed pump units, the available pressure at the alarm valve is at least 105% of the highest design pressure for that installation; and
(e) Subsequently, that the available pressure at the alarm valve is not at any time less than the highest design pressure for that installation.

NOTE – In evaluating the test results in items (c), (d), and (e), the pressures recorded during flow tests need to be corrected to take account of variance in suction conditions, that is, tank or town's main minimum permitted suction condition.

6.7.2.3 *Waterway fittings*

The following requirements apply:
(a) The pump suction and delivery shall be connected to the fixed piping through listed flexible couplings to prevent transmission of running vibration and seismic movement, and to ensure that the pump alignment is not stressed by the pipes. Any elastomeric type couplings shall be mechanically restrained;
(b) Stop valves are not permitted between the pump delivery and the main stop valve, unless supervised and the location approved;
(c) Pump suction isolation valves are to be supervised;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(d) The pump suction pipe shall terminate at the pump suction flange with a straight length of pipe either the same diameter as the pump flange, or one size larger, and at least 5 pipe diameters in length.
However, if there are devices or fittings such as butterfly valves, strainers, or backflow prevention units in the suction pipe that protrude into the waterway in the normal state, these shall be located at least 10 nominal pipe diameters from the pump flange. Any bend or tee in this section shall be at least 5 nominal pipe diameters upstream of the pump flange; and

NOTE – Alternative arrangements for horizontal split case pumps may be accepted by the SSC if the suction pipe arrangements of NFPA 20 are used.

(e) When a reducer is required in the pump suction pipework, it shall be installed so that no air will be trapped in it, usually necessitating the use of eccentric style reducers. See Figure 6.12.

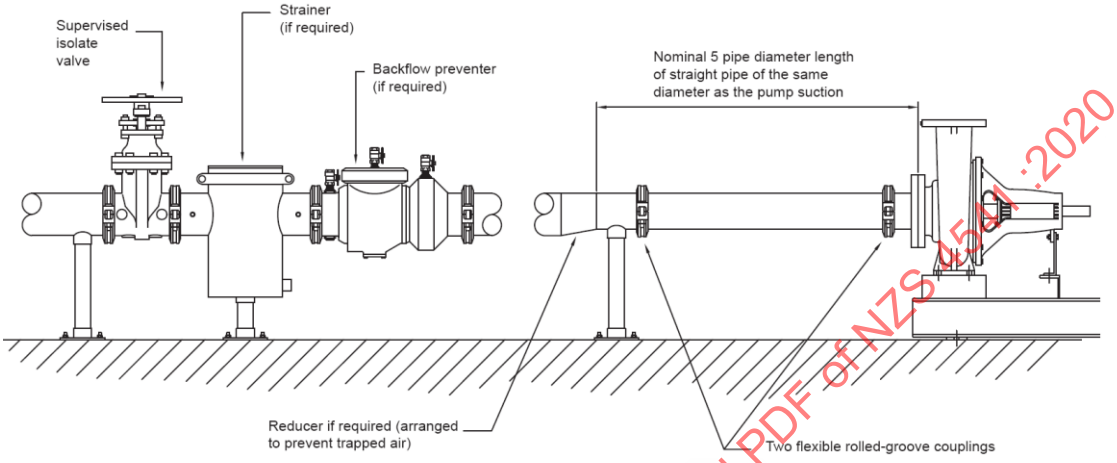


Figure 6.12 – Pump suction waterway fittings

6.7.2.4 *Pump casing cooling*

Means shall be provided to prevent the temperature of the water in the pump casing rising to more than 35°C during nil or low-flow discharge conditions over a 1-hour period. Acceptable means of achieving this include:
(a) A pressure relief valve set to open at a pressure higher than the highest design pressure;
(b) A differential pressure valve;
(c) The diesel motor cooling water supply; and
(d) A normally open discharge line to a tank.

Where an around the pump pressure relief and/or test pipe is provided to allow full flow testing, either the foregoing devices or an additional device (manual or automatic) shall be arranged to provide cooling of the pump casing at high-flow rates (see Figures 6.5 to 6.7) during pump testing. Manual devices shall be labelled.

6.7.2.5 *Vertical shaft pumps*

Vertical shaft pumps shall be installed to the pump manufacturer's particular specifications and:
(a) Shall be constructed of materials suitable for the quality and acidity of water to be pumped;
(b) Vertical immersion, end suction, radial discharge pumps are not acceptable for installations requiring a shaft longer than 4 m. Where greater depths are involved, a vertical shaft turbine pump shall be used; and
(c) Vertical shaft bearings shall be of the water lubricated type and the bearing taking the hydraulic thrust and shaft weight shall be of adequate capacity.

6.7.2.6 *Submersible electric pumps*

The following requirements apply:
(a) Submersible electric pumps shall be installed to the pump manufacturer's particular specifications;
(b) They shall be constructed of materials suitable for the quality and acidity of water to be pumped;
(c) The motor cable may have only one joint between the controller and the motor and this shall be made in a listed waterproof jointing box; and
(d) The insulation resistance and circuit continuity of the motor and circuit from the controller shall be supervised as required by 6.7.7.6.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

6.7.3 *Diesel engines*

6.7.3.1 *General*

Single cylinder engines are not permitted. Only those engines for which spare parts are likely to remain readily available may be used.

6.7.3.2 *Power*

The following requirements apply:

(a) The engine shall be able to produce 110% of the power requirement for the highest design flow when measured against the manufacturer's continuous power rating as defined in Part 1 of BS 5514 or approved equivalent standard.
The highest power requirement shall include power absorbed by any supplementary devices driven by the engine and any angled drive.

(b) In the case of a diesel engine driving a boosted town's main pump, 'highest design flow' in the preceding paragraph shall mean the higher of:

(i) The highest installation design flow, and
(ii) 110% of the maximum flow that can be induced in any pressure relief return loop that is provided to limit pump delivery pressure (6.7.1.11), at the selected setting of the pressure relief valve; and

(c) Any ratings or deratings specified by the engine manufacturer shall be observed. In the absence of manufacturer's data, the engine shall be derated in kilowatts at the rate of 1.5% for every 100 m of altitude over 200 m above sea level.

6.7.3.3 *Performance and commissioning*

The engine shall be able to be started automatically at an engine room temperature of 5°C and shall accept full load within 30 seconds of receiving the signal to start.

On *in situ* commissioning, the pump unit shall be run for a period of at least 1 hour on increasing load up to duty flow. During this commissioning period, at least 10 consecutive starts shall be completed.

The adequacy of the ventilation and aspiration air supply shall be demonstrated following this initial commissioning period by running the pump at full load for a period of one hour, with the pump house doors closed. (See 6.7.10.9).

6.7.3.4 *Governing/electronic control module*

The engine shall be provided with a governor to control the engine speed within 10% of its rated value under all stable conditions of load up to full load rating.

6.7.3.4.1 Mechanical governing

The engine shall be provided with a governor to control the engine speed within 10% of its rated value under all stable conditions of load up to full load rating.

6.7.3.4.2 Electronic governing

Where electronic governing is used, the engine and its control unit shall meet the requirements of NFPA 20 and shall be either UL listed or FM Approved.

To provide automatic control of excess pump delivery pressure for electronically governed engines the pressure control can be integrated into the engine control unit. The complete engine and control system shall meet the requirements of NFPA 20 and shall be either UL listed or FM Approved.

Where a listed electronic governing of a diesel engine is used to control the pump delivery pressure it shall include the following provisions:

(a) It shall be possible to test the pump at its full rated duty speed through the test circuit without over pressurising any components of the pump set or downstream systems;

(b) It shall not be permitted to close off the water supply through the pump to the sprinkler system for routine testing through the test circuit unless one of the following is provided:

(i) The pump is part of a dual supply and the testing arrangements are such that one water supply will always be on line and available to the sprinkler system,
(ii) In the case of a single water supply, there shall be a large bore bypass around the pump that is able to meet the flow and pressure requirements of the six hydraulically most remote sprinklers, or
(iii) There shall be a flow switch fitted to the bypass configured to activate a blue strobe, which shall be visible from adjacent to the pump controller, on detection of flow in the bypass. There shall be an engraved sign affixed adjacent to the strobe with minimum 25 mm high lettering giving clear instructions for reinstating the water supply through the pump in the event that flow is detected in

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

the bypass. All valves that need to be operated shall be identified with engraved tags having minimum 12 mm high lettering;

(c) If the requirements of (b) cannot be met, then the use of a variable speed pressure control device to control the pump delivery pressure shall not be permitted and other means are to be used to control pressure;
(d) A valved test connection shall be installed downstream of the pump to allow the pump to be flow tested at its full rated duty speed without over pressurising any components of the pump set or downstream systems. The test connection shall discharge to a safe location that will permit flow testing without damage to property;
(e) Facilities shall be available to confirm operation of speed control device over its entire operating range during the weekly pump test;
(f) Where the engine is water cooled the cooling system shall be listed as part of the engine build and shall be configured such that it operates correctly over the full speed and pressure ranges of the engine and pump; and
(g) A schedule and schematic diagram shall be affixed either to the pump controller or adjacent to the pump controller detailing the procedure for the routine testing of the pump set and confirming correct operation of the speed control device to ensure correct and reliable operation. The schedule shall list the operating pressures that should be expected if the system is operating correctly to facilitate checking.

6.7.3.5 *Heating*

Where the pump unit enclosure is not automatically maintained at a temperature above 10°C, the engine shall be artificially heated by an approved device so as to maintain an engine temperature of at least 25°C where:

(a) Either the minimum ambient temperature or the minimum engine temperature is maintained by devices dependent upon electrical power, provision shall be made to raise an alarm at an approved place in the event that temperatures drop below the point at which the engine could be relied upon to start;
(b) The temperature sensing and alarm devices shall be listed and shall not depend upon mains electric power. If the alarm device can also be triggered by other supervisory functions, there shall also be a local, labelled, latching indication of the source of the alarm; or
(c) An SSC may waive this requirement if ambient temperatures are not expected to drop to this level.

NOTE – See also 6.7.10.9 and 6.7.10.10.

6.7.3.6 *Engine cooling*

The engine shall be cooled by transferring the excess heat, to either:

(a) Air, automatically vented to outside the pump house in a manner which complies with 6.7.3.6.1; or
(b) Water from the pump delivery discharged to waste or returned to storage in a manner which complies with 6.7.3.6.2.

Under full load running conditions, with all doors and windows in their normal positions, the rise in ambient pump room air temperature, measured close to and at the level of the aspirating air intake, shall not exceed 18°C over a 1-hour period.

6.7.3.6.1 Air cooling

Where motors are cooled by air the following requirements apply:

(a) Direct: The fan for direct air cooling shall be mounted on the engine crankshaft or be gear or multiple belt driven directly from the crankshaft. The rated capacity of the belts shall not be exceeded if one belt fails;
(b) Indirect: A radiator resiliently mounted in accordance with the motor manufacturer's recommendations, designed for stationary service and with all of the following facilities:
    (i) A shaft, gear, or belt driven fan that pushes the cooling air away from the motor
    (ii) A shaft, gear, or belt driven coolant circulating pump
    (iii) The radiator header tank shall be fitted with the motor manufacturer's overflow/makeup tank and shall have a means of readily checking the level of coolant in it
    (iv) The engine manufacturer's coolant circuit shall be used
    (v) That the radiator may require to be adequately ducted to control pump enclosure temperatures and/or ensure that adequate fresh cooling air is drawn through the radiator;
(c) Ducting forming part of the air cooling arrangements shall be sized so that the pressure drop across the ducting does not exceed 80% of the maximum recommended by the manufacturer. Ducts shall discharge to a safe place outside the pump enclosure;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(d) Any louvre forming part of, or required by, the air cooling system shall operate automatically but shall not be dependent on electricity.

6.7.3.6.2 Water cooling

Where motors are cooled by water the following requirements apply:

(a) Cooling water supply, control, and discharge:

(i) Water to cool the engine shall be taken from the pump delivery to two isolation valves
(ii) One isolation valve shall supply the normal cooling circuit and be labelled 'MOTOR COOLING, normally open'
(iii) The cooling water shall then pass through an easily accessible strainer, labelled 'CLEAN MONTHLY'. It shall have a screen that can be removed without taking the strainer out of the pipework. The screen shall have holes in it not less than 2 mm or greater than 5 mm in any dimension and the total screen area shall be equivalent to at least eight times the cross sectionarea of its supply pipe
(iv) The strainer shall be fitted with a listed device that automatically bypasses it should the strainer become blocked
(v) A flow regulating device, where required, shall be fitted downstream of the strainer
(vi) Where the suction head would cause water to flow through the cooling circuit when the pump is not running, a listed flow control device may be fitted downstream of the strainer
(vii) The other isolation valve shall enable cooling water to bypass items (iii) and (iv) and shall be strapped shut and labelled 'OPEN FOR EMERGENCY COOLING, normally shut'. This valve shall discharge into the motor cooling system upstream of the flow indicator
(viii) The cooling water shall then flow through a listed water flow indicator
(ix) If the engine requires a coolant circulating pump it shall be shaft, gear, or belt driven;
(x) The discharge pipe from the heat exchanger shall be at least one size larger than the inlet pipe. There shall be a flexible connection between the pipework and the engine cooling system or heat exchanger
(xi) The cooling water assembly shall be of an indirect heat exchanger type
(xii) The cooling system shall be designed in accordance with Figure 6.13, unless otherwise approvedby the SSC;

NOTE – To comply with this item, a listed pump unit manufacturer may obtain a listing for a generic cooling system in which the makes and models of the components are nominated together with pipe sizing, fittings, and labelling requirements.

(b) Indirect heat exchangers: The cooling water assembly may discharge into the secondary circuit of a suitably sized heat exchanger, which shall be capable of withstanding the maximum supply pressure that can be applied.
The primary cooling circuit shall have a header tank with a water volume at least equivalent in capacity to the engine's cooling jacket. It shall be connected to a suitable automatic overflow/makeup tank.
The header tank shall have a means of readily checking the level of coolant in it;

(c) No part of the engine's water jacket shall be subjected to a pressure of more than 100 kPa; and

(d) All of the above should be agreed to by the engine manufacturer.

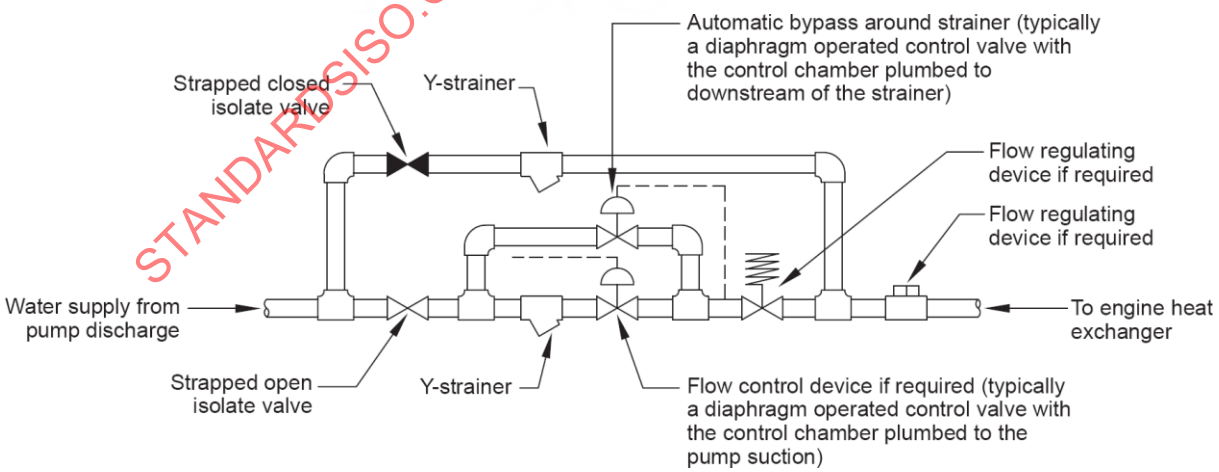


Figure 6.13 – Diesel engine water cooling unit

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.7.3.7 *Electric starter motor*

The engine shall be provided with the manufacturer's specified electric starter which shall be nominated in motor listing. The electric starter motor shall be able to crank the engine continuously for 60 seconds followed by one restart, without failure.

6.7.3.8 *Emergency start device*

In addition to a manually operated starting button, each diesel engine shall have an approved means by which it can be manually started in emergency. One of the following is acceptable:

(a) A manual crank handle provided that sufficient energy can be imparted to the fly wheel to enable it to carry the engine through at least two compression strokes when the decompression lever is released. Any device used to assist manual starting shall return to the automatic start position when released. Theentire manual cranking operation shall be capable of being performed by one person;

(b) The electric starter motor used for automatic starting (or an additional listed electric starter motor) provided that it is fitted with approved devices that will switch either battery on to the start solenoid of thestarter motor. The operating levers for these devices shall be labelled 'EMERGENCY STARTING' with an arrow to indicate the direction of operation. They shall be spring loaded and rated for the load current; or

(c) Listed inertia and spring driven starters engaging the main ring gear or a separate ring gear. The operating lever shall be painted green and labelled to indicate its function and method of operation. It shall be strapped in the released position.

6.7.3.9 *Batteries*

Two separate lead-acid starting batteries each capable of supplying the controller load for a period of not less than 24 hours, and thereafter capable of cranking the engine for 60 seconds shall be provided and be indelibly marked 'A' and 'B' and with the date of installation.

Both batteries shall be normally electrically isolated on their non-earthed side and simultaneously connected to the starter motor only for starting. They shall be located so as to give ease of access for hydrometer testing, be adjacent to, but not over any part of, the pump unit and be protected with a strong non-conductivecover. They shall be secured in accordance with 1.7.1.

Batteries shall be suitable for continuous operations under float charge conditions, designed for stationary engine starting use, and have a minimum service life of 3 years. They shall also comply with the provisions of IEC 60896-11.

NOTE –

(1) AS 4029.1 is a satisfactory means of compliance with IEC 60896-11.

(2) The use of automotive batteries of the semi-sealed 'maintenance free' or 'low maintenance' type is not recommended, and it is also important to use batteries specifically designed for a stationary role.

(3) The battery must be suitable for use with the installed charger. Refer 6.7.4.5 for specific requirements for the battery charger.

Display the following indelible label in a prominent position near the batteries:

WARNING

CHECK ELECTROLYTE LEVEL AND CHARGING RATE WEEKLY.
LOW ELECTROLYTE LEVEL AND/OR HIGH CHARGING RATE MAY CAUSE BATTERIES TO FAIL OR EXPLODE.

WHEN CHANGING BATTERIES ENSURE THE RATING OF ANY REPLACEMENT BATTERY MEETS ORIGINAL COMBINED CONTROLLER LOAD AND ENGINE CRANKING LOAD REQUIREMENTS.

6.7.3.10 *Combustion air*

The air intake shall be fitted with an adequate filter.

6.7.3.11 *Exhaust*

Every engine shall have an exhaust which:

(a) Independently discharges to a safe location outside the pump unit enclosure, the outlet so positioned that it is guarded from the entry of rain water and birds;

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(b) Is provided with a flexible metallic connection between the exhaust manifold and the exhaust pipe. Where the exhaust pipe rises above the manifold means shall be provided to trap any condensate and prevent it flowing back into the engine;
(c) Is provided with a screwed and plugged manometer hole in the exhaust manifold outlet to facilitate the measurement of manifold pressure. Under full load conditions, the pressure shall not exceed 7.5 kPa except where the manufacturer recommends a lesser maximum pressure;
(d) Has the exhaust pipe adequately supported from the building and kept at least 225 mm from combustible materials. Alternatively, it may be sleeved so that the pipe is at least 50 mm from the sleeveand the sleeve is at least 25 mm from combustibles and with the engine operating at full load, the temperature on the external surface of any exposed combustible material shall not exceed 70°C;
(e) Is fitted with an adequate silencer, preferably outside the pump unit enclosure; and
(f) Has the exhaust pipe guarded wherever it is within 2 m of the floor and could cause injury. Proprietary exhaust pipe wraps shall be permitted to the exhaust pipe only (not manifold, turbo, and so on) provided they are installed in accordance with the engine and the product manufacturers' instructions.

6.7.3.12 *Drip tray*

A drip-tray of lateral dimensions larger than the engine sump shall be provided under the engine.

6.7.4 *Diesel engine controllers*

6.7.4.1 *Component parts*

A diesel engine controller shall be a listed device consisting of a cabinet housing or supporting instruments, a controller logic unit, battery chargers, listed start pressure switches, manually operated start switch, test logbook, nameplate, and such manual controls and technical data sheets as are specified. The electrical connection between the controller and the engine shall be made with a mechanically restrained multi-contact plug and socket and the entire controller shall be listed. Removal of the plug from the socket shall cause an indication at an approved location. Where the indication is made at a location which is not staffed at all times, a defect signal shall be generated through the FBA.

6.7.4.2 *Location*

The controller shall be located in the pump unit enclosure close to the engine and pump.

The controller shall either:
(a) Be mounted physically separate from the engine and pump set base and be free from engine vibration; or
(b) Where mounted to the engine or pump set base, be listed for mounting in this manner and shall have been demonstrated by tests during the listing process to be able to withstand any vibration from the engine without harmful effect on the operation or durability of the controller. Where mounted on the engine or pump set base, the controller shall be mounted to a rigid support frame or bracket which shall then be mounted to the engine or pump set base via resilient vibration isolators. The resilient vibration isolators shall be sized to be suitable for the combined mass of the controller and support frame or bracket, and the design shall be such that should any elastomeric or resilient components fail, the controller shall continue to be supported and restrained without suffering damage or disruption to its operation.

Attention is drawn to the need to comply with 1.7 for restraint against seismic forces.

6.7.4.3 *Instruments, manual controls, alarms, and lamps*

The information in the following table shall be displayed in an easily seen and read form on the face of the controller. Analogue displays shall indicate the acceptable duty range by green shading and unacceptable levels by red shading. Tachometers should be digital, with the minimum number of display digits as specified below, or an analogue tachometer of suitable scale.

The controller shall have instruments, manual controls, alarms, and lamps which shall enable the operator to determine information relating to the pump set in an easily recognised manner as set out as follows:
(a) Digital displays shall have digits at least 15 mm high and comply with the requirements of the following:

Information	Min. no. of significant figures on digital displays
Pump suction pressure	3
Pump delivery pressure	3
Pump rotational speed	4

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Engine run time (hourmeter)	5
Engine lubricant pressure	3
Engine block temperature °C	3
Voltage of each battery	4
Charging current to each battery	3

Optionally, a single digital display may be used to annunciate:

(i) The voltage and charging current for each battery
(ii) The engine lubricant pressure and engine block temperature provided the display automatically defaults to annunciate any parameter in an alarm condition;

(b) The following manually operated devices shall be provided in easily visible positions on the face of the controller:

(i) A manual start button
(ii) A push button device or devices to permit the isolation of each start pressure switch
(iii) The manual start button shall over-ride any isolated pressure switch;

(c) The following lamps or LED (light-emitting diode) indicators shall be provided in easily visible positions on the controller to indicate:

(i) Whether each battery charger is energised
(ii) Operation of pressure switch
(iii) The controller unit status
(iv) Closed or isolated state of each pressure start switch
(v) The start logic controller status;

(d) All instruments, controls, and lamps shall be clearly labelled as to their function. Where duplicate instruments associated with batteries are provided they shall be labelled either 'A' or 'B'; and

(e) Remote annunciation shall be provided for off-normal conditions, including:

(i) Pump running
(ii) Battery charger off
(iii) High engine temperature
(iv) Engine heating failure
(v) Low engine oil pressure
(vi) Mains power supply failure
(vii) High battery charger output current.

An alarm unit shall be provided and mounted on the controller to assemble and transmit such signals either individually or collectively. A timing device may be incorporated to suppress such alarms for a period of 60 minutes provided that it will automatically reset.

6.7.4.4 *Controller logic unit*

The following requirements apply:

(a) A controller logic unit to control the automatic starting sequences of the pump unit shall be provided. Continuity of service and availability of spare parts for the unit shall be considered;
(b) The controller logic unit's functions shall comply with Figure 6.14 and the notes thereto;
(c) Crankshaft speed shall be measured by a sensor driven directly by the crankshaft or a layshaft gear driven from it. The sensor device shall be considered part of the controller logic unit; and
(d) If the unit incorporates polarity sensitive devices, it shall be protected against or undamaged by reversal of its power supply polarity.

6.7.4.5 *Battery chargers*

A listed constant voltage current-limited battery charger shall be provided within the controller cabinet for each of the two starting batteries. The battery chargers shall each:

(a) Have automatic output control that maintains the battery fully charged within the 'float' levels specified by the battery manufacturer;
(b) Have automatic control to limit the output current to the maximum rated value of the unit when lead acid batteries discharged to 1.85 V per cell are connected;
(c) Be capable of restoring the full nominal ampere-hour capacity of the battery within a period of 24 hours while simultaneously supplying the full quiescent current (controller load);
(d) Be capable of tolerating continuous reversed polarity or short circuit on the output terminals without damage, and shall self-restore on removal of the same; and

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

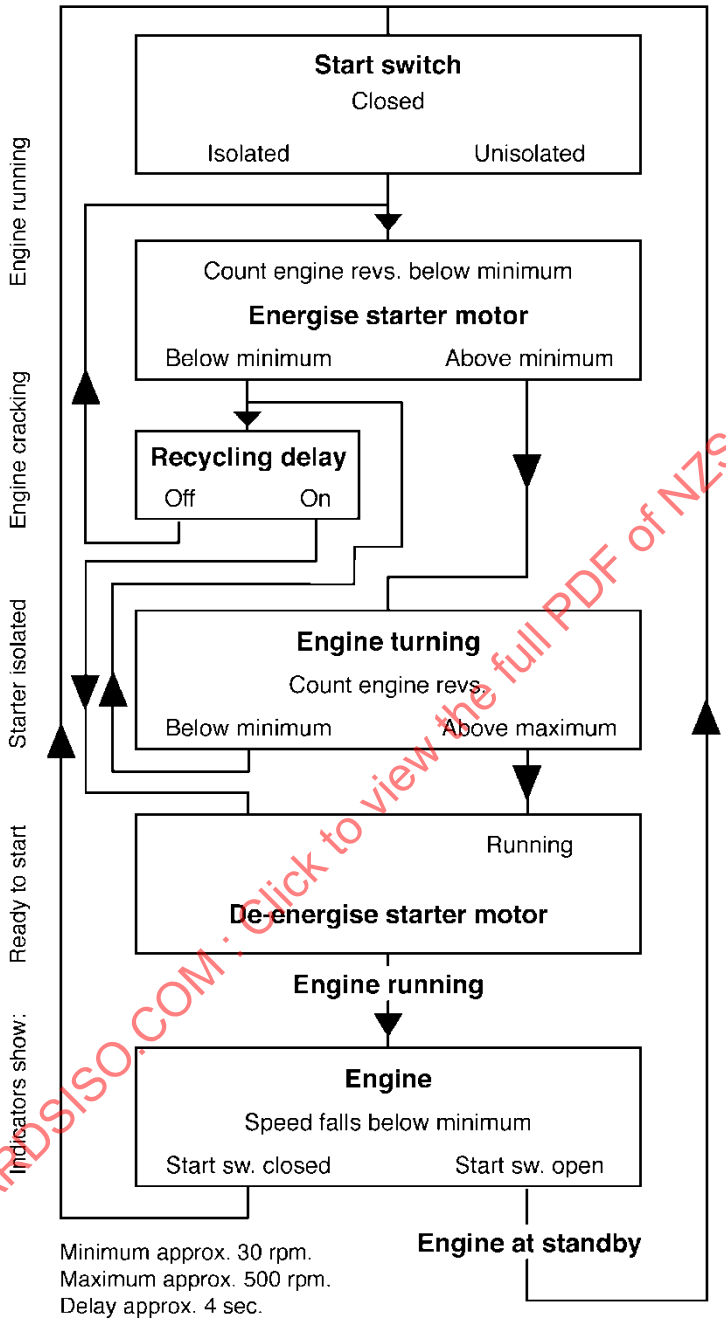
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

(e) Provide visual indication that the charger is energised.

The charger manufacturer shall specify any design constraints on charger output or the size and length of battery voltage sensing conductors. Compliance shall be required.

The 230 V mains supply for the controller and battery chargers shall be connected to a separate subcircuit on the building's main distribution board which is clearly labelled 'FIRE PUMP BATTERY CHARGERS'.



NOTE –

(1) 'Isolated' is a device which individually isolates each start pressure switch that is closed when the isolate button is manually operated. Each pressure switch then remains individually isolated until it reopens.

(2) '30 RPM' and '500 RPM' indicate that the crankshaft is rotating at approximately the stated speed. Actual speeds are to be adjusted in accordance with the engine manufacturer's recommendations.

(3) 'Energise' means simultaneously connecting both batteries to the starter motor.

(4) 'Ready to Start', 'Starter Isolated', 'Engine Cranking', and 'Engine Running' to be indicated by status lamps or LED indicators.

Figure 6.14 – Diesel engine controller logic unit

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

6.7.4.6 *Start pressure switches*

Listed start pressure switches shall be mounted on the cabinet. They shall comply with 6.7.1.6. When they close, the initial current shall exceed 0.5 A.

6.7.4.7 *Nameplate*

An engraved label shall be affixed to the face of the cabinet and give the following information:
(a) Name of pump unit manufacturer;
(b) Unit number;
(c) Duty speed;
(d) Engine make, model, and continuous power at duty speed;
(e) Pump make, model, and impeller diameter; and
(f) Flow and pressure at duty speed.

6.7.4.8 *Operator's handbook and logbook*

The following shall be kept in the cabinet:
(a) A copy of the electrical circuits associated with the controller logic unit, battery chargers, and engine;
(b) Manufacturers' operator handbooks for the pump, controller, and engine unit; and
(c) An approved logbook for recording all faults and the results of all tests including engine maintenance, oil changes, battery condition, hours run, fuel consumption, and annual surveys.

A label showing the name and telephone number of the pump unit maintenance contractor shall be affixed to the inside of the cabinet.

6.7.5 *Diesel engine fuel supply*

6.7.5.1 *General requirements*

Every pump engine shall have its own individual fuel supply tank.

NOTE – Attention is drawn to the need to comply with the relevant requirements of the Health and Safety at Work (Hazardous Substances Regulations) 2017, specifically those dealing with tank size and attachments, pipes, protection of fuel lines, oil level gauges, and fuel secondary containment provisions. If the volume of fuel contained within any enclosure is 500 litres or greater, the provisions of Health and Safety at Work (Hazardous Substances Regulations) 2017 may exceed the requirements of this standard. In such cases, a Compliance Certificate under those regulations will be required.

6.7.5.2 *Tank mounting*

The tank may be mounted inside the pump house, but it shall be mounted separately from the engine with the fuel outlet not lower than the injector pump or more than 1000 mm above the injector pump, unless this voids the manufacturer's warranty. Tank mounting shall comply with 1.7.2.

6.7.5.3 *Tank capacity*

The fuel capacity shall be assessed on the engine manufacturer's specified fuel consumption for the power absorbed by the pump unit at duty RPM for the periods nominated in Table 6.2.

Table 6.2 – Nominal fuel duration

Hazard class	Fuel duration (minimum)
ELH	6 hours
OH	6 hours
EHH	6 hours but not less than twice the primary supply duration required by Table 6.1

6.7.5.4 *Fuel gauge*

The tank shall be fitted with a listed gauge. The gauge shall be marked indicating that the top half of the tank is fuel for test running and the bottom half is for fire duty running. It shall also indicate that the fuel level shall not normally fall below that allowed for testing.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

6.7.5.5 *Tank construction*

The tank shall be constructed of at least 1.5 mm mild steel coated internally with a suitable anti-corrosiveand oil resistant.

NOTE – Health and Safety at Work (Hazardous Substances Regulations) 2017 requires that fuel tanks are constructed in accordance with nominated standards, including AS 1692. These may require the tank material thickness to exceed that nominated above.

6.7.5.6 *Tank connections*

The following connections, none of which shall be galvanised pipe, shall be provided:

(a) A 25 mm vent pipe from the top of the tank that has a continuous upward grade to a down-turned flared and gauze-sealed vent to the exterior of the building;

(b) A minimum 20 mm filling pipe into the top of the tank. The tank may be filled only by pumping from a mobile tanker, storage tank, or a portable drum. A minimum 20 mm filling pipe fixed into the top of the tank for use by a mobile tanker may be supplied, provided that this fill pipe shall extend to the outside of the building, or other suitable location and have a suitable threaded and sized locked valve attached at the delivery end. Suitable precautions shall be taken to ensure that if the tank is overfilled, by a mobile tanker, that diesel is not discharged into the pump house;

(c) A 25 mm overflow pipe from the top of the tank which shall be carried on a continuous downward gradient to discharge in a safe place – usually the storage tank or a portable drum;

NOTE –

(1) The use of plastic hoses is discouraged, unless secondary containment ensures any fuel spill is retained within it if the hose fails.

(2) If the overflow pipe discharges into a portable drum, this is acceptable as long as there are provisions for secondary containment.

(d) A sludge sump at the lowest part of the tank, fitted with a normally closed and plugged stopcock;

(e) A sealed opening not less than 100 mm diameter for tank cleaning purposes;

(f) A minimum of a 10 mm fuel outlet drawing from at least 25 mm above the bottom of the sludge sump and fitted with a stop valve padlocked in the open position; and

(g) A fuel return line sized and installed in accordance with the engine manufacturer's recommendations.

6.7.5.7 *Fuel secondary containment*

Where required by the Health and Safety at Work (Hazardous Substances Regulations) 2017, provisions shall be made for diesel fuel secondary containment. One such method is to install the diesel fuel tank in a bunded area.

6.7.5.8 *Fuel lines*

The fuel lines shall be at least 10 mm seamless copper or stainless steel tube with double ferrule compression fittings, brazed joints or black steel pipes and fittings and shall:

(a) Be well protected and supported, preferably in a continuous down-gradient to the engine. However, it is permissible to have one low point, provided there is a continuous rise from this point to both the engine and the fuel tank;

(b) Incorporate a transparent agglomerator bowl, immediately downstream of the fuel line stop valve, to indicate the presence of water, and an accessible, engine mounted, filter; and

(c) Terminate at the engine at a metal armoured flexible connection.

NOTE – This clause does not apply to any fuel lines forming part of the engine manufacturer's original equipment manufacturer (OEM) equipment.

6.7.5.9 *Air lock avoidance*

Care shall be taken to avoid air locks in the system. No air relief valves are permitted and where air relief is essential, screwed plugs shall be used.

6.7.5.10 *Fuel type*

The type and grade of diesel fuel shall be as specified by the engine manufacturer and shall be suitable for the expected environmental conditions.

NOTE – Fuel suppliers use a different grade of fuel in winter and summer due to the effect of ambient temperature on fuel. If the fuel tank or system is located in an area where it may be exposed to lower temperatures over winter, then the tank will need to be drained and refilled with winter grade diesel before winter.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSGO.COM : Click to view the full PDF of NZS 4541:2020

6.7.6 *Electric motors*

6.7.6.1 *Type*

Electric motors shall be of the three-phase low voltage squirrel cage drip-proof or totally enclosed type.

6.7.6.2 *Power*

The following requirements apply:

(a) The motor shall have 110% of the capacity required to ensure that the continuous rated current is not exceeded under any conditions of pump discharge when power is being supplied at the nominal voltage. Should the motor have a service factor of 10% or greater, this requirement shall be deemed to have been met; and

NOTE –

(1) This 10% capacity margin is necessary to take account of fluctuations in the supply voltage that will increase the current.

(2) Attention is drawn to the need to check the actual pump set turning speed to ensure that the motor can provide the power absorbed by the pump at that speed.

(b) The locked rotor current shall not exceed 750% of the full load current of the motor.

6.7.6.3 *Nameplate*

The motor shall have a nameplate attached to it, on which is indelibly marked:

(a) Manufacturer's name;
(b) Type and serial number;
(c) Continuous rated power output;
(d) Working voltage and frequency;
(e) Rotational speed at full load; and
(f) Full load current.

6.7.6.4 *Height above floor*

Other than with submersible pumps, the pump unit shall be so mounted that no current carrying part of the motor is less than 150 mm above the floor.

6.7.6.5 *Vertical shaft motors*

Motors driving vertical shaft pumps shall be constructed for vertical operation and, if driving an assembly longer than 4 m, shall have a hollow shaft. Alternatively, the motor shall be of a listed submersible type.

6.7.6.6 *Motor starting*

The motor shall be started and stopped by means of a listed electric motor controller.

6.7.7 *Electric motor controllers*

6.7.7.1 *Component parts and listing*

An electric motor controller shall be a listed device the component parts of which are:

(a) A cabinet supporting or enclosing items (b) to (j);
(b) A listed start pressure switch or switches and associated test devices;
(c) Pressure switch isolation devices;
(d) Manual start and stop buttons;
(e) Start contactor;
(f) Power supply supervisory equipment;
(g) Overload protection supervisory equipment;
(h) Pump running alarm switching devices;
(i) For submersible pumps insulation resistance and circuit continuity supervisory equipment; and
(j) A nameplate showing the following information:

(i) Name of manufacturer
(ii) Unit number
(iii) Pump make, model, turning speed and impeller diameter
(iv) Duty flow and pressure.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

6.7.7.2 *Location*

The controller shall be located in the pump unit enclosure as close as practicable to the motor with all electrical components at least 450 mm above the floor.

6.7.7.3 *Starting and stopping*

Automatic starting shall be provided by means of listed pressure switches and manual starting shall also be provided.

Stopping and isolation devices shall comply with 6.7.1.7. Additionally, there shall be a lockable ON/OFF switch to isolate the power supply to the contactor.

6.7.7.4 *Start contactor*

The following requirements apply:

(a) The motor starting method shall be an approved electronic variable power soft starter, or an approved electronic variable frequency starter and speed controller;
(b) The current rating of the contactor shall be at least 125% of the nameplate continuous current rating of the motor; and
(c) The short circuit category of duty shall be AC-3 to IEC 60947-4.

6.7.7.5 *Overload protection*

The following requirements apply:

(a) The thermal overloads shall be arranged to reset automatically. They shall be capable of adjustment to carry 30% more than the nameplate continuous current rating of the motor;
(b) Overload protection features shall be supervised in such a way as to comply with 6.7.7.6; and
(c) Motor winding temperature sensors, if fitted, may be used to operate a motor overheat alarm but they shall not automatically trip the motor contactor.

6.7.7.6 *Supervisory monitoring*

The following requirements apply:

(a) Approved supervisory monitoring of all of the following conditions shall be provided:

    (i) Pump running
    (ii) Loss or reversal of any phase at the line terminal of the contactor
    (iii) Opening of any section of the contactor control circuit except the start button
    (iv) In submersible motor-driven pumps, low insulation resistance and discontinuity in the motor circuit;

(b) Except in the case of (a)(i), the absence of the above conditions (that is, normal state) shall be indicated on the face of the motor controller by means of continuous visual indicators;
(c) The detection of any of the conditions specified in (a) above shall, after approximately 120 minutes, cause two sets of clean changeover contacts to switch. A test device shall be incorporated to compress the gating time to approximately 12 seconds; and
(d) A listed alarm device, located in an approved location external to the pump unit enclosure, shall be connected to the supervisory device. The alarm shall be labelled 'SPRINKLER FIRE PUMP MALFUNCTION ALARM', followed by instructions on who to contact.

6.7.8 *Power supply*

6.7.8.1 *Source*

The following requirements apply:

(a) The power supply shall be obtained from an electrically reliable and physically secure source, preferably from a public supply by an exclusive separate connection;
(b) Where a suitable public supply is not available, approval of the generating plant shall be obtained from the SSC;
(c) Where a separate connection from the public supply is not provided, a separate circuit shall be taken from a point on the line side of a switch by which all other electrical services in the premises can be isolated to directly and exclusively supply the pump motor, motor starter, and other ancillary services in the pump room; and
(d) Conductors shall be appropriately sized to meet the motor manufacturer's requirements for nameplate voltage.

NOTE – AS/NZS 3000 provides additional guidance on the requirements for power supplies for electrically-driven fire pumps.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.7.8.2 *Security*

The following requirements apply:

(a) No part of either the high voltage or low voltage circuit inside the boundary of the protected premises shall pass through an unprotected building. Exterior overhead cables inside the boundary of the protected premises shall not pass closer than 10 m (measured horizontally) to any unprotected building or unprotected fire loads;
(b) There shall not be any switches on the circuit supplying the pump between the isolator on the pump unit controller and the point at which it is connected to the main supply;
(c) All switches on the protected premises, which are capable of isolating the pump, shall be clearly labelled 'SPRINKLER FIRE PUMP – LEAVE ON' in white letters on a red background; and
(d) The normally open circuit wiring between the pump contactor and the motor shall be protected against physical damage. In the case of submersible pumps, this part of the circuit shall comply with 6.7.2.6(c).

NOTE – AS/NZS 3000 provides guidance on the mechanical protection of cables.

6.7.9 *Facilities for routine testing*

6.7.9.1 *General*

Every pump unit shall have facilities to allow routine test running under load and to prevent overheating in situations of nil or low discharge (see Figures 6.6 to 6.10).

6.7.9.2 *Open water source*

Where a pumping unit draws directly from a tank or open water supply a test return pipe shall be provided and sized to enable the unit to be tested to a minimum of 110% of the highest design flow (± 10%). For pumps fitted with pressure relief valves complying with 4.4.6.4, test return pipework and valving may not be required if the pressure relief valve circuit produces at least 110% of the highest design flow (± 10%).

In the case of tank supplies, the test return pipe shall terminate at least 1 m below normal water level to prevent air entrainment during testing and shall be restrained against jet reaction. If the same pipe is usedfor the pressure relief valve discharge, then it shall be terminated at vortex plate level.

The test return pipe shall be fitted with a supervised, labelled, indicating stop valve normally padlocked in the closed position. This valve shall signal 'defect' when opened greater than 5%.

6.7.9.3 *Boosted town's main*

A test return loop from the pump delivery to the pump suction shall be provided and sized to enable the unit to be routinely test run at least 110% of the highest design flow (± 10%). For pumps fitted with pressure relief valves complying with 4.4.6.4, test return pipework and valving may not be required if the pressure relief valve circuit produces at least 110% of the highest design flow (± 10%).

This test return loop shall be fitted with a supervised, labelled, indicating stop valve normally padlocked in the closed position. This valve shall signal 'defect' when opened greater than 5%.

6.7.10 *Pump unit enclosure*

6.7.10.1 *General*

All pump units shall be installed in a clean dry weathertight enclosure with secure access to the sprinkler apparatus. It is recommended that the pump unit enclosure is provided with direct external access.

NOTE – Pump unit enclosures must comply with the NZBC. The NZBC's acceptable solutions have design requirements for rooms that contain machinery which uses solid fuel, gas, or petroleum products as the energy source. T

6.7.10.2 *Protection from hazards*

The enclosure shall be situated where it is as free as possible from exposure to fire, explosion, flooding, and windstorm damage and, in the case of below ground enclosures, care shall be taken to avoid or deflect run-off storm water from draining into it.

No liquid or gaseous fuels except those required as a fuel source for the pump unit prime mover shall be reticulated or stored in the enclosure and a fire extinguisher appropriate to the hazard shall be provided.

6.7.10.3 *Plant rooms*

With approval, a pump unit may be located in a screened area of a plant room protected by the sprinkler system complying with this standard. In considering any such application, an SSC shall ensure that there is:

(a) No boiler or other explosion hazard;

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(b) No uncontrolled dust problem;
(c) No likelihood of water from other services discharging over the pump unit; and
(d) No uncontrolled access by unauthorised persons to the pump unit.

All other requirements for pump unit enclosures shall be met.

6.7.10.4 *Sprinkler protection*

All pump unit enclosures shall be sprinkler protected. Where the enclosure is a detached building and is some distance from the nearest protected building, the sprinklers in the enclosure may be supplied through alabelled and strapped stop valve from the hydraulic connection to the start pressure switches, provided that this has been suitably sized, or a connection is provided from the pump delivery, through a check valve, to a point downstream of the stop valve to boost the supply to the pump house sprinklers. Acceptable arrangements to sound an alarm if such sprinklers operate shall be provided.

6.7.10.5 *Enclosure size*

The enclosure shall be of sufficient size to allow free access for testing, maintenance and removal of all equipment therein.

6.7.10.6 *Access*

Access shall be by a lockable door or hatch sufficiently large and located in such a position as to allow the removal of any individual component of the pump unit without disturbance or damage to other components.

6.7.10.7 *Drainage*

The floor shall be graded to drain to a sump which shall be emptied by means of a gravity drain or an automatic sump pump at a flow of at least 50 L/min. The sump shall be at least 600 mm deep and shall have a capacity of at least 0.05 m^3 or equivalent arrangement.

6.7.10.8 *Lighting*

The enclosure shall be provided with artificial lighting.

6.7.10.9 *Ventilation*

There shall be sufficient ventilation to prevent condensation, to provide aspiration for any diesel engines, and to limit the temperature rise to 18°C above ambient under all conditions of pump load for a 1-hour period.

Ventilation and/or louvres shall not be dependent on mains electrical power supply.

Powered ventilation systems using the diesel engine shall be permitted. The requirements of 6.7.3.2 shall be complied with.

6.7.10.10*Heating*

The enclosure shall be provided with a maximum/minimum type thermometer permanently fixed not more than 1.5 m from the floor. A reliable source of artificial heating shall be provided where necessary so as to maintain the temperature in the enclosure above 5°C at all times.

NOTE – In the case of diesel engines, heating of the engine may also be necessary.

6.8 Elevated tanks

An elevated tank shall:
(a) Comply with 6.6.2 and 6.6.3;
(b) Be owned by, and under the sole control of, the owner of the sprinkler system or shall, in terms of suitable written guarantees, be available at all times for the use by the owner of the sprinkler system;
(c) Be of sufficient capacity to comply with 6.6.1; and
(d) Be of sufficient height above the alarm valves to furnish, without the use of pumps, the requisite pressures at the design flows specified by 6.3.

6.9 Pressure tanks

Pressure tanks shall be accepted in the case of ELH class only subject to the approval of an SSC.

6.10 Fire sprinkler inlets

6.10.1 *Function*

All automatic sprinkler systems shall be fitted with a fire sprinkler inlet connection to:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(a) Enable the fire brigade to pump water into the installation by the use of their own equipment during a fire;
(b) Permit proving tests of the water supplies to the installation to be regularly carried out; and
(c) Facilitate the connection of an emergency water supply to the sprinkler installation if the usual supplies have been disabled.

6.10.2 *Location*

Fire sprinkler inlets shall be on the outside of the protected premises in a location approved by the fire brigade so as to permit effective fulfilment of each function. The fire sprinkler inlets may be located remote from the building provided that all criteria of the standard are met.

6.10.3 *Enclosure*

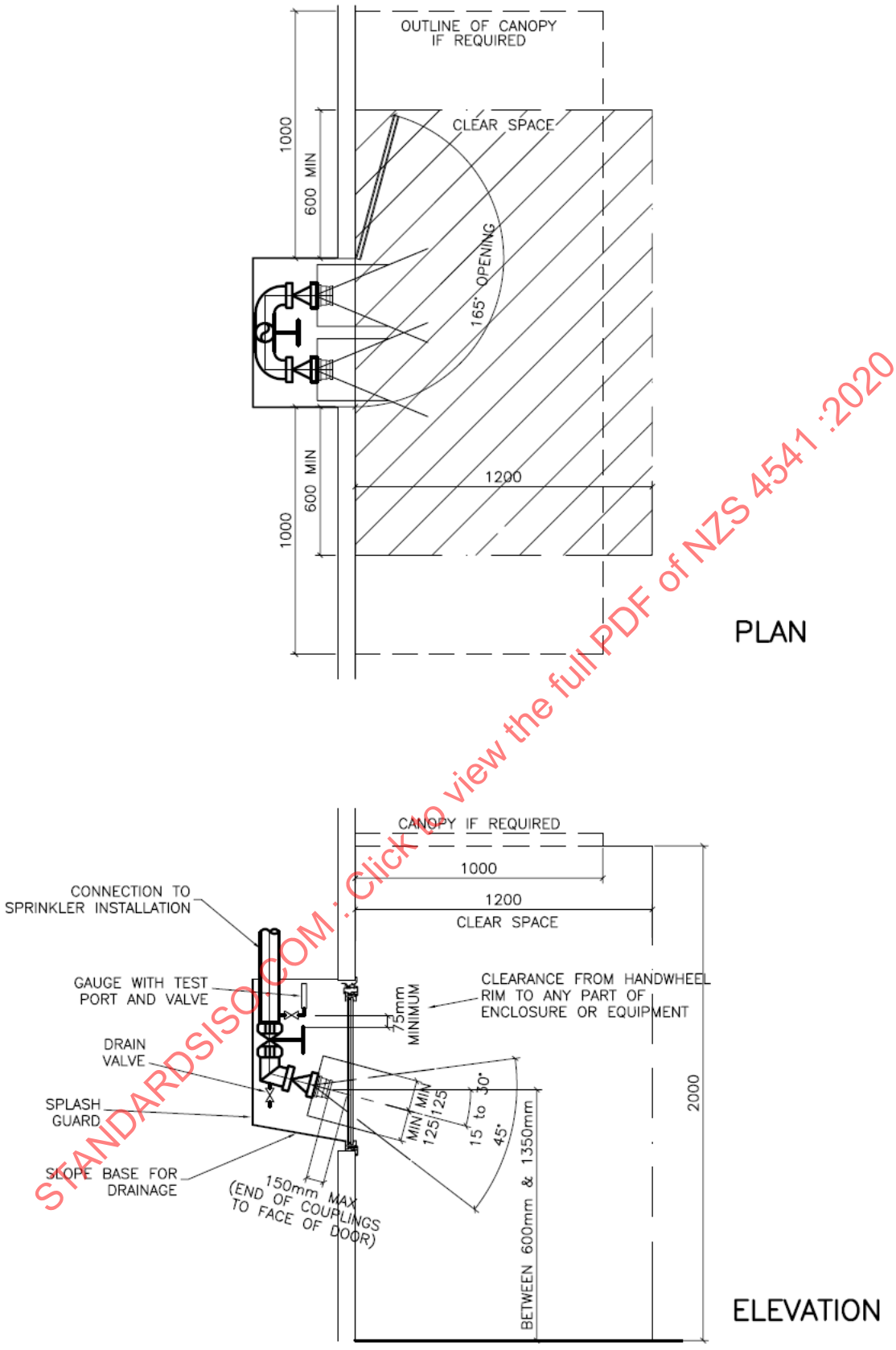
6.10.3.1 *Construction*

The following requirements shall be met:
(a) Fire sprinkler inlets shall be housed in enclosures constructed to ensure that delivery hoses can be connected to the couplings without kinking. The enclosure shall be of such dimensions to allow a solid cone having an included angle of 45° to be placed in each connection coaxially with the connection, without the cone touching any part of the enclosure or open door. No part of the enclosure or the door when open shall be a lesser distance than 125 mm from the axis of any connection projected. Couplings shall be located no more than 150 mm from the internal face of the enclosure door. The axis of the couplings shall be between 15° and 30° down from the horizontal. See Figure 6.15;
(b) A clearance of at least 75 mm shall be provided between the rim of any handwheel and any part of the enclosure or equipment;
(c) This enclosure may be deleted where sprinkler valve enclosures open to the exterior of the building through double doors with a total open width of at least 1.5 m. The fire sprinkler inlet shall be located on one side of the door opening. Where there are water supply pump sets in the enclosure, the fire sprinkler inlet assembly shall be fitted with a splash guard as per 6.10.3.3; and
(d) This enclosure may be deleted where valve sets are installed within self-contained cabinets designed for mounting on the exterior face of the building.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



NOTE – Dimensions are in mm unless otherwise stated.

Figure 6.15 – FSI standard requirements

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

6.10.3.2 *Door*

Doors may be side hung or bottom hung and shall, in either case, open through not less than 165°. The door shall be locked by a triangular key locking device, as shown in Figure 6.16, requiring no more than 5 revolutions to open the lock.

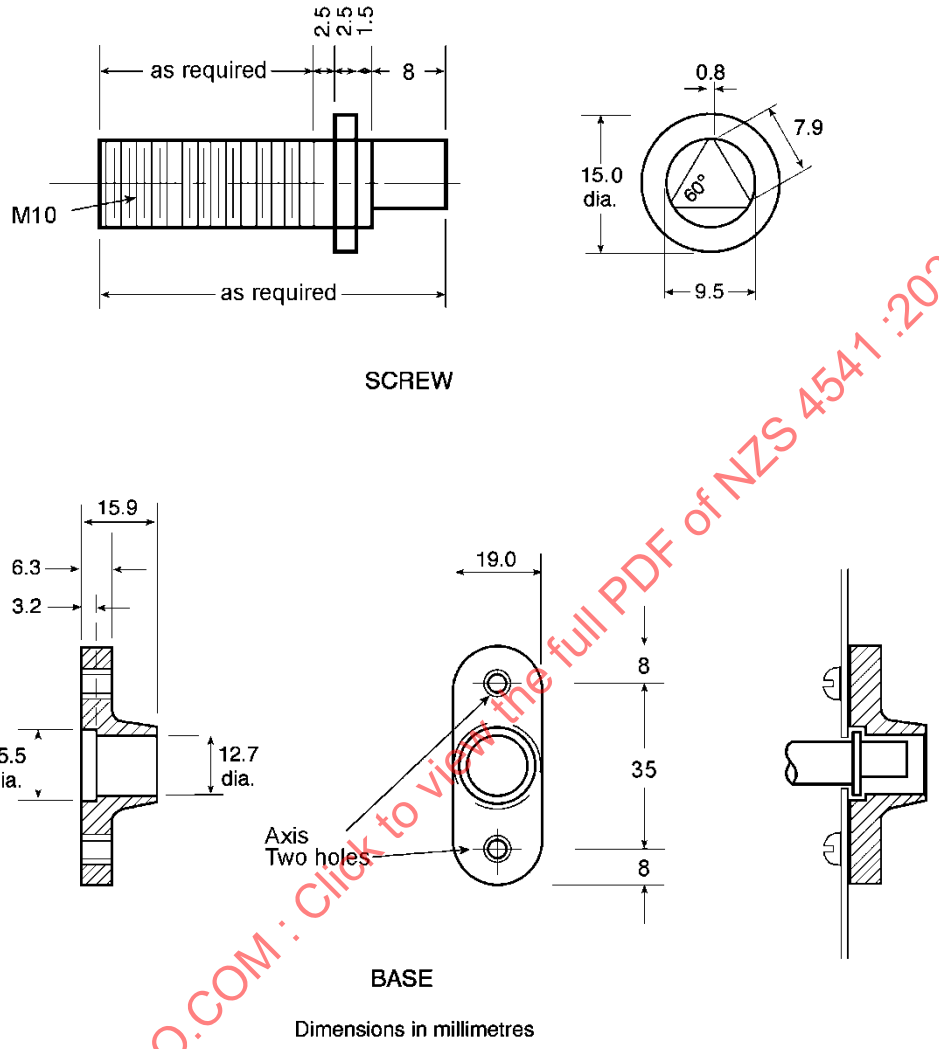


Figure 6.16 – Details of box lock

The door shall have a break-out panel large enough to enable delivery hoses to be connected without kinking, so that if the door cannot be opened, emergency access can be made by breaking out the panel.

The break-out panel should be designed so that on removal no sharp edges shall remain.

The outside of the enclosure door shall bear the words ‘FIRE SPRINKLER INLET – KEEP CLEAR’ in contrasting letters of at least 50 mm high.

The inside of the enclosure shall have an engraved label bearing the words ‘FIRE BRIGADE! BOOST PRESSURE IF GAUGE IN RED SECTOR’. In the case of enclosures housing more than one stop valve the words ‘FIRE BRIGADE! BOOST PRESSURE ON ANY INSTALLATION WITH GAUGE IN RED SECTOR’ shall be used. The sign shall be collocated to the gauge specified in 6.10.5.3.

6.10.3.3 *Splash guards*

With the exception of fire sprinkler inlets installed in compliance with 6.10.3.1(c) and (d), a splash guard shall be provided to the sides, rear, and bottom of the enclosure to ensure that the risk of water damage to the interior of the building is minimised. The splash guard shall be provided with suitable drainage.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

6.10.3.4 *Usage*

The enclosure may also be used to house the fire sprinkler inlet for any fire hydrant system serving the building. In such cases, the fire hydrant system and the fire sprinkler inlet shall be separate assemblies, each bearing the words 'FIRE SPRINKLER INLET' and 'FIRE HYDRANT INLET' in contrasting letters of at least 50 mm high, respectively.

Other than any indication and control panels for the control of fire hydrant systems, the enclosure shall not be used to house any other equipment.

6.10.4 *Inlets*

6.10.4.1 *Specification*

Each inlet shall consist of a 70 mm male instantaneous hose connection and shall comply with SNZ PAS 4505. It shall be fitted with a clapper valve of the swing-hinged type.

The inlet assembly shall be listed by the SSC. In considering listing, the SSC shall confirm that:

(a) The manufacturer has a documented quality system such as AS/NZS ISO 9000, with a scope conducive to manufacturing fire brigade waterway equipment complying with SNZ PAS 4505;
(b) The couplings are clearly identified with the manufacturer's mark, manufacturing date or batch number, and manufacturing standard; and
(c) If the check valve is not an integral part of the inlet assembly, it is manufactured of LG2 gunmetal complying with BS EN 1982 or equivalent.

NOTE – SNZ PAS 4505 currently does not permit FSI assemblies to be manufactured out of aluminium alloys. Should SNZ PAS 4505 be amended, see 4.1.1.

6.10.4.2 *Number of inlets*

The number of inlets shall be provided in accordance with Table 6.3.

Table 6.3 – Number of inlets

Highest system design flow (L/min)	**Minimum number of inlets required**
Up to 1350	1
Up to 2700	2
Up to 4050	3
Up to 5400	4
Up to 6750	5
Greater than 6750	6

6.10.4.3 *Height of couplings*

The fire sprinkler inlet shall be positioned so that the axis of the highest and lowest coupling is not closer to the surrounding standing surface than 600 mm or further than 1350 mm.

6.10.4.4 *Clear working space*

A space measuring 600 mm either side of the inlet enclosure, 1200 mm out from the face of the enclosure, and extending up 2000 mm from the surrounding standing surface shall be clear of all objects.

6.10.4.5 *Falling objects*

To guard against building elements and other objects falling from above in the event of a fire, where the door of the enclosure is on an exterior wall of a multistorey building, either a verandah or other assembly shall be provided extending at least 1 m in front and 1 m either side of the door.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.10.4.6 *Routine testing*

A valved connection shall be permitted between the FSI manifold and a fire hydrant system manifold to permit the routine (5 yearly) testing of the fire hydrant system. The valve shall be chained and padlocked in the closed position

6.10.5 *Connection pipe to system*

6.10.5.1 *Point of connection*

The following requirements apply:

(a) The inlets shall be connected by pipework through a stop valve directly into the installation downstream of the alarm valve and main stop valve;

(b) Where there is more than one alarm valve, they may all be connected through check valves and a manifold to the same inlet provided that a normally open, locked, supervised isolation valve is fitted to each connection. The isolation valve shall signal 'Fire' when closed for more than two turns or 5%;

(c) Where there is more than one alarm valve, and the provisions of (b) are incorporated into the fire sprinkler inlet design, a normally locked, closed, and monitored test valve shall be installed to bypass the manifold check valve for the system with the highest design flow. Where multiple alarm valves are not collocated at one valve house a bypass test valve shall be located at each valve house;

(d) Where there is more than one alarm valve and the provisions of (b) are incorporated into the FSI design, install an FSI check valve test valve (normally locked close) to allow the check valves to be exercised in accordance with 12.2.5(g);

(e) In wet pipe and antifreeze systems, the pipework downstream of the manifold check valves shall be primed from the water supply by a 15 mm NB connection via a locked open isolation valve. See Figure 6.17;

(f) Where a second stop valve is installed downstream of the alarm valve (as in a dry pipe valve situation), the fire sprinkler inlet connection shall be connected upstream of such a stop valve, to permit flow testing; and

(g) The pipework and manifold(s) shall comply with the requirements of 1.12.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

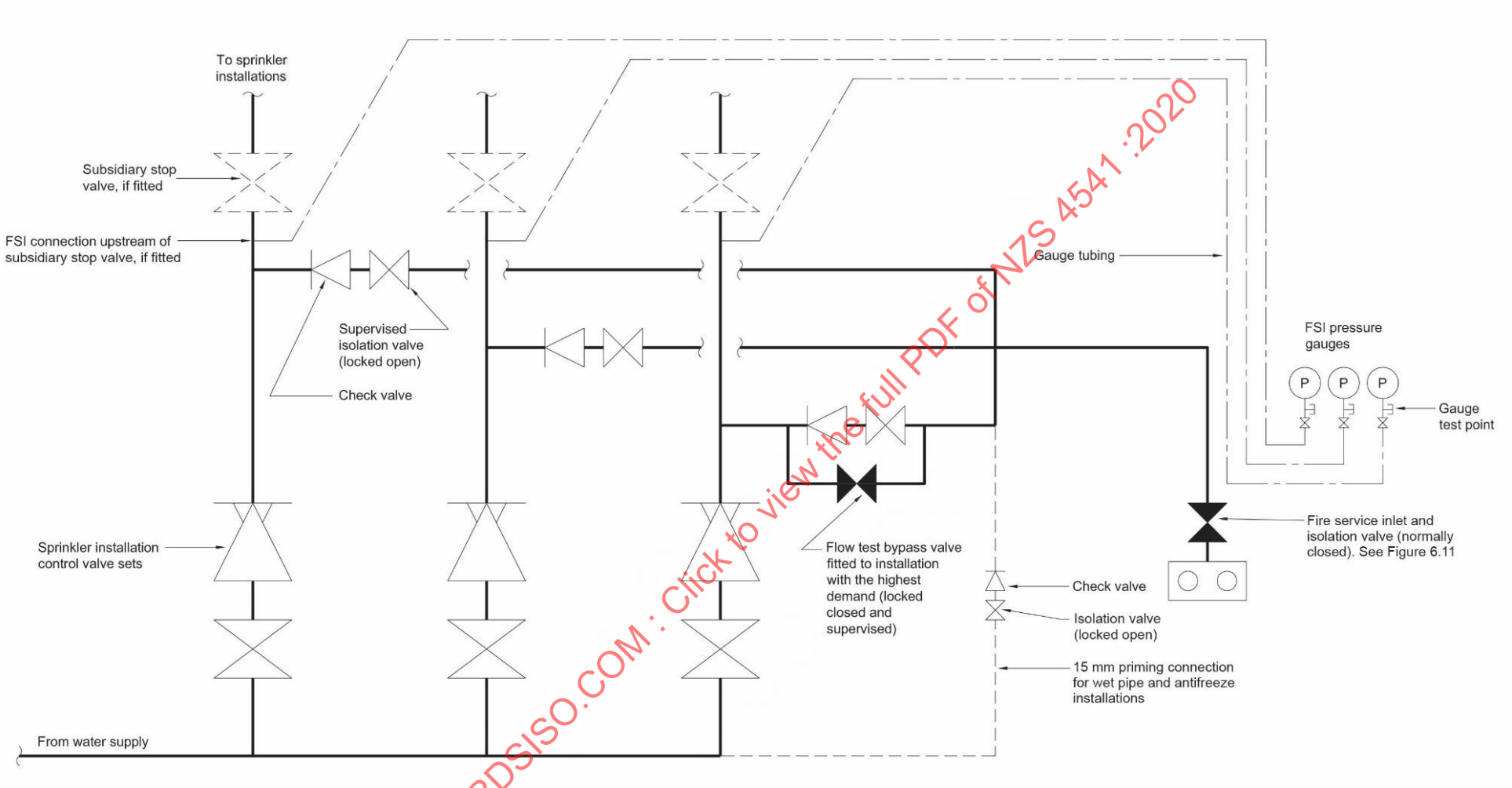


Figure 6.17 – Fire sprinkler inlet arrangement for multiple valve sets

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

6.10.5.2 *Stop valves*

Stop valves shall be suited to the duty pressure, be slow closing, provide a drip tight seal, and not incorporate metal to metal seating. The valve shall be housed in the cabinet. A metal or plastic label bearing the words 'OPEN BEFORE PUMPING' shall be fitted to the handwheel or collocated directly adjacent.

Where there is more than one stop valve, each valve shall be numbered in contrasting numerals at least 40 mm high according to the installation which it controls.

6.10.5.3 *Pressure gauges*

A pressure gauge shall be fitted in the cabinet, connected to the installation side of each stop valve and shall be marked with a red sector between zero pressure and a pressure 100 kPa above the highest design pressure requirement for that particular installation. The remainder of the scale shall be shaded green. Where there is more than one pressure gauge, it shall be labelled with the number of the installation to whichit is connected. Where the direct access to the fire sprinkler inlet is via the valve house doors, it shall be permissible, in a single installation system, to comply with this requirement by shading the installation gauge.

6.10.5.4 *Pipe size*

The size of the connecting pipework and stop valve shall be such that at the highest design flow, the pressure loss due to friction between the inlet coupling and the alarm valve does not exceed 100 kPa. In the case of any secondary fire sprinkler inlets installed on the installation, connecting pipework to the system shall be such that at the highest design flow, the pressure loss due to friction between the secondary FSI and the most hydraulically remote area of operation, plus the design point pressure, does not exceed P_{NC} (refer to NZS 4510).

6.10.5.5 *Pipework bracing*

The fire sprinkler inlet valves and pipework (including any permanent test outlet) shall be braced to withstand the forces developed during flow testing of sprinkler system water supplies.

6.10.5.6 *Duty pressures exceeding 1050 kPa*

If, in the event of failure of the sprinkler system water supply, the maximum required boost pressure at the fire sprinkler inlet exceeds 1050 kPa then special provisions in the fire sprinkler inlet design shall be provided. These special provisions shall be approved by an SSC.

Such special provisions may include the provision of a valved connection which would allow the building's wet riser diesel-driven pump set (designed and installed in accordance with NZS 4510) to boost the sprinkler system fire sprinkler inlet pipework. In such cases, the valve shall be operable from the sprinkler system fire sprinkler inlet cabinet and its purpose clearly and indelibly marked in letters at least 50 mm high.

NOTE – It is not acceptable to connect the sprinkler system fire sprinkler inlet to the suction side of the sprinkler system pumps, as this does not cater for any event where the sprinkler system water supply has failed. In such cases, it is expected that the sprinkler system pumps may have seized, prior to the fire brigade providing water to them.

6.11 Proving of water supplies

6.11.1 *Test outlets*

To facilitate tests to verify that each of the sprinkler installations water supplies satisfies the pressure/flow requirements appropriate to the installation, provision is to be made for water flow testing. This provision shall be as follows: Where the water supply is taken from a stored water source in proximity to the installationcontrol valves, a test pipe with in-line flow meter shall run from downstream of the installation control valves back to the stored water source, terminating at a level that is at least 1 m below the nominal level of the water storage tank. The installation of the flow meter in this situation shall be permanent unless deemed otherwise by the SSC who may accept other configurations in certain circumstances. The pipe and in-line flow meter shall be sized to allow flow testing at least 125% of the highest design flow.

Where the water source is from a town's main or from a stored water source that is remote from the installation control valves, a test outlet for the connection of a portable flow measuring device to the fire sprinkler inlet or a permanent test outlet shall be provided.

In the case of a supplemented town's main, a facility shall be provided to allow the water level in the tank to be lowered to permit a displacement test to be undertaken to measure the infill rate into the tank.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

6.11.2 *Location of test outlet*

Where testing involves discharge of water to atmosphere, the location of the test outlet shall consider the following:

(a) The location of the test outlet shall allow free discharge of at least 125% of the highest duty flow without causing damage to property;

(b) Where practicable the test outlet shall be located to avoid discharging across footpaths and roadways.

NOTE –

(1) The test outlet does not need to be co-located with the fire sprinkler inlet.

(2) It is not desirable to have water from test outlets jet across footpaths and roadways as this may necessitate traffic management plans for testing and may restrict the times at which testing can be undertaken or may render testing impracticable.

(3) Where storm water retention tanks are installed on site, consideration should be given to whether sprinkler test water could be better directed to these via a fixed in-line flow meter and discharge pipe.

6.11.3 *Fixed in-line flow meters*

Fixed in-line flow meters shall be a simple device such as an orifice plate, venturi nozzle, or pitot tube type configuration that measures differential pressure and converts this to a flow reading. The differential gauge for the meter shall be permanently mounted adjacent to the meter.

The flow meter shall be listed and shall be installed in accordance with the manufacturer's listing instructions.

A laminated differential pressure to flow chart, in the units of kPa and l/min, shall be permanently fixed in place adjacent to the flow meter.

The outlet connections from the flow meter shall be fitted with isolate valves and connection ports to allow an inspector to attach a portable differential pressure gauge.

Alternatively, other flow meter arrangements, such as ultrasonic or magnetic flow meters may be used with specific approval of the SSC.

NOTE – A current calibration certificate will be required for differential gauges when used during routine biennial inspections.

6.11.4 *Portable flow meters*

Provision for connection of a portable flow measuring device to the fire sprinkler inlet or permanent test outlet, as applicable, shall be provided.

The provision of the test device shall be located to allow free discharge of at least 125% of the design flow without causing damage to property.

For design flows exceeding 3500 L/min, a permanent test outlet shall be connected between the firesprinkler inlet stop valve(s) and the inlet clapper valve(s) to allow the connection of large flow testingdevices. The test connection shall consist of either a 100 mm or 150 mm rolled groove fitting with, under normal conditions, a blank cap. For design flows in excess of 9000 L/min, two independently valved test connections shall be provided.

6.11.5

Where a number of installation control valves are sited together and all are associated with installations ofthe same hazard class, this testing facility is necessary only on one installation control valve provided that itis fitted to the valve which is hydraulically the least favourably situated.

6.11.6

Where more than one hazard class is involved, whether on the same or separate installation control valves, testing facilities shall be provided to enable the full range of flows to be measured. This requirement may be waived by an SSC where it is obvious, from testing of the higher flow rate, that the lower pressure/flow requirements are satisfied.

6.11.7

Where the fire pump is remote from the sprinkler valves, a test point local to the fire pump shall be provided for proving tests of the fire pumps.

Where the pump draws from a water tank, a test pipe with in-line flow meter shall run from the pump discharge back to the stored water source, terminating below the level of the anti-vortex plate. The pipe and in-line flow meter shall be sized to allow flow testing at least 125% of the highest design flow. Flow meters shall comply with 6.11.3.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

6.12 Private site fire mains (see 6.2.1 Class B2)

6.12.1 *Piping*

6.12.1.1

Pipework may be reticulated throughout the site through a combination of buried or above-ground pipework. Where pipe is above ground, it shall be located to minimise the potential that it may be damaged, by natural events, or by explosions, vehicle accidents and the like.

6.12.1.2

Buried pipework shall be provided with thrust restraint in accordance with best trade practice and with allowance for anticipated vehicle movements.

6.12.1.3

Pipework above ground shall be installed on suitably constructed pipe supports or pipe bridges designed to AS/NZS 1170 series as applicable.

6.12.1.4

Piping shall be sized by hydraulic calculation to allow for the isolation and/or repair of any section of the fire main, or the impairment of either of the water supplies, and still provide the design flow and pressure.

6.12.2 *Valves*

All valves shall comply with 6.2.1, 6.2.4, and 6.4.1.7.1(d).

6.12.3 *Water supply*

Each water supply to the fire main shall conform to this standard except that:

(a) Where the ring main forms part of a dual supply (6.2.1), pumps may be started by detection of pressure drop in the fire main, providing the normal means of pressurisation can be maintained for a minimum period of 24 hours without reliance on the standard power supply (see also 6.7.1.6.3);

(b) The continuous rating of diesel engines forming part of a water supply shall provide the power requirements of the pump under any condition of pump discharge; and

(c) To facilitate tests to verify that the fire pump satisfies the pressure/flow requirements appropriate to the facility, provision for connection of a portable flow measuring device to a permanent test outlet shall be provided local to any fire pump.

Where the pump draws from a water tank, a test pipe with in-line flow meter shall run from the pump discharge back to the stored water source, terminating below the level of the anti-vortex plate. The pipe and in-line flow meter shall be sized to allow flow testing at least 125% of the highest design flow. Flow meters shall comply with 6.11.3.

NOTE – Details of how the ring main will be pressurised are to be supplied to an SSC as part of the information required within the basic design decision submission (see 1.14.1(p)).

6.12.4 *Other*

6.12.4.1

Details of the site fire main shall be incorporated on a block plan in every fire pump enclosure supplying the fire main.

6.12.4.2

The flow and pressure characteristics of each connection to the private site fire main shall be determined by applying the requirements of Appendix R2 as if the site fire main was a town's main.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

7 Extra light hazard system design data

7.1 Water supplies

7.1.1 *Design criteria*

ELH systems shall be designed to meet one of (a) to (c):

(a) To allow the hydraulically most remote six heads to provide a flow of at least 57 L/min from each sprinkler regardless of the area covered by an individual sprinkler;

(b) In areas where residential sprinklers are fitted, to provide for the four most hydraulically demanding sprinklers; or

(c) In areas where ECLH sprinklers are fitted, to include an assumed area of operation of five sprinklers, but not less than 140 m^2, discharging in accordance with the listing for the sprinkler head.

In (a) above, the hydraulically most remote group of sprinklers shall be selected to form as near as possible a square with the longest side positioned so that it imposes the greatest hydraulic demand. Except as varied by this clause, hydraulic calculation methods shall conform to the requirements of Part 10. Sprinklers in cupboards and wardrobes need not be included in the calculation.

In (b) above, the minimum discharge from each sprinkler is to be the greater of the following: the listed flow rates for NFPA 13D and NFPA 13R systems; or a minimum discharge density of 4.1 mm/min over a design area of the four most hydraulically demanding sprinklers for the actual coverage areas for the sprinklers.

NOTE – Users of this standard should be aware that the use of outdated data sheets may not provide the latest listing data called up for residential heads. Attention is also drawn to the need to apply the more onerous of the two design criteria provided above.

In (c) above, interpolation of criteria between listed spacings shall not be used. The minimum discharge density shall be 4.1 mm/min.

7.1.2 *Water supplies*

7.1.2.1

Each water supply shall be capable of providing at the installation control valves, the design flow at the design pressure. The design pressure for systems having any sections fitted with residential sprinklers shall not be less than the pressure required to operate any single residential sprinkler at its appropriate listed flow and pressure.

7.1.2.2

Pipe sizes shall be determined by full hydraulic calculation in accordance with Part 10.

7.1.2.3

Where external sprinklers impose a demand greater than that of the protected area, the values of the design flow and design pressure shall be increased accordingly.

7.1.3 *Extensions to existing systems*

7.1.3.1

Existing systems, installed in accordance with superseded editions of this standard, may be extended by a maximum of four sprinklers with pipe sizes in accordance with the method set out in 7.3. Where the array pipework beyond the design points is sized to Table 7.1, the design flow shall be 270 L/min and the design pressure 190 kPa plus whichever is the greater of 90 kPa or the pressure equal to the distribution pipe losses between the control valves and the hydraulically most remote design point, plus the pressure equivalent of the difference in height between the valves and the highest sprinkler. In such cases, only10 mm sprinklers may be used.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

Table 7.1 – Minimum pipe sizes for pre-calculated extra light hazard sprinkler arrays

	Normal diameter of pipe			
	From last to 2nd head (mm)	Between 2nd and 3rd head (mm)	Between 3rd and 4th head (mm)	Between 4th head and design point (mm)
Option A*	20	25	32*	–
Option B	20	25	40	50
Option C	25	25	32	40
Option D	25	32	32	32
Option A* provides for a three head range and the 32 mm diameter and, therefore, relates to the pipe between the third head and the design point.				

7.1.3.2

Where the ranges in an area of operation are connected to a section of looped distribution pipe, the design point is the hydraulic mid-point of that section of distribution pipe.

7.1.3.3

Design points are those points on the pipework at an equivalent hydraulic length not greater than 7 m upstream from the fourth sprinkler on any range under consideration, or on ranges of less than four heads at the junction of the next upstream range on the distribution pipework.

7.1.3.4

The designs of hydraulically calculated systems may incorporate any pipe sizes that are permitted by Part 10 and proven to satisfy the design requirements of that part.

7.2 Sprinkler type and spacing

7.2.1 *Sprinkler types*

7.2.1.1

In sleeping areas, sprinkler heads shall be residential type or quick response standard spray.

In this context, ‘sleeping areas’ includes bunkrooms; hospital wards; bedrooms; dormitories; and individual suites in hotels, motels, and apartment buildings. ‘Individual suites’ means that area (whether partitioned or not) to which access is controlled by the room key that is, bedrooms, bathroom suite, lobby, lounge, and kitchen where provided.

Hospital wards containing more than four beds per room shall not be protected with residential sprinklers. Quick response standard spray sprinklers shall be used.

NOTE – To achieve comparable detection, some ECLH sprinklers are fitted with a more responsive heat activated element, they are not necessarily listed as quick response sprinklers.

7.2.1.2

In all other areas, except as provided for in 7.2.1.3, either quick response or standard response spray pattern 10 mm or 15 mm sprinkler heads shall be used.

7.2.1.3

In areas related to sleeping areas, including corridors, lift lobbies, stairways and foyers, and in care institutions, day rooms or lounge areas, residential or quick response or standard response spray pattern sprinklers may be used. Residential sprinklers shall not be used in kitchens, cafeterias, restaurants, bars, storerooms, laundries, plant rooms, ceiling spaces, or roof spaces.

NOTE – This needs to be read in context with 7.2.1.1 and 7.2.1.4. The intention of this clause is to relax the requirements for quick response heads outside sleeping areas, such as hotel corridors and the like. It is not the intention to relax the requirement for quick response heads within sleeping areas, such as internal apartment corridors and the like.

7.2.1.4

Standard response sprinklers may be used in small ancillary spaces, related to sleeping occupancies, such as cupboards, laundries, and toilets and bathrooms, where such spaces are protected by one head.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

7.2.2 *Coverage*

The maximum area coverage per sprinkler shall be:

(a) Sidewall sprinklers .....17 m^2;
(b) ECLH sprinklers ..... as indicated on the listing;
(c) Other spray sprinklers .....21 m^2;
(d) Residential sprinklers .....as indicated on the listing.

7.2.3 *Spacing*

7.2.3.1

The maximum distance between sprinklers on range pipes and between adjacent rows of sprinklers shall be:

(a) Sidewall sprinklers .....see 5.9;
(b) ECLH sprinklers ..... as indicated on the listing;
(c) Other spray sprinklers .....4.6 m;
(d) Residential sprinklers .....as indicated on the listing.

7.2.3.2

The maximum distance between sprinklers and walls or partitions shall be half the distance set out in the above clauses. Where staggered spacing is used, see part 5.

7.3 Pipework

7.3.1 *Sizing (ELH pipework)*

7.3.1.1

Pipework shall be sized either on the basis of full hydraulic calculations in accordance with Part 10, or, in the case of extensions to existing systems in compliance with 7.1.3, shall have those pipes downstream of any design point (the array) sized at least as large as is specified in Table 7.1. Where roof or ceiling gradients exceed 1 in 4 and ranges are fed up the slope, full hydraulic calculation shall be used.

7.3.1.2

Where array pipework is installed in accordance with Table 7.1, pipework between the control valves and the design points shall be sized according to hydraulic calculations so as not to exceed the available water supply pressure measured at the design flow. Values for friction losses in pipes at a flow of 270 L/min are as follows (See Table 7.2):

Table 7.2 – Friction losses for pipe diameters at 270 L/min

Pipe diameter (mm)	25	32	40	50	65	80	100
Loss (kPa/m)	29	7.4	3.6	1.1	0.33	0.15	0.04

7.3.2 *Fittings*

The loss of pressure at each elbow, bend, or tee, where the water is turned through an angle, shall be taken as equal to that of 1.5 m of straight pipe of the smallest diameter pipe of the waterway direction change.

7.4 Storage areas and drying rooms

7.4.1

The fire loads in small storage rooms and drying rooms require higher discharge densities than 2.7 mm/min.

Any such rooms, which are separated from other areas by full height partitions or walls and which are of an area that may be protected by up to six sprinklers spaced at not more than 12 m^2 when pipework is fully hydraulically calculated, or up to four sprinklers when installed in accordance with 701.3 spaced at not more than 12 m^2, shall be protected by 15 mm sprinklers where pipework is sized according to Table 7.1.Pipework shall be sized to ensure that the density is not less than 5 mm/min.

7.4.2

Any storage or drying room larger than the area specified in 7.4.1, shall be regarded as a separate occupancy and be classified as OH3 or EHH. See 2.3.2.5.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

NOTES

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

8 Ordinary hazard system design data

8.1 Design criteria, pipe sizing, and water supplies

8.1.1 *Design criteria*

8.1.1.1 *Ordinary hazard Groups 1 to 3 (OH1 to OH3)*

OH systems in occupancies classified OH1, OH2 with ceiling heights up to 6 m, or OH3 shall:

(a) Provide a design density discharge of at least 5 mm/min in accordance with area coverage rules for groups of sprinklers in Table 8.1; or
(b) Use ECOH sprinklers with system design based on either five sprinklers operating in accordance with their listing, or the number operating in an assumed area of operation of 140 m^2, whichever is the greater.

If the ceiling height in OH1 or OH2 occupancies exceeds 6 m, then the criteria for OH3 shall be applied.

Interpolation of criteria between listed spacings is not permitted.

Table 8.1 – OH1, OH2, and OH3 sprinkler numbers for coverage areas

Design density discharge shall be at least 5 mm/min over …	… any group of at least (x) sprinklers	… but if coverage is less than:	… up to (x) sprinklers
OH1 Light (with less than 6 m ceiling height)	6	54 m^2	9
OH2 Medium (with less than 6 m ceiling height)	12	108 m^2	18
OH3 High	18	162 m^2	24

8.1.1.2 *Ordinary hazard Group 3 Special (OH3S)*

OH systems in occupancies classified OH3S with ceiling heights up to 18 m shall be designed as follows for density of discharge, assumed area of operation, and height of ceiling. See also Table 9.1.

Ceiling heights over 18 m and up to 30 m shall have the design of either:

(a) 12 x K36 70°C quick response sprinklers with an operating pressure of at least 50 kPa; or
(b) 6 x K36 70°C quick response extended coverage sprinklers with an operating pressure of at least 190 kPa.

Table 8.2 – OH3S– Minimum design density of discharge for ceiling heights

Ceiling heights up to (x) m:	…shall have minimum design density discharge of:
6	5 mm/min over a design area of 360 m^2, with the use of *K* = 8 sprinklers
11	12 mm/min over a design area of 230 m^2, with the use of *K* = 11.5 sprinklers;
18	18 mm/min over a design area of 230 m^2, with the use of *K* = 16 sprinklers.

NOTE – OH3S is an extension of OH3 occupancies where flash fires are likely, covering somewhat larger areas of operation, such as preparatory processes in textile mills and other occupancies as identified in Table 2.1.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

8.1.1.3 *Ordinary hazard Group 4 (OH4)*

The design density and assumed area of operation for systems in occupancies classified OH4 (severe OH) shall be in accordance with Tables 8.3 and 8.4.

The type of sprinkler head used shall comply with the following:

(a) Roof/ceiling sprinklers for OH4 shall be 15 mm or 20 mm orifice standard spray type (SSP or SSU), or ELO;

(b) Spray sprinklers with a minimum *K* factor of 8 shall only be used for roof/ceiling densities of up to 10 mm/min; and

(c) Spray sprinklers with a minimum *K* factor of 11.5 shall only be used for roof/ceiling densities of up to 15 mm/min.

ECOH sprinklers are not permissible for OH4.

Where permitted storage height or ceiling height options in Tables 8.3 and 8.4 are exceeded, the firecell shall be protected as an EHH occupancy as per Part 9. See 9.5.7 for specific advice on warehouse occupancies.

Table 8.3 – Design criteria for storage of Category 1 to 4 commodities in OH4 occupancies storage height ≤ 3.7 m

Storage height (m)	Ceiling height (m)	Category Roof design density (mm/min)			
		1	2	3	4
≤ 1.5	Any	5	5	5	5
> 1.5 to ≤ 2.0	≤ 18	5	5	5	6
> 2.0 to ≤ 2.5	≤ 12.2	5	5	6	10
	> 12.2 to ≤ 13.7	5	5	6	12
	> 13.7 to > 18	5	5	6	n/p
> 2.5 to ≤ 3.0	≤ 9.8	5	6	7	8
	> 9.8 to ≤ 10.7	5	6	7	10
	> 10.7 to ≤ 12.2	5	6	8	12
	> 12.2 to ≤ 13.7	5	6	10	n/p
	> 13.7 to ≤ 18	5	6	n/p	n/p
	> 18	5	n/p	n/p	n/p
> 3.0 to ≤ 3.7	≤ 9.8	6	7	8	10
	> 9.8 to ≤ 10.7	6	7	8	12
	> 10.7 to ≤ 12.2	6	7	10	14
	> 12.2 to ≤ 13.7	6	7	12	n/p
	> 13.7 to < 18	6	n/p	n/p	n/p

NOTE –

(1) Roof design area minimum 186 m².

(2) Applies to palletised, bin box, shelf, rack with shelves < 6.0 m², and back-to-back shelves.

(3) For roof slopes greater than 10 degrees, or dry/pre-action systems, multiply design area by 1.3.

(4) Where no design criteria are provided, see EHH.

(5) Maximum number of simultaneous sprinklers to operate is 24.

(6) n/p – Not permitted.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 8.4 – Design criteria for storage of Category 5 and 6 commodities in OH4 occupancies storage height ≤ 3.7 m

Storage height (m)	**Ceiling height** (m)	**Category** **Roof design density** (mm/min)			
		5 **cartoned**	**5** **uncartoned**	**6** **cartoned**	**6** **uncartoned**
≤ 1.5	≤ 9.1	7	8	8	10
	> 9.1 to ≤ 9.8	8	10	10	12
	> 9.8 to ≤ 10.7	10	12	12	14
	> 10.7 to ≤ 12.2	12	14	14	16
	> 12.2 to ≤ 13.7	14	16	16	18
	> 13.7 to ≤ 18	16	18	18	20
	> 18	n/p	n/p	n/p	n/p
> 1.5 to ≤ 2.0	≤ 4.6	8	10	10	14
	> 4.6 to ≤ 6.1	10	12	12	16
	> 6.1 to ≤ 7.6	12	14	14	18
	> 7.6 to ≤ 9.1	14	16	16	20
	> 9.1 to ≤ 9.8	16	18	18	n/p
	> 9.8	n/p	n/p	n/p	n/p
> 2.0 to ≤ 2.5	≤ 4.6	8	12	12	18
	> 4.6 to ≤ 6.1	12	14	14	21
	> 6.1 to ≤ 7.6	14	16	16	25
	> 7.6 to ≤ 9.1	16	18	18	28
	> 9.1 to ≤ 9.8	20	22	22	n/p
	> 9.8	n/p	n/p	n/p	n/p
> 2.5 to ≤ 3.0	≤ 4.6	10	14	14	24
	> 4.6 to ≤ 6.1	14	16	16	26
	> 6.1 to ≤ 7.6	16	18	18	28
	> 7.6 to ≤ 9.1	20	20	20	30
	> 9.1 to ≤ 9.8	22	24	24	n/p
	> 9.8	n/p	n/p	n/p	n/p

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 8.4 – Design criteria for storage of Category 5 and 6 commodities in OH4 occupancies storage height ≤ 3.7 m (continued)

Storage height (m)	Ceiling height (m)	Category Roof design density (mm/min)			
		5 cartoned	5 uncartoned	6 cartoned	6 uncartoned
> 3.0 to ≤ 3.7	≤ 4.6	12	16	16	n/p
	> 4.6 to ≤ 6.1	16	20	20	n/p
	> 6.1 to ≤ 7.6	20	22	22	n/p
	> 7.6 to ≤ 9.1	22	24	24	n/p
	> 9.1 to ≤ 9.8	24	26	26	n/p
	> 9.8	n/p	n/p	n/p	n/p

NOTE –

(1) Roof design area minimum 232 m².

(2) Applies to palletised, bin box, and shelf for Category 5 cartoned and uncartoned, and Category 6 cartoned and uncartoned.

(3) Applies to rack with shelves < 6.0 m² for Category 5 cartoned and uncartoned, and Category 6 cartoned.

(4) For roof slopes greater than 10º, or dry/pre-action systems, multiply design area by 1.3.

(5) Where no design criteria are provided, see EHH.

(6) Maximum number of simultaneous sprinklers to operate is 36.

(7) n/p – Not permitted.

8.1.2 *Water supplies*

8.1.2.1

Each water supply shall be capable of providing at the installation control valves the design flow at the design pressure provided that in installations where the pipework downstream of the '18 sprinkler points' (see note to design point definition in 1.3) has been sized according to Table 8.5, each water supply need provide (for the OH occupancy) only the following rates, at the design pressure (see note below):

OH1 occupancy 540 L/min
OH2 occupancy 1100 L/min
OH3 occupancy 1350 L/min

NOTE – In this context, the design pressure is that which is needed at the alarm valves to provide at each 18 sprinkler point:

(1) For OH1 occupancies, 200 kPa when 540 L/min is flowing; and

(2) For OH2 and OH3 occupancies, 300 kPa when a flow of 1350 L/min is assumed to be flowing.

8.1.2.2

Where external sprinklers impose a demand greater than that of the protected area, the values of the design flow and design pressure shall be increased accordingly.

8.1.2.3

For new sprinkler systems, ECOH installations or extension of existing sprinkler systems which exceed 18 sprinklers, or which are installed in OH3S occupancies, all new pipework shall be sized by full hydraulic calculation in accordance with Part 10, so as to comply with 8.1.1 and 8.1.2.

It is not a requirement of this standard to limit water velocities in pipes.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Table 8.5 – Maximum number of sprinklers on tabular pipework

(1) Range pipes		
Ranges	**Pipe size (normal diameter) (mm)**	**Maximum number of sprinklers allowed on range pipes**
Ranges at remote end of all distribution pipes		
Two end-side layouts	25	1
Last two ranges	32	2
Three end-side layouts	25	2
Last three ranges	32	3
All other layouts	25	2
Last range	32	3
	40	4
	50	9
All other ranges	25	2
	32	4
	40	6
	50	9
The number of sprinklers on a range pipe when the ranges run longitudinally under roofs sloping at an angle in excess of 6° shall not exceed six. This provision shall apply only where ranges are above the elevation of the design point.		
(2) Distribution pipes		
Distribution pipes within the array	**Pipe size (normal diameter) (mm)**	**Maximum number of sprinklers to be fed by distribution pipe**
Pipes at extremities of system		
Two end-side layouts	32	2
	40	4
	50	8
	65	16
All other layouts	32	3
	40	6
	50	9
	65	18

8.1.3 *Sizing of pipework*

Existing sprinkler systems (except OH3S occupancies) may be extended by a maximum of 18 sprinkler heads, using pipe sizes determined in accordance with Table 8.5.

The following criteria apply:

(a) Table 8.6, in (c) below, shall be used to size pipes downstream of the 18 sprinkler point;

(b) There shall be available at each 18 sprinkler point, the following minimum design pressure:

OH1 occupancy 200 kPa
OH2 and OH3 occupancies 300 kPa

(c) To calculate pressure availability at the 18 sprinkler point, allowance shall be made for any difference in height to the alarm valve. The pressure loss due to friction shall be calculated at a flow rate of 540 L/min

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

for OH1 occupancies and 1350 L/min for OH2 and OH3 occupancies using either the Hazen-Williams formula or the following values for loss of pressure per metre length of pipe (Table 8.6 below);

Table 8.6 – Loss of pressure per metre of pipe

Pipe size (NB) (medium grade) (mm)	Loss of pressure/metre at Flow rate = 540 L/min (kPa)	Loss of pressure/metre at Flow rate = 1350 L/min (kPa)
50	3.8	21.6
65	1.1	6.0
80	0.51	2.8
100	0.14	0.76
150	0.021	0.11
200	0.005	0.028

(d) Sprinkler spacing of the extension, both between the sprinklers and between the ranges, shall not exceed 3.0 m;
(e) Where range pipework incorporates changes of direction, and pipe sizes are not increased to compensate for the additional friction losses, it shall be demonstrated that the use of pipe sizes to Table 8.5 in that situation is not hydraulically worse than the worst case permitted by Table 8.5 using straight pipe; and
(f) Where the roof or ceiling gradient exceeds 1 in 4, and the ranges are fed up the slope, full hydraulic calculation shall be used.

8.2 Sprinkler type and spacing

8.2.1 *Sprinkler types*

8.2.1.1

In sleeping areas, sprinkler heads shall be 15 mm quick response.

In this context, 'sleeping areas' includes bunkrooms; hospital wards; bedrooms; dormitories; and individual suites in hotels, motels, and apartment buildings. 'Individual suites' means that area (whether partitioned or not) to which access is controlled by the room key, that is, bedrooms, bathroom suite, lobby, lounge, and kitchen where provided.

NOTE – To achieve comparable detection, some ECOH sprinklers are fitted with a more responsive heat activated element but are not necessarily listed as quick response sprinklers.

8.2.1.2

In all other areas, unless otherwise specified in the standard (such as 8.1.1.3 for sprinklers in OH4 occupancies) either quick response or standard response sprinkler heads shall be used.

8.2.1.3

Standard response sprinklers may be used in small ancillary spaces, related to sleeping occupancies, such as cupboards, laundries, and toilets and bathrooms, where such spaces are protected by one head.

8.2.2 *Sprinkler spacing*

8.2.2.1

Maximum area coverage per sprinkler shall be:
(a) Sidewall sprinklers .....9 m^2;
(b) Other sprinklers.....12 m^2; and
(c) ECOH sprinklers .....see sprinkler listing.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

8.2.2.2

The maximum spacing for sprinklers is as follows:
(a) For standard spray sprinklers – 4.6 m;
(b) For standard sidewall sprinklers – refer to 5.9; For
(c) extended coverage sprinklers – as per listing.

NOTE – In the case of corn, provender, and rice mills (other than those using the pneumatic system of conveying), film and television production studios, theatres, and music halls (stage protection), the maximum area coverage is limited to 9 m^2 per sprinkler and the maximum distance between sprinklers to 3 m.

8.3 Special requirements for vehicle stacker sprinkler systems

8.3.1 *General*

This section specifies requirements and provides necessary information and procedures for the design of standard sprinkler system protection of vehicle stacker arrangements. These can vary from a simple two vehicle stacker (one over another), to multi-level arrangements with vehicles transported vertically, horizontally, circumferentially, or a combination of all three.

Due to the peculiarities of vehicle stackers, there are several requirements that differ from those specified in Part 5.

NOTE – The general design and hydraulic design requirements of Part 5 and Part 8 shall apply, unless otherwise specified, for vehicle stackers.

8.3.2 *Design and hydraulic requirements for vehicle stacker sprinkler systems*

8.3.2.1 *System type*

Where there is no likelihood of freezing, systems shall be wet type. Where there is a likelihood of freezing, a dry pipe or a pre-action system shall be installed in accordance with the requirements of 3.2.2, 3.2.3, or 3.2.4.

8.3.2.2 *Special requirements for roof and ceiling sprinklers*

Roof/ceiling sprinklers shall be installed in accordance with the requirements of Part 5, except that sprinklers shall:

(a) Be *K*8 minimum;
(b) Have a nominal temperature rating of 68°C; and
(c) Have a standard response.

8.3.2.3 *Clearance over vehicle*

The clearance from the top of the highest possible vehicle stored, to sprinklers below roofs/ceilings or mezzanines, shall be at least 500 mm. Where this is not possible, sprinklers shall be located between all vehicles. If they are likely to suffer mechanical damage, they shall be fitted with guards.

NOTE – It is the intent of this section to provide sprinkler coverage to the front and the rear of each vehicle.

8.3.3 *Protection requirements for different storage arrangements and vehicle configurations*

8.3.3.1 *General*

Protection for designs of vehicle stackers covered in this clause are detailed in Table 8.7. Protection requirements vary in relation to vehicle configuration and storage arrangements. If the arrangement of a vehicle stacker is not covered by this section, protection shall be agreed with an SSC.

NOTE – 'Open frame' means no solid platforms (except on the lowest level). A stacker with solid moving platforms for a single vehicle that does not impact the distribution of water from sprinklers, any more than one vehicle in the stack, may be deemed open frame.

8.3.3.1.1 Two level open-frame stacker

Where vehicles are stacked only two high, they may be protected by roof/ceiling protection only, or with roof/ceiling protection and in-stack sprinklers as per Table 8.7.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

8.3.3.1.2 Multiple level open-frame stacker

Where vehicles are stacked more than two high they shall be protected with roof/ceiling protection and in-stack sprinklers as per Table 8.7.

8.3.3.1.3 Solid moving platform stacker

Where vehicles are stored on solid moving platforms that do not fit the definition of open frame, they shall be protected with roof/ceiling protection and in-stack sprinklers as per Table 8.7.

NOTE – Solid moving platforms would typically be two vehicles wide.

8.3.3.1.4 Solid stationary platform stacker

Where vehicles are stored one vehicle high on solid platforms that do not move, they shall be protected with roof/ceiling protection as per Table 8.7.

8.3.4 *Roof/ceiling sprinkler hydraulic design*

Sprinklers at roof/ceiling level shall be designed in accordance with the requirements of Table 8.7 as appropriate to the stacker arrangement.

8.3.5 *Special requirements for in-stack sprinklers*

8.3.5.1 *Type of sprinkler*

In-stack sprinklers shall be installed in accordance with the requirements of Part 5, except that sprinklers shall:

(a) Be *K*8 minimum and fast response;
(b) Have a nominal temperature rating of 68°C;
(c) Be conventional for open-frame stackers, spray pattern if the stacker has solid platforms, or be a spray pattern sidewall sprinklers;
(d) Be provided with guards; and
(e) Be provided with water shields where exposed to sprinkler water spray from above.

8.3.5.2 *Hydraulic design*

When in-stack sprinklers are a requirement of Table 8.7, they shall be hydraulically designed, based on the simultaneous operation of the hydraulically most disadvantaged in-stack sprinklers and the roof/ceiling-level sprinklers above. The in-stack sprinklers designed to operate shall be sprinklers located within flues adjacent to a vehicle on the most hydraulically remote two levels of sprinklers (unless there is only one level of in- stack sprinklers).

For example –

- A two level, open-frame stacker with sprinklers located at each vehicle corner has two flues, each with two sprinklers. There is only one level of in-stack sprinklers. The design is to allow for four in-stack sprinklers.
- A three level, open-frame stacker with sprinklers located at each vehicle corner has two flues, each with two sprinklers. There are two levels of in-stack sprinklers. The design is to allow for eight in-stack sprinklers.
- A three level, two vehicle solid platform stacker with sidewall sprinklers located at each platform corner spraying each direction has two flues, each with four sprinklers. There are two levels of in-stacksprinklers. The design is to allow for eight in-stack sprinklers.
- A three level, nose to tail stacker with sidewall sprinklers located at each vehicle end has two flues, each with two sprinklers. There are two levels of in-stack sprinklers. The design is to allow for eight in-stack sprinklers.

Consideration needs to be given to the number of sprinklers that will be exposed to sufficient heat from a vehicle fire to activate. The design needs to allow for this quantity to operate.

The minimum rate of flow from each operating in-stack sprinkler shall be 80 L/min.

In the sizing of distribution pipework, the water flow required for the in-stack sprinklers shall be added to that required for the roof/ceiling sprinklers. At the points where the in-stack pipework meets the roof/ceiling pipework, the respective flows shall be balanced in accordance with Part 10.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 8.7 – Design criteria for vehicle stackers

Vehicle stack levels	Configuration	rDD (1) (mm/min)	rDA (m^2) (2)		In-stack sprinklers
			Wet system	Dry/Pre-action system	
1	Solid stationary platform	5	162	210	Not required
2	Open frame	16	230	300	Not required
2	Solid moving platform	5	162	210	Yes
2	Open frame	5	162	210	Yes
3+	Solid moving platform	5	162	210	Yes
3+	Open frame	5	162	210	Yes

NOTE –

(1) rDD – Roof/ceiling design density, mm/min.

(2) rDA – Roof/ceiling design area, m^2.

8.3.5.3 *Spacing and area coverage*

Where in-stack sprinklers are a requirement of Table 8.7, the spacing and area coverage of sprinklers shall be installed in accordance with OH requirements in Part 5.

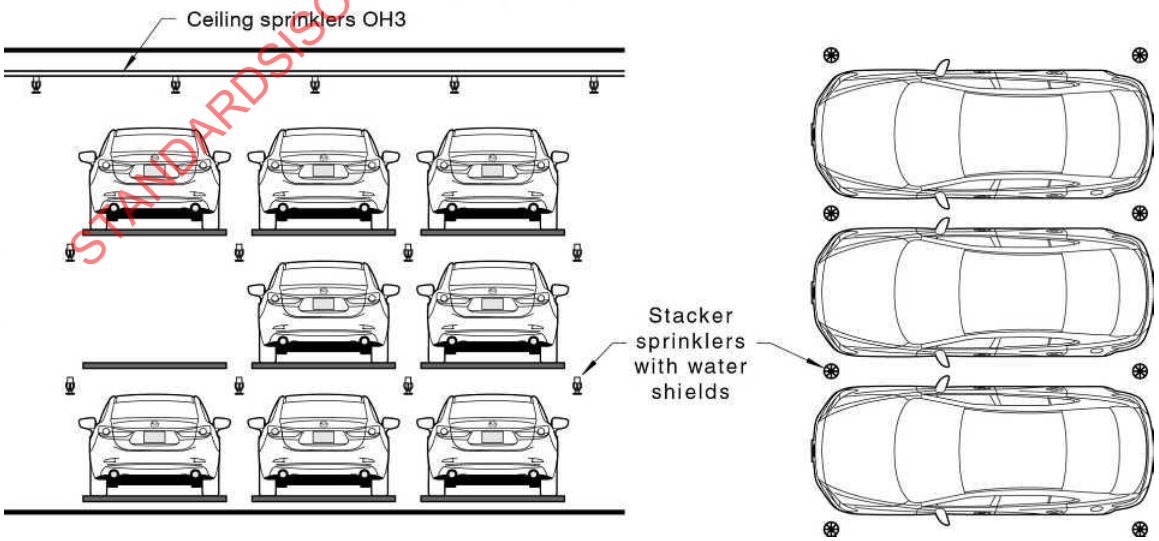
8.3.5.4 *Location*

The in-stack sprinklers shall be located in accordance with Part 5 and the following:

(a) In the flue space between vehicles or walls;
(b) The sprinkler deflector shall be located below the supporting structural members of the vehicle above to ensure the sprinkler spray pattern is not obstructed;
(c) The sprinkler deflector shall be not more than 150 mm below the vehicle platform/support; and
(d) Additional sprinklers shall be installed in accordance with Part 5 where the spray pattern or coverage is obstructed by structural members or piping.

8.3.5.5 *Arrangement*

Unless the vehicle stacker construction prevents it, in-stack sprinklers shall be located near the corner of each vehicle. Sprinklers shall be located a maximum of 600 mm from the front and rear end of the vehicle space. (See Figure 8.1).



SOURCE: Reproduced with permission of Standards Australia Limited © 2017
Copyright in AS 2118:2017 vests in Standards Australia Limited

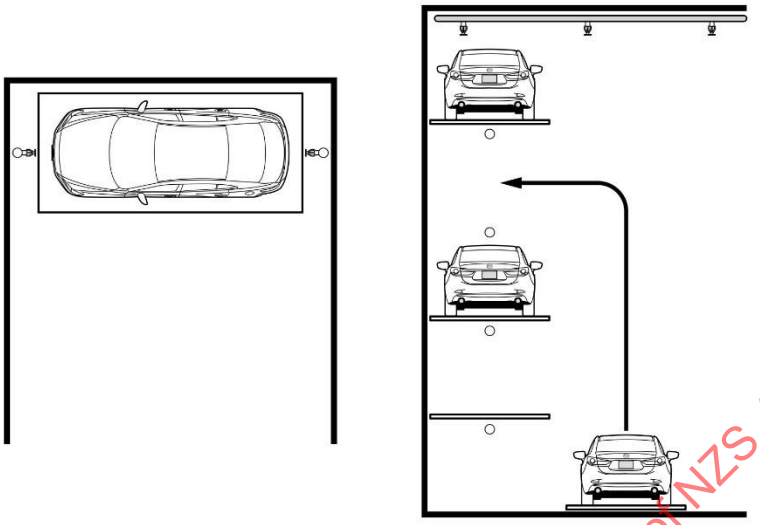
Figure 8.1 – Typical arrangement of open-frame vehicle stacker sprinklers

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

(a) Single column stacker

(i) Where vehicles are stacked individually, with walls around the front, side and rear of the vehicle, as an alternative to Figure 8.1, sidewall sprinklers shall be provided on the end walls or structure, covering the front and rear of each vehicle, see Figure 8.2;

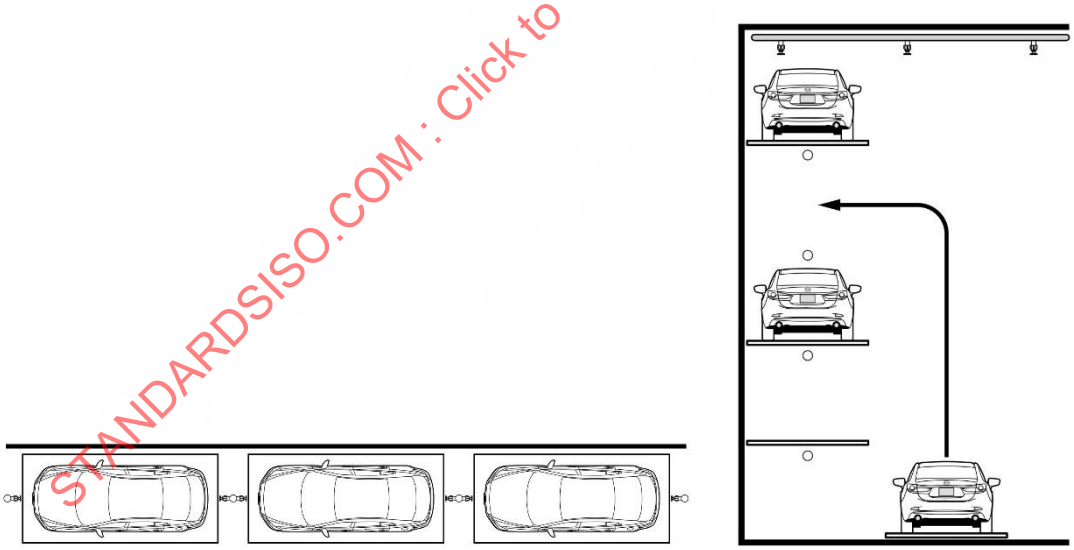


SOURCE: Reproduced with permission of Standards Australia Limited © 2017
Copyright in AS 2118:2017 vests in Standards Australia Limited

Figure 8.2 – Typical arrangement of single column vehicle stacker sprinklers

(b) Single-row stacker

(i) Where vehicles are arranged in a single row nose to tail individually, as an alternative to Figure 8.1, sidewall sprinklers shall be provided on the structure, covering the front and rear of each vehicle, see Figure 8.3;



SOURCE: Reproduced with permission of Standards Australia Limited © 2017
Copyright in AS 2118:2017 vests in Standards Australia Limited

Figure 8.3 – Typical arrangement of single-row vehicle stacker sprinklers

(c) Pit stacker

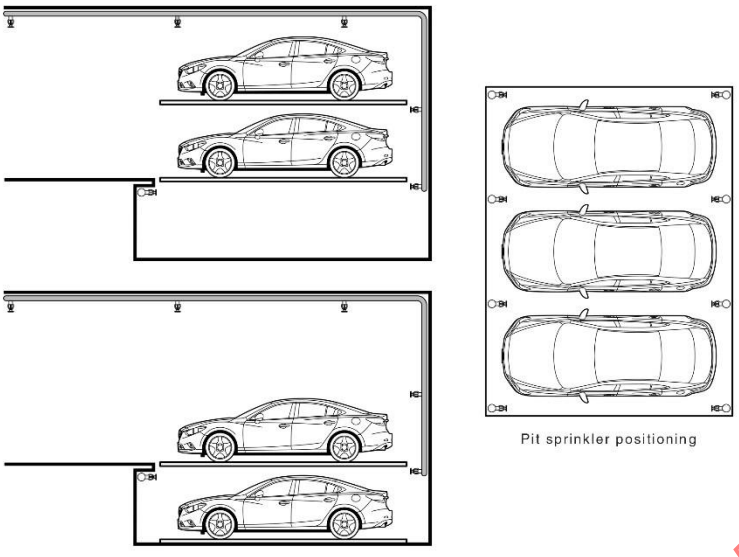
(i) Where stackers descend into pits, there shall be sprinklers installed in the pit to cover each corner of every vehicle

(ii) Only where there is no structural support for sprinkler piping for a maximum two-tier high stacker with the front open to the driveway and with a wall at the rear, sidewall sprinklers shall be installed between each vehicle at the rear only, with the front of the stacker protected by ceiling sprinklers, see Figure 8.4;

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

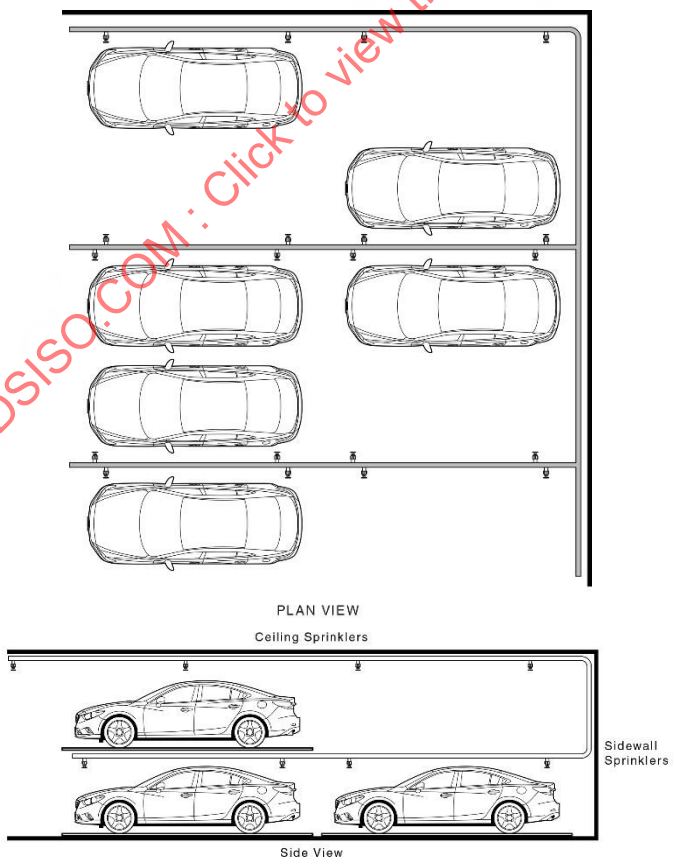
COPYRIGHT © Standards New Zealand



SOURCE: Reproduced with permission of Standards Australia Limited © 2017
Copyright in AS 2118:2017 vests in Standards Australia Limited

Figure 8.4 – Typical arrangement of pit vehicle stacker sprinklers

(d) Semi-automatic multidirectional two high stacker
  (i) In-stack sprinklers shall be located near the corner of each vehicle
  (ii) Where there is no intermediate structural support for sprinkler piping between a maximum of two vehicle spaces, sidewall sprinklers shall be installed covering both the front and rear of both vehicles, see Figure 8.5.



SOURCE: Reproduced with permission of Standards Australia Limited © 2017
Copyright in AS 2118:2017 vests in Standards Australia Limited

Figure 8.5 –Typical arrangement of pit vehicle stacker sprinklers

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

8.3.5.6 *Pipework*

Pipework connections between building structure and in-stack sprinklers in the stacker structure shall be provided with adequate flexibility for the expected movement of the vehicle stacker during normal use as well as seismic flexibility as required in Part 4.

8.3.6 *Vehicle stacker shut down*

Upon sprinkler system activation, a controlled shutdown of a vehicle stacker system shall be initiated.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

9 Extra high hazard system design data

9.1 Scope

9.1.1 *General*

This part specifies the requirements and provides necessary information and procedures for the design of standard sprinkler system protection for EHH class sprinkler systems incorporating process occupancies and storage occupancies.

NOTE –

(1) Testing has shown that small increases in ceiling heights can have a detrimental impact on sprinkler performance. The maximum ceiling heights stated in this part should not be the subject of any engineering judgement.

(2) The existence of alternative special sprinkler systems incorporating new technologies is recognised (see 1.19 and 4.1.1).

(3) For the purposes of extensions and alterations of existing systems, EHH areas installed to NZS 4541:2013 are deemed to comply with this standard.

(4) This clause is not intended to allow new installations to be installed in accordance with NZS 4541:2013.

9.1.2 *Excluded commodities*

This standard does not provide design criteria for the following commodities:

(a) Limited volumes in retail or other ordinary hazard areas, flammable or ignitable liquids;
(b) Rubber tyre storage;
(c) Rolled paper storage;
(d) Waste paper storage;
(e) Baled fibre storage;
(f) Hanging garments;
(g) Carpet storage;
(h) Aerosol storage;
(i) Distilled spirits storage; and
(j) High bay records storage.

Specific designs for occupancies containing storage of such commodities shall be approved by an SSC. Guidance for designing protection systems for these commodities may be sought from the following documents (see Table 9.1 below):

Table 9.1 – Reference standards for special commodities

Commodity or occupancy	FM Global Property Loss Prevention Data Sheet	NFPA standard
Storage of flammable or ignitable liquids in portable containers	Data Sheet 7-29	NFPA 30
Occupancies using or creating ignitable liquids	Data Sheet 7-32	
Rubber tyre storage	Data Sheet 8-3	NFPA 13 section 23.8
Rolled paper storage	Data Sheet 8-21	NFPA13 section 23.9
Waste paper storage	Data Sheet 8.22	
Baled fibre storage	Data Sheet 8-7	
Hanging garments	Data Sheet 8-18	
Carpet storage	Data Sheet 8-33	
Aerosol storage	Data Sheet 7-31	NFPA 30B
Distilled spirits storage	Data Sheet 7-74	
High bay records storage		NFPA 13 section 23.12

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.2 Extra high hazard class terminology

9.2.1 *General*

The following clauses provide brief descriptions of special terms used throughout this part relating to the storage and protection of commodities. For other terms, see 1.3.

9.2.2 *Aisle*

The clear access space of greater than 600 mm, normally maintained between commodities stored in racks or on the floor. Aisle width is measured from face of upright to face of upright, or face of storage to face of storage, whichever is the lesser.

9.2.3 *Bin box storage*

A storage arrangement that typically consists of solid shelves vertically located no more than 900 mm apart in combination with solid full-height wooden or metal vertical barriers that are horizontally located no more than 1.2 m apart. There is usually a solid backing for each bin-box storage unit, but this is not always the case. The depth of a bin is typically no more than 600 mm.

9.2.4 *Clearance*

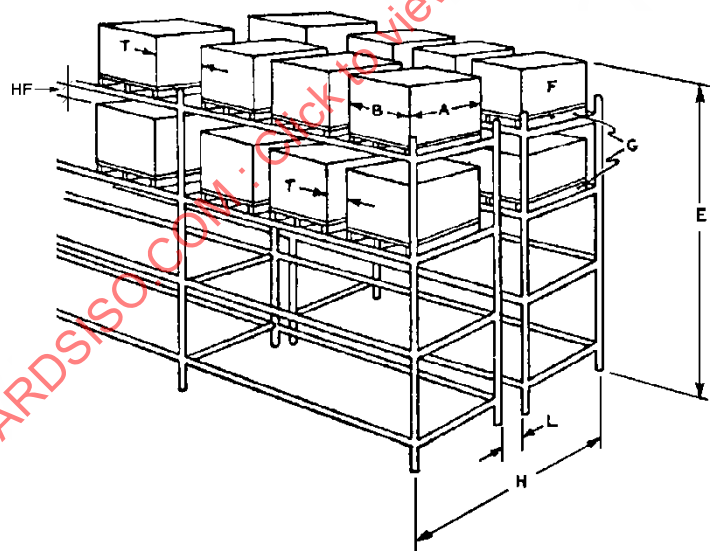
The clear space maintained between the top of storage and the deflector of the sprinkler (ceiling or in-rack) located above it.

9.2.5 *Commodity*

The combination of product, packaging material, container, and material handling aids (such as a pallet), upon which commodity categorisation is based.

9.2.6 *Double-row rack (DRR)*

A rack not exceeding 3.7 m in depth, formed by two single-row racks placed back-to-back separated by a longitudinal flue space, and separated from adjacent racks by an aisle not less than 600 mm wide (see Figure 9.1(a), (b), and (c)).



A – Load depth
B – Load width
E – Storage height
F – Commodity
G – Pallet
H – Rack depth
HF – Horizontal flue space
L – Longitudinal flue space
T – Transverse flue space

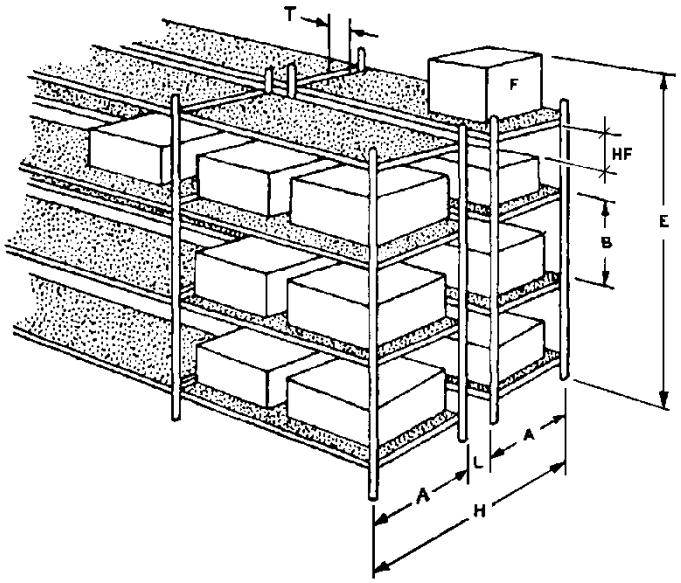
(Figure reproduced courtesy of FM Global)

Figure 9.1(a) – Double-row racks – Without solid or slatted shelves

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

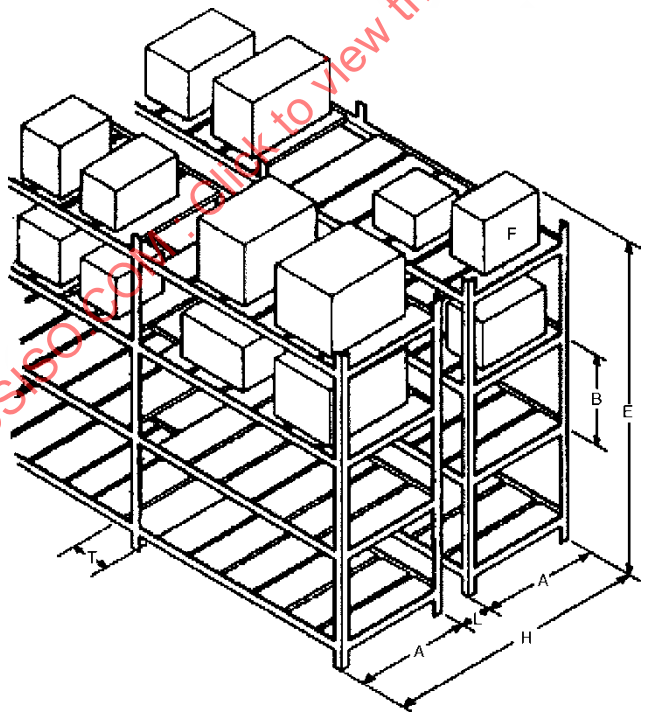
COPYRIGHT © Standards New Zealand



A – Shelf depth
B – Shelf width
E – Storage height
F – Commodity
H – Rack depth
HF – Horizontal flue space
L – Longitudinal flue space
T – Transverse flue space

(Figure reproduced courtesy of FM Global)

Figure 9.1(b) – Double-row racks – With solid shelves



A – Shelf depth
B – Shelf height
E – Storage height
F – Commodity
H – Rack depth
L – Longitudinal flue space
T – Transverse flue space

(Figure reproduced courtesy of FM Global)

Figure 9.1(c) – Double-row racks – With slatted shelves

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

9.2.7 *Draft curtain*

A non-combustible partition, bulkhead, or structure extending down at least 600 mm from the underside of the roof/ceiling which fits tightly against the underside of the roof or ceiling. The construction is required to be non-combustible and to fit tightly against the underside of the roof/ceiling. Openings created by channels in a ribbed deck are permitted; however, openings created between purlins or other structural members need to be adequately sealed. It is desirable to keep the bottom edge of the curtain relatively level. In buildings with peaked roofs, it is important to keep the bottom edge of the curtain at a constant height above floor level while the height of the upper edge varies with the roof height.

Examples of acceptable forms of draft curtain construction include the following:

(a) Structural features, such as solid beams, girders, or steel joists, extending down the minimum required distance from the underside of the ceiling/roof; and

(b) A purpose-built partition mounted on timber or steel framework, constructed of 10 mm gypsum board or 0.6 mm sheet steel.

Apertures are permitted provided that such openings are for the passage of pipes, conduits, and mechanical ductwork and are reasonably close fitting.

9.2.8 *Encapsulation*

A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity or a group of combustible commodities or combustible packages. Totally non-combustible commodities on wood pallets, enclosed only by a plastic sheet as described above, are not considered to be encapsulated.

The term ‘encapsulation’ also applies to individual cartons, which are enclosed on the top and sides in plastic, or to cartons waterproofed by coatings on the exterior surfaces. An example of a waterproof carton is one that is used to export sensitive equipment by ship and needs to be protected from the salt-laden atmosphere.

The term ‘encapsulation’ does not apply to individual plastic enclosed items inside a larger non-plastic enclosed or non-waterproofed container. If holes or voids in the plastic or waterproof cover, on the top of the carton, exceed more than one-half of the area of the top, the term ‘encapsulation’ does not apply.

NOTE – The protection design requirements in this part account for the presence of encapsulation and do not need to be adjusted.

9.2.9 *Face sprinkler*

In-rack sprinklers used to oppose vertical development of fire on the external face of the storage and simultaneously provide a water curtain between two adjacent racks to hinder fire spread across the aisle, located in transverse flue spaces along the aisle, or in the rack within a maximum distance of 460 mm from the aisle face of storage (see 9.2.24).

9.2.10 *False ceiling*

A solid continuous sub-ceiling that is installed parallel to floor level at a given vertical distance below the primary ceiling or roof. Sprinkler protection is installed under the false ceiling as specified. The purpose of a false ceiling with sprinklers installed below it is to typically address hazards that can negatively affect sprinkler performance, such as excessive clearance, excessive airflow velocities, excessive ceiling slope, or loss of the heat plume through exhaust openings at ceiling level. Design the false ceiling to withstand a minimum fire plume uplift velocity pressure of 14.4 kg/m^2. Suitable ceiling materials include minimum 10 mm plywood or gypsum board, as well as corrugated or sheet steel. If the false ceiling is made of ordinary plywood or other combustible construction, sprinkler protection shall also be needed above the false ceiling.If the false ceiling is hung from the existing roof framework, ensure the roof can withstand the additional dead load.

9.2.11 *Flue spaces*

The open spaces between rows and columns of storage. In the case of rack storage, the longitudinal flue spaces are perpendicular to the direction of loading, and transverse flue spaces are parallel to the direction of loading (see Figure 9.2). In solid-pile and palletised storage, flue spaces may run in either direction, or may be non-existent.

NOTE –

(1) Flue spaces are necessary for rack storage arrangements to allow heat from a fire to vent vertically. This allows the ceiling-level sprinklers (and in-rack sprinklers if provided) to operate as quickly as possible, as well as slowing down the horizontal fire spread within the rack. Flue spaces are also necessary to allow sprinkler water penetration down through the racks. Without sufficient water penetration to burning commodities stored on the

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

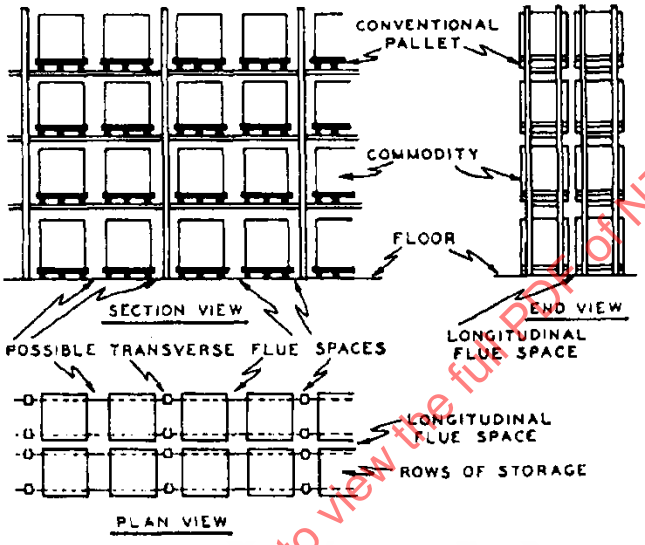
STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

lower tiers of the racks, fire control may not be achieved. Transverse and longitudinal flue spaces are required. to be a minimum net width of 75 mm and ideally 150 mm wide or more. Flue space net width is a measure of its gross width minus any horizontal obstructions, such as bracing between rack uprights located within the flue space. Except where in-rack sprinklers are provided at every tier level, all rack storage arrangements require transverse flue spaces to minimise horizontal fire spread and to allow automatic sprinkler protection to be effective. Vertical alignment of flue spaces should be maintained as closely as possible.

(2) Multiple-row rack storage, where pallet loads are butted together in one direction have a lack of longitudinal flues that allows for horizontal fire spread and creates a problem for ceiling-level sprinkler protection.

(3) Vertical fire growth develops at a faster rate within flue spaces compared to up the face of storage. Therefore, with adequate flue spaces vertical fire growth is maximised, horizontal fire spread is minimised, and sprinkler discharge has a path through which it can reach the base of storage. The situation where there are open flues at lower levels in racks that are blocked at higher level does create a severe fire protection challenge as there is a place for fire growth and spread that is shielded from sprinkler discharge. If there are longitudinal flues at any level in the rack, they need to be open and clear for the full height of the rack. A common example of this is high rack storage where lift operators cannot see precisely where the pallet loads at the top level, and the longitudinal flue can easily be blocked at that level but remain open at lower levels.



(Figure reproduced courtesy of FM Global)

Figure 9.2 – Typical double-row (back-to-back) rack arrangement

9.2.12 *Horizontal barriers (within and above racks)*

A solid barrier installed on a horizontal plane within a rack, beneath which in-rack sprinklers are installed. They are typically constructed of minimum 0.7 mm sheet metal; however, minimum 10 mm plywood can also be used. They extend to both ends and both aisle faces of the racks covering up both the longitudinal and transverse flue spaces of the rack bays in which they are installed. They are fitted to within 75 mm of any vertical rack member or other equipment that would create an opening such as vertical in-rack sprinkler pipe drops.

9.2.13 *Horizontal flue space*

An uninterrupted space in excess of 1.5 m in length between horizontal layers of storage. Such channels may be formed by pallets, shelving, racks or other storage aids, see Figures 9.1(a) to (c).

9.2.14 *Ignitable liquids*

Any liquid or liquid mixture that will burn. A liquid is defined as having the ability to burn if it has a measurable fire point.

NOTE – Ignitable liquids include flammable liquids, combustible liquids, inflammable liquids, or any other term for a liquid that will burn.

9.2.15 *Inner core sprinkler discharge pattern*

The portion of the water discharge from a sprinkler that is directed nearly straight downwards from the sprinkler deflector. The area of the inner core is generally based on a 600 mm radius from the centre of the sprinkler deflector.

9.2.16 *In-process non-rack storage (aerosols)*

Small quantities, of not more than six pallets, stored not more than one pallet load high.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.2.17 *In-rack sprinklers (also called rack storage sprinklers or intermediate level sprinklers)*

In-rack sprinklers (IRS) are typically located in the longitudinal flues, the transverse flues, or at the face of the rack. Sprinklers within flue spaces oppose vertical fire growth up through the flues. Additionally, face sprinklers (see 9.2.13) oppose vertical fire growth on the external face of storage and simultaneously provide a water curtain between two adjacent racks to hinder fire spread across the aisle.

Depending upon the location, the IRS shall be equipped with an integral water shield or fitted with a guard incorporating a shield, which shall be approved and shall be a minimum of 75 mm in diameter. The water shield prevents wetting of the operating element by water from sprinklers at a higher elevation in the rack or at the roof/ceiling. Note that the water shield is not a heat collector and has virtually no effect on how fast the in-rack sprinkler will operate.

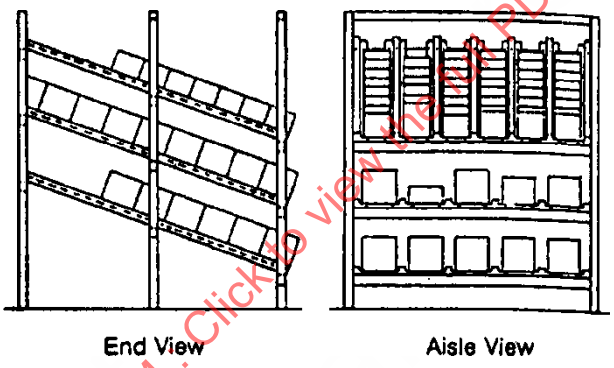
9.2.18 *Movable rack*

A rack on fixed rails or guides. They can be moved in one direction only in a horizontal two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks. Movable rack arrangements generally result in the same protection needs as for multiple-row racks.

9.2.19 *Multiple-row rack (MRR)*

A rack greater than 3.7 m deep, or a combination of single-row or double-row racks separated by aisles less than 0.6 m wide having an overall width, including flues, greater than 3.7 m. Multiple-row racks can be drive-in, drive-through, flow-through, push-back, shuttle-deposited or double-deep standard racks (see Figures 9.3(a) and (b)).

Not all MRR can be classified as open-frame racks.



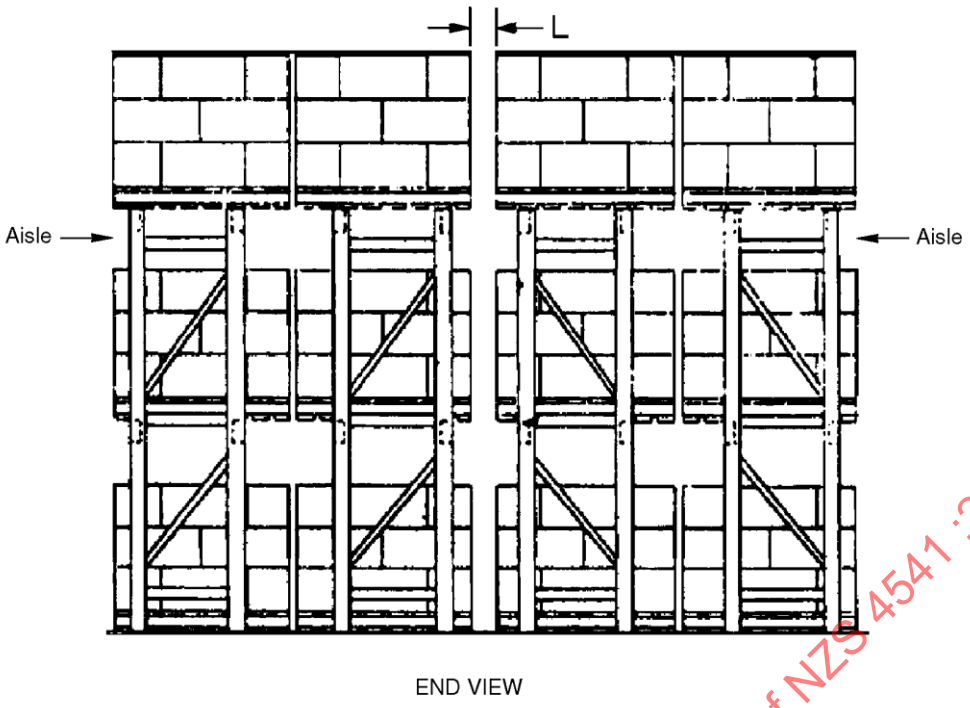
(Figure reproduced courtesy of FM Global)

Figure 9.3(a) – Multiple-row rack – Flow-through racks

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand



(Figure reproduced courtesy of FM Global)

Figure 9.3(b) – Multiple-row rack – Double deep rack, serviced by reach (forklifts) truck

9.2.20 *Open-frame rack storage*

Rack storage that is void of any solid shelves within the storage array and has adequate flue spaces to minimise horizontal fire spread and allow rapid vertical fire growth. It also allows a path for downward sprinkler water penetration throughout the height of the rack. Open-frame rack storage allows water discharge to reach all vertical surfaces of a commodity.

For rack storage to qualify as open framed it shall: Have adequate transverse flue spaces throughout the height of the rack.

Transverse flue spaces shall:

(a) Be a minimum 75 mm net, if provided between every pallet load (nominally up to 1.5 m wide) and line up vertically through the entire height of the rack; or

(b) Be a minimum 150 mm net, if provided only every other pallet load (nominally up to 3.0 m wide) and line up vertically throughout the entire height of the rack; or

(c) Be a total minimum 300 mm net, provided for each rack bay (nominally up to 3.0 m wide). In this case the flue spaces do not have to line up vertically, but the overall flue space in each rack bay must be equivalent to 300 mm between rack uprights.

Open-frame racks can be equipped with solid shelves provided the solid shelves are fixed-in-place, they are no larger than 2.0 m^2 in area, and they do not block transverse flue spaces.

The storage racks can also be provided with grated shelves as long as the grating is at least 70% uniformly open, or they can be provided with fixed-in-place solid slats. In both cases, adequate flue spaces are required to qualify as being open-framed racks.

Treat rack storage of nested or pyramided rolled fabric storage on side, or rack storage of other products that can create large shielded areas with no chance for sprinkler water penetration as rack storage having solid shelves, depending on the total area of shielding and the degree of obstruction to water penetration.

If rack storage does not meet the guidelines above for open-frame rack storage, then it shall be treated as if it has solid shelves. See 9.2.31 for the definition of solid shelves.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

9.2.21 *Open-top containers*

Containers having at least one side and open on top. Five-sided, open-top containers made of wood, cardboard, or other combustible materials which prevents water from running over the top of the container and down the flues or stops water from discharging roof/ceiling sprinklers which prevents that water from reaching the lower levels of burning storage where it is needed to either suppress or control the fire. Containers with less than five full-height sides redirect the discharged water from operating sprinklers, so that the water delivered down through the flues is not uniform. Open-top containers with non-solid sides, such as wire mesh, do not fall into this category.

Five-sided, open-top containers made of wood, cardboard, plastic, or other combustible material promote faster horizontal fire spread compared to closed-top combustible containers. Non-combustible open-top containers help promote faster horizontal fire spread if combustible containers are located below them within a storage rack.

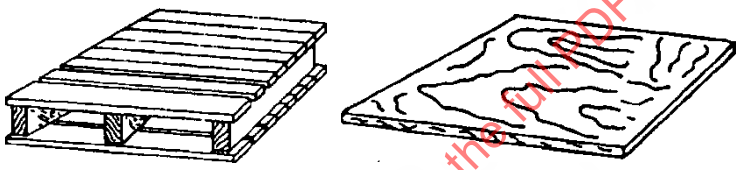
9.2.22 *Palletised storage*

The use of pallets for commodity storage. Pallet loads of storage are placed one on top of another.

9.2.23 *Pallets*

Pallets are material handling aids upon which unit loads of commodity are placed to ease the transport of commodity from place to place (see Figure 9.4). Pallets may be wood, metal or plastic. Conventional pallets have stringers to accommodate forklift trucks for handling unit loads. Slave pallets (less than 1.9 m^2) are special flat-bottomed pallets captive to a material handling system.

Idle pallets are to be protected as an uncartoned unexpanded plastic commodity.



(a) Conventional pallet (b) Slave pallet

(Figure reproduced courtesy of FM Global)

Figure 9.4 – Typical pallets

NOTE – When protecting wooden pallets, FM Global Data Sheet 8-24 may give additional design options for some storage configurations.

9.2.24 *Portable rack*

A rack not fixed in place. Portable racks can be arranged in any number of configurations, including wire baskets without solid sides and bottoms and open-top containers without solid sides but with solid bottoms. Five-sided open-top combustible containers with solid sides and bottoms are treated as open-top combustible containers. Portable rack protection needs are determined by depth of racks as applicable to single-row, double-row, and multiple-row racks (see Figure 9.5).

9.2.24.1 *Portable racks with bottoms at least 70% open*

If the portable racks are not provided with proper flue spaces between them (or with another means of allowing heat from a fire to vent vertically while at the same time water from sprinklers to penetrate down through them), fire control will not be possible. Portable racks with bottoms at least 70% open: Treat as open-frame rack storage as long as the storage within the portable rack:

(a) allows heat from a fire to vent vertically up through the portable rack;
(b) allows water to penetrate down through the portable rack; and
(c) does not absorb water.

Otherwise, treat the portable rack as having a solid bottom.

9.2.24.2 *Portable racks with solid bottoms or bottoms less than 70% open*

Portable racks with solid bottoms or bottoms less than 70% open: Limit the footprint size of a portable rack to a maximum of 2.0 m^2 and provide minimum 75 mm wide flue spaces around all sides of the portable rack. Protect such a portable rack arrangement in accordance with the guidelines for open-frame rack storage as outlined in 9.5.3. As an alternative, limit the footprint size of a portable rack to a maximum of 4.0 m^2 and equip the portable rack with three full-height, fixed-in-place, solid wooden or non-combustible sides that will

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

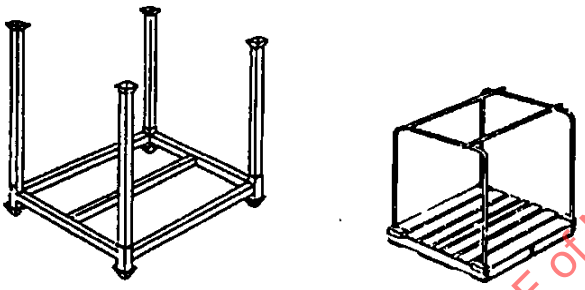
inhibit horizontal fire spread. Protect such a portable rack arrangement in accordance with the guidelines for solid-piled storage as outlined in 9.5.3.

9.2.24.3 *Non-conforming portable racks*

Treat portable racks that do not meet the guidelines in 9.2.25.1 or 9.2.25.2 as rack storage having solid shelves. Size the shelf area using the guidelines for rack storage.

9.2.24.4

If ceiling-only protection options are not available from the applicable protection table, then limit the storage area of the portable racks to a maximum of 9.3 m^2, as defined by a minimum 2.4 m wide clear space on all sides of the storage area, and limit the storage height to a maximum of 3.0 m for cartoned commodities or 1.5 m if the commodity hazard is uncartoned plastics. Base the automatic sprinkler system design requirements on the occupancy surrounding the portable storage instead of the portable storage itself.



(Figure reproduced courtesy of FM Global)

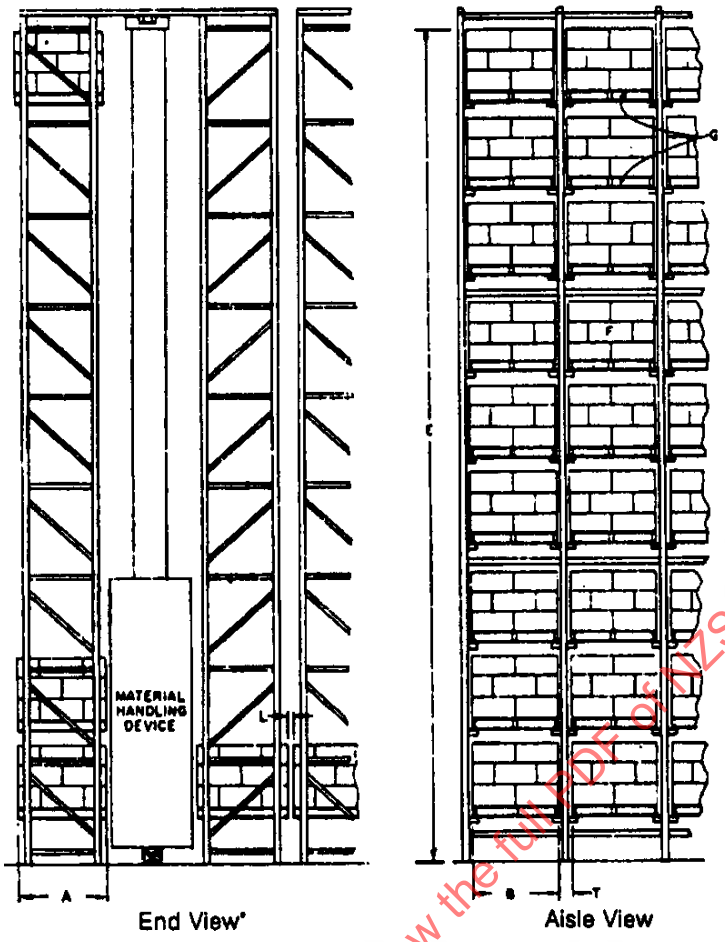
Figure 9.5 – Portable racks

9.2.25 *Rack storage*

Storage in racks that use combinations of vertical, horizontal, and diagonal members, with or without solid shelves, to support stored material. Racks may be fixed in place or portable (see Fig 9.5 for examples of portable racks.) Loading may be manual (using forklift trucks, stacker cranes, or hand placement) or automatic (using machine-controlled storage and retrieval systems) (see Figures 9.6(a) to (d)).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



A – Load depth
B – Load width
E – Storage height
F – Commodity
G – Pallet
L – Longitudinal flue space
T – Transverse flue space

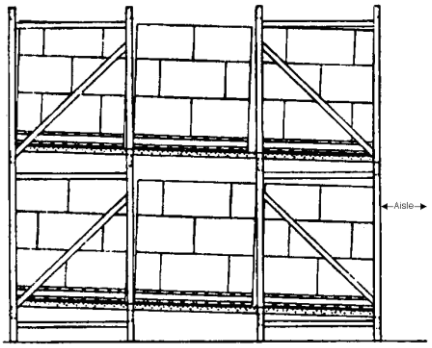
(Figure reproduced courtesy of FM Global)

Figure 9.6(a) – Rack storage – Automatic storage type rack

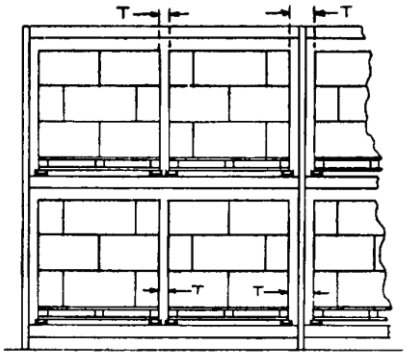
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand



End View

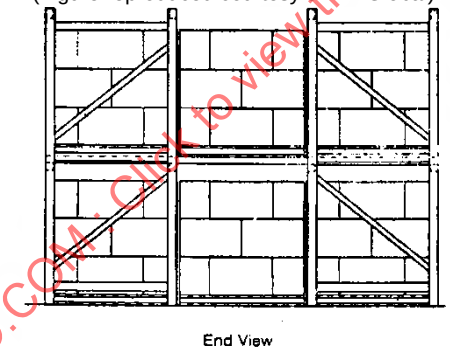


Aisle View

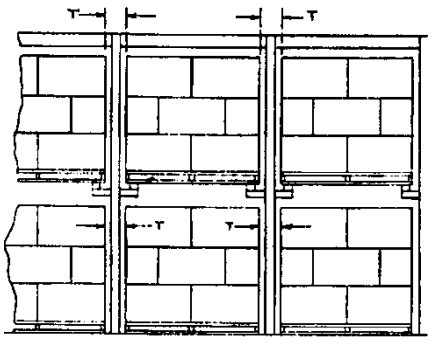
T – Transverse flue space

Figure 9.6(b) – Rack storage – Flow-through pallet rack

(Figure reproduced courtesy of FM Global)



End View



Aisle View

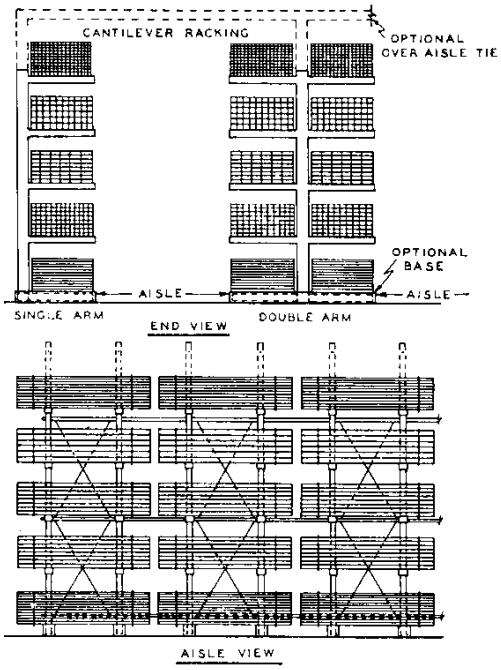
T – Transverse flue space

(Figure reproduced courtesy of FM Global)

Figure 9.6(c) – Rack storage – Drive-in rack, two or more pallets deep – Forklift truck drives into rack to deposit or withdraw loads in the depth of the rack

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



(Figure reproduced courtesy of FM Global)

Figure 9.6(d) – Rack storage – Cantilever rack

9.2.26 *Roof/ceiling sprinklers*

Sprinklers fixed to the underside of the roof structure, or in the case of suspended ceilings, the sprinklers installed at the ceiling surface.

9.2.27 *Shelf storage*

Storage on a structure where solid shelves are less than 800 mm deep, measured from aisle to aisle, are usually less than 600 mm apart vertically. Storage height is usually not greater than 3.6 m, with 800 mm aisles and should not be confused with palletised rack storage on solid shelving (see 9.2.31).

9.2.28 *Shelving, solid or slatted*

Shelving that is fixed-in-place solid, slatted, or other types of shelves located within racks. Solid shelves in racks (see Figure 9.1(b)), can promote horizontal fire spread throughout the racks and negatively impact the amount of sprinkler water that can reach the entire vertical height of the rack.

The area of a solid shelf is defined by a minimum of at least 75 mm completely open flue space vertically.

Note 125 mm flues that have 50 mm wide horizontal rack members within the space would be acceptable because at least 75 mm of the total flue space is completely open.

Racks with fixed slatted shelves (see Figure 9.1(c)), having uniform openings of at least 50%, with the maximum slat width between openings not exceeding 150 mm and with at least 75 mm transverse flue spaces at rack uprights, or at least every 3.1 m of rack length, can be treated as racks without solid shelves (see Figure 9.1(a)).

Racks with grated, mesh, or other types of shelves having uniform openings not more than 150 mm apart, comprising at least 70% of overall shelf area, and with adequate flue spaces between blocks of storage on the same rack level, can be treated as racks without solid shelves.

If specifically listed, proprietary rack shelving may be listed to allow the racks as being able to be treated as racks without solid shelves.

Racks with solid shelves of less than 1.9 m^2 and surrounded by flues of a nominal width of 150 mm but not less than 75 mm of completely open flue space vertically, with no horizontal or vertical rack members obstructing that space, can be treated as racks without solid shelves.

Multiple-row racks that have pallet loads abutting in one direction, and with transverse flue spaces on each side of each abutting row, are not considered to be rack storage having solid shelves. Racks with slats that are not fixed in place should be treated as solid shelves.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

Portable racks (see 9.2.24), having solid bottoms not exceeding 1.9 m^2, and having flue spaces at least equal to those needed for multiple-row racks, are not considered to be rack storage having solid shelves. Rack storage of nested or pyramided rolled fabric storage on side, or rack storage of other products which can create large shielded areas, with no chance for sprinkler water penetration, need to be evaluated carefully. It may be necessary to treat such storage as rack storage having solid shelves, depending on the total area of shielding and the degree of obstruction to water penetration.

9.2.29 *Single-row rack*

A rack with a depth not exceeding 1.8 m, separated from adjacent racks by an aisle not less than 1.2 m wide. Single-row racks have no longitudinal flue spaces. Single-row racks with a depth exceeding 1.8 m shall be considered as double-row racks. Single-row racks separated from adjacent racks by an aisle of 600 mm or less shall be regarded as multiple-row racks.

9.2.30 *Solid-pile storage*

On-floor storage, without pallets or other material handling devices. Unit loads are placed on top of each other leaving no vertical spaces between unit loads.

9.2.31 *Storage height*

Maximum height of storage measured from the floor to the top surface of the uppermost level of stored material.

9.2.32 *Storage sprinkler*

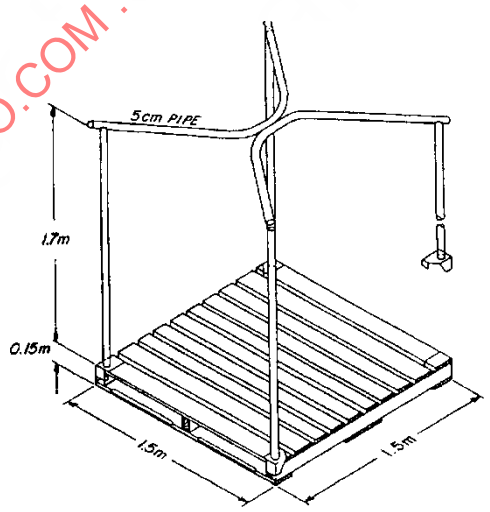
A large orifice, closed head sprinkler with either a fast response or a standard response element and designated as a ‘storage sprinkler’. Permitted for use in those portions of the building classified as EHH or OH4 as specified in Part 8 or Part 9 of this standard. Predominantly designed to achieve fire suppression without the use of in-rack sprinklers. Installation shall be in strict accordance with the listing for spacing, required pressure, distance below ceiling, storage type and method, and roof height.

9.2.33 *Tier*

Each vertical segment of storage within a rack. The term ‘tier’ is used only to define the vertical location for in-rack sprinklers when storage racks are equipped with solid shelves greater than 6.0 m^2 in area.

9.2.34 *Tyre rack (tyre storage)*

Any combination of vertical, horizontal and diagonal members that support tyres. Racks may be fixed or portable (see 9.2.24). Some portable racks use a wood pallet as the base (see Figure 9.7). Portable racks are called palletised storage in the tyre industry.



(Figure reproduced courtesy of FM Global)

Figure 9.7 – Portable rack using wood pallet base and steel frame

9.2.35 *Vertical barriers*

Solid barriers on a vertical plane within a rack extending to the entire height and depth of the rack arranged to limit horizontal fire spread.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

NOTE – Examples of acceptable vertical barrier construction materials include the following:

(1) Suitably fixed and supported sheet metal, minimum thickness 0.76 mm.

(2) Plywood, minimum thickness 9.5 mm for all commodities except in the case of idle pallets where the minimum thickness should be 19 mm.

9.2.36 *Water delivery time*

The time interval, measured in seconds, of both the trip time and the water travel time of a sprinkler system. It can also be defined as the time interval, in seconds, between the following two events:

(a) The point in time when the most hydraulically remote sprinkler on a dry-pipe, pre-action, or similar type of sprinkler system equipped with an automatic system valve opens; and

(b) The point in time when pressure at the most remote sprinkler reaches or surpasses the design pressure for the sprinkler system.

9.3 General system design requirements

9.3.1 *General*

Before selecting one of the protection options in this section for either a new building or a building being retrofitted with a new protection system, consider possible future changes in storage arrangements, available water supplies, and/or commodity hazards. Also consider the susceptibility of the occupancy to non-thermal (smoke and water) damage. If ceiling-only protection options are available, consider protecting to the highest commodity hazard that the ceiling height and the available water supply will allow to provide as much flexibility as possible for future changes in occupancy or water supply.

Regardless of the sprinkler system protection option chosen, it is imperative to coordinate a facility's construction, occupancy, and protection details in the planning stages so they are all compatible. It is critical that no objects between the top of storage and the ceiling-level sprinklers interfere with the sprinkler's proper discharge pattern. See 9.4.1.18 for guidelines on obstructions of storage sprinklers.

9.3.2 *Wet systems*

Where there is no likelihood of freezing, EHH sprinkler systems shall be a wet type. EHH wet sprinkler systems shall comply with the requirements of 2.3.3 and this section.

9.3.3 *Antifreeze, dry systems, or pre-action systems*

EHH class dry sprinkler systems, pre-action sprinkler systems, and EHH class alternate wet and dry sprinkler systems shall comply with the requirements of 3.2.2, 3.2.3, or 3.2.4 as appropriate, and this part. EHH class dry or pre-action sprinkler systems shall also comply with the requirements of 4.4.4.2, 4.4.5 as appropriate, and this part.

Where there is a likelihood of freezing, an antifreeze (if specifically listed), dry system or pre-action type system shall be installed.

Base water demands for antifreeze solution sprinkler systems on wet-pipe systems.

Gridded pipework configurations are not permitted for EHH class dry, pre-action, or alternate wet and dry sprinkler systems.

The maximum water delivery time for all dry, pre-action, and wet and dry sprinkler systems is 60 seconds based on the operation of the hydraulically most remote sprinkler or 40 seconds based on the hydraulically most remote four sprinklers (two sprinklers on two lines).

NOTE – Water delivery times may be significantly less than the maximums stated above. Refer to the notes associated with Tables 9.14(a) to (j).

9.3.4 *Storage occupancies*

9.3.4.1 *General*

EHH storage occupancies are those with combustible goods stored to a height which, considering the burning characteristics of the material and the manner of storage, will generate exceptionally intense fires with a high rate of heat release.

The design criteria for EHH storage occupancies therefore depends on the combustibility of the materials and the height and manner of storage as well as the building height and the characteristics of the sprinkler heads.

EHH storage occupancies are those in which storage exceeds the limits for various types of combustible commodity that are permitted for ordinary hazard (including limits for 'incidental storage' of such types) – see 2.3.2.7. Combustible commodities are subdivided as follows:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(a) Categorised commodities, including rack storage, solid pile, palletised, shelf and bin box storage of commodity Categories 1 to 6 (Categories 5 and 6 include plastics);
(b) Special commodities including roll paper, rubber tyres, hanging garments, baled fibres and waste paper, carpet, and aerosols.

See Appendix H for categorised and special commodity listings (Table H1), and 2.3.3 and the remainder of Part 9 for sprinkler design requirements.

9.3.4.2 *Mixed commodities*

Except where the provisions of this clause are met, mixed commodity storage shall be permitted where all the following are met:
(a) Up to pallet load of a higher commodity shall be permitted to be present to be stored for every 400 m^2 of the storage compartment's area.
(b) The higher hazard commodity shall be randomly dispersed with no adjacent loads in any direction, including diagonally.
(c) Where the ceiling protection is based on Category 1 to 3 goods, the allowable number of pallet loads shall be 1 for every 800 m^2 of the storage compartment's area.

C9.3.4

Storage fires tend to be very severe. In solid blocks of storage, a fire typically develops on an exterior face of the pile and travels upward, spreading out in a fan-shaped pattern.

Not only does the fire at the base pre-heat the material above to prepare it for burning, but the radiant heat from this flame usually comes in contact with a parallel, vertical surface in nearby storage, preparing it too for burning. Eventually, the surface ignites. Once the fire is established in both parallel vertical surfaces, the radiation and re-radiation of heat between the surfaces results in a fast developing, very severe fire. The rapidly rising air column makes penetration by roof/ceiling sprinkler water very difficult. This face-fire development depends on the surface material. For example, it is almost as rapid and intense on paper bags containing empty steel cans as it is on cartons of combustibles. However, fire duration depends mostly onthe materials within the containers.

Generally, the larger the spaces within a pile the more severe the fire because of the availability ofcombustion air. Conversely, the more a pile is closed, the less severe the fire will be. The fire intensity also increases with pile height.

The severity can be further enhanced by horizontal spaces, such as those between rack levels. This space allows the fire to burn from one aisle to another and also shields the fire from sprinkler water applied from above.

The more stable a pile is, the more severe the fire will be because surfaces are held in a position that is ideal for burning. Conversely, early pile collapse usually contributes to fire control.

Rack storage adds further complications. It exaggerates the above phenomena, usually increases the number of burning surfaces, allows for adequate combustion air and holds the combustibles in a stable arrangement that is ideal for burning. Sprinkler water has difficulty penetrating through narrow vertical spaces in racks.

The narrower and higher the space, the less penetration can be expected. The overall result is a persistent fire that needs manual assistance with small hose streams for control and mop-up operations.

A bin box-storage fire usually will spread up the open face and into the bins. Even though the fire inside the box is shielded from sprinkler water, adequate water will confine the fire to the boxes until manual aid arrives. Shelf storage will behave similarly.

Metal and fire resistant-treated wood pallets may retard initial fire development. However, after the fire is established, it continues in about the same way as fire in material on untreated wood pallets.

The severity of the fire, of course, depends on the material burning. Generally, plastics and synthetics tend to burn more furiously than natural or ordinary combustibles.

9.3.5 *Process occupancies*

Process occupancies involve processes, materials, and particular types of storage likely to develop into rapidly and intensely burning fires. Such occupancies may have scattered but small amounts of in-process storage.

See 2.3.4 for categorisation of process occupancies and Table 9.2 for sprinkler system design criteria.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.2 – Design density and design area for process occupancies

Occupancy	Design density (mm/min)	Design area (m^2)
Aircraft engine testing	10.0	260
Aircraft hangars (1)	7.5	Zone protection (deluge system)
Celluloid manufacturers and celluloid goods manufacturers	12.5	260
Coal fired energy plants	10.0	260
Distilleries (still houses)	12.0	260
Electrical/electronic manufacturing and assembly (predominantly plastic components)	7.5	260
Exhibition halls (ceilings greater than 18 m and high concentration of combustibles)	12.0	360
Firelighter manufacturers (2)	10.0	260
Firework manufacturers	10.0	Complete deluge protection required for each building
Flammable liquid spraying	12.0	260
Floor cloth and linoleum manufacturers	7.5	260
Foam plastics goods manufacturers and processing	12.0	260
Foam rubber goods manufacturers and processing	12.0	260
LPG bulk storage tanks	10.0	Entire exterior of tank
Paint and varnish works (solvent based) (2)	7.5	260
Plastics goods manufacturing and process works (where plastic is one of the basic materials in the operation)	12.0	260
Resin and turpentine manufacturers (2)	7.5	260
Theatrical scenery store	10.0	260
Tar distillers (2)	10.0	260
Heavy vehicle repair workshops	10.0	260

NOTE –

(1) A suitable alternative design approach to the protection of aircraft hangars is provided in NFPA 409.

(2) Supplementary protection by high or medium velocity sprayers, as appropriate, will be required in these occupancies in areas where solvents or other flammable liquids are stored or handled (see 2.3.5).

9.3.5.1 *Design densities and areas for process occupancies*

For EHH process occupancies, design densities and design areas shall be as given in Table 9.2.

General design requirements (such as type, temperature rating, area coverage, and spacing) for roof/ceiling-level sprinklers, shall be in accordance with 9.4.1.

9.3.5.2 *General design requirements for process occupancies*

For process occupancies, sprinklers shall be located in accordance with the requirements of Part 5.

Roof/ceiling sprinklers for process occupancies shall have nominal temperature rating of at least 93°C for standard sprinklers or a temperature rating in accordance with the requirements of a selected general or non-storage sprinkler defined by *K* factor.

NOTE – When selecting sprinklers for process occupancies the following shall be considered:

(1) Control mode sprinklers defined by *K* factor may be used in accordance with the manufacturer's listed data to meet the design density of this standard.

(2) In some instances, reduced temperature ratings may achieve the same sprinkler performance. Selection of the lower temperature rating also depends upon installation requirements.

9.3.5.3 *Spacing of roof/ceiling sprinklers for process occupancies*

The spacing of 15 mm or 20 mm orifice standard spray type, or extra-large orifice roof/ceiling sprinklers for process occupancies, shall be in accordance with the following requirements:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(a) The maximum distance between sprinklers along range pipes and between adjacent rows of sprinklers shall be 3.7 m;
(b) The minimum distance between any two adjacent sprinklers shall be 2 m;
(c) The distance of roof/ceiling sprinklers from walls or partitions shall not exceed half the design spacing; and
(d) The spacing of control mode roof/ceiling sprinklers defined by *K* factor for process occupancies or categorised commodities shall be in accordance with their specified approval listing and spacing requirements.

9.3.5.4 *Maximum area coverage for roof/ceiling sprinklers for process occupancies*

The area covered by each sprinkler shall be defined by lines drawn midway between adjacent sprinklers at right angles to the line joining the sprinklers and by the perimeter of the area covered.

For process occupancies, the maximum area coverage per roof/ceiling sprinkler of 15 mm or 20 mm orifice standard spray type, extra-large orifice or control mode sprinklers defined by *K* factor shall be in accordance with Table 9.3.

Table 9.3 – Maximum area coverage per roof/ceiling sprinkler

Design density for design area (mm/min)	**Maximum area of coverage** (m^2)
Up to 10	12.0
Greater than 10	9.3

Sprinklers with a *K* factor of 8 shall only be used for densities of up to 10 mm/min.

Sprinklers with a *K* factor of 11.5 shall only be used for densities of up to 15 mm/min.

9.3.5.5 *Spacing of sprinklers for special commodities*

The spacing of sprinklers for special commodities shall be in accordance with the requirements as specified for the particular special commodity.

9.3.6 *Extension of higher hazard into lower hazard*

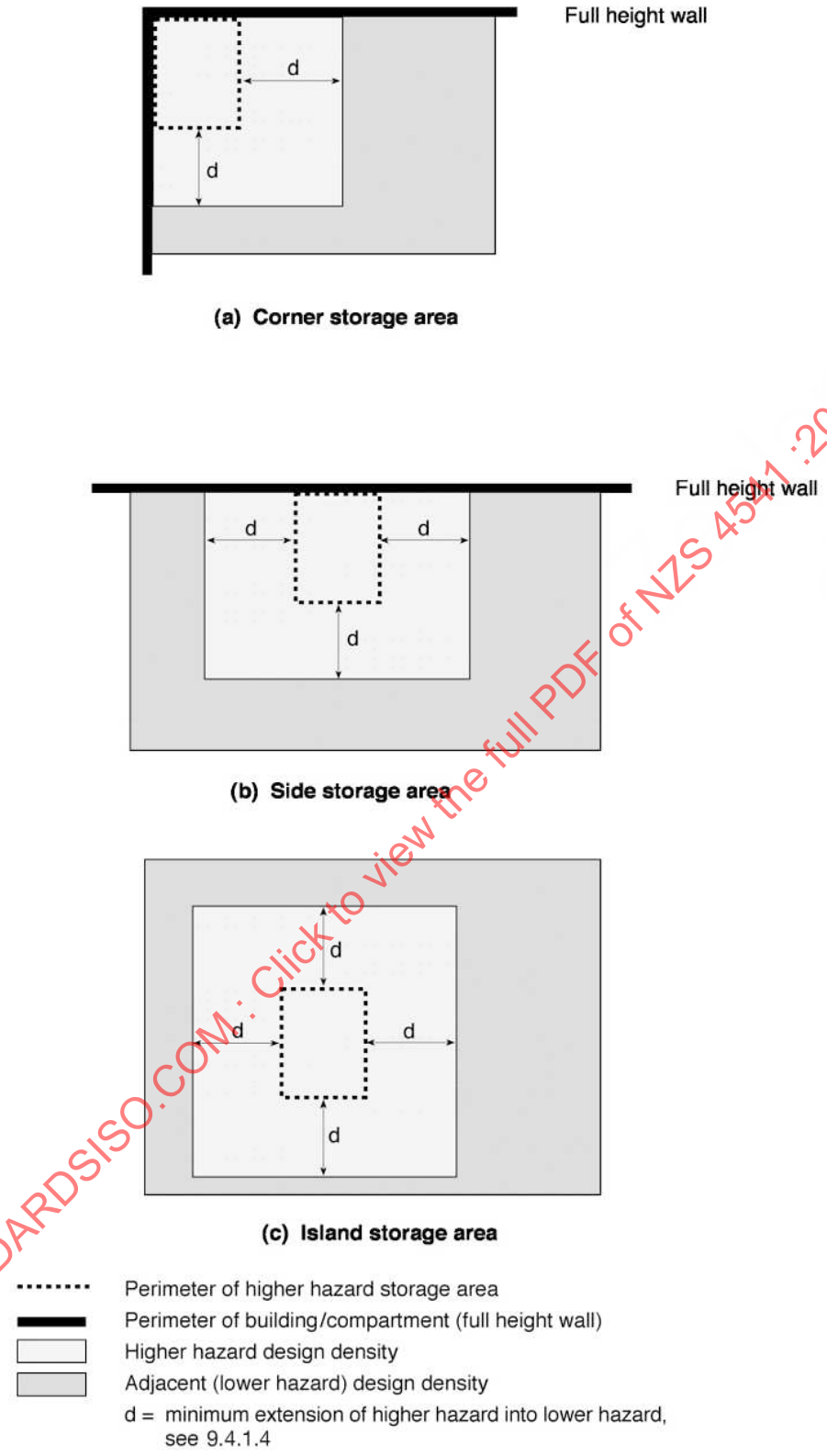
Where ceiling sprinklers have the same RTI, temperature rating and *K* factor, and where two adjacent areas within the same compartment are protected to requirements of differing design criteria, the design for the higher hazard shall be extended into the lower hazard area at least 4.6 m beyond the perimeter of the higher hazard area, or to a full height wall. See also 9.3.6.

Where an area of higher hazard is surrounded by a draft curtain and a clear aisle of 3.0 m is kept, centrally located below curtain board, then differing RTI and temperature ratings and *K* factor can be used without extending the area of higher hazard protection.

Figure 9.8 details several typical EHH class storage arrangements with adjacent areas of differing design requirements.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



(Figure reproduced courtesy of FM Global)

Figure 9.8 – Examples of adjacent areas with differing design criteria

9.3.7 *Hydraulic calculation for mixed hazard classifications*

Where two adjacent areas within the same building are protected to requirements of differing design criteria, the effect of one type of protection on the other shall be carefully analysed to ensure that the greatest hydraulic demand on the system is established. Hydraulic analysis shall include moving the boundaries of

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

the design area by one sprinkler along the length of range pipes, progressively, in each direction, until the area of greatest hydraulic demand has been established.

NOTE – This procedure is commonly known as peaking.

Hydraulic calculations shall incorporate the requirements of 9.3.5 (4.6 m extension of higher hazard into lower hazard), and any group of four adjacent sprinklers within this 4.6 m zone which fall within the design area shall discharge at a flow rate appropriate to the higher density.

Regardless of the number and mixture of sprinklers meeting differing design criteria within each of the areas of operation being analysed, the following requirements shall apply:

(a) The design area for each hydraulic analysis shall be the greater of the two occupancy classification design requirements;
(b) Hydraulic calculation methods and the shape of the design area in each hydraulic analysis shall be in accordance with the requirements of Part 10; and
(c) The flow rate for any group of four adjacent sprinklers within the design area shall be not less than that required to maintain the minimum density appropriate to the occupancy classification of each of the two adjoining areas.

9.3.8 *Air handling plant*

For EHH risks, unless engineering analysis states otherwise, the air handling plant shall be automatically shut down on detection of fire.

9.4 General installation requirements, EHH

9.4.1 *Roof/ceiling sprinklers, EHH sprinkler systems*

9.4.1.1 *Acceptable and non-acceptable sprinkler types*

Roof/ceiling sprinklers for storage occupancies shall be listed storage sprinklers with a *K* factor of *K*16 or higher.

The following sprinklers are not acceptable as ceiling-level storage sprinklers:

(a) *K*11.5 and smaller orifice sprinklers;
(b) On-Off type sprinklers;
(c) ECLH type sprinklers; and
(d) ECOH type sprinklers.

Roof/ceiling sprinklers for process occupancies, shall be 15 mm or 20 mm orifice standard spray type, or ordinary (non-storage) sprinklers defined by *K* factor and type (for example, standard spray, extended coverage, or sidewall) as appropriate to the sprinkler listing.

Roof/ceiling sprinkler types for special commodities shall be in accordance with the requirements as specified for the particular special commodity.

9.4.1.2 *Temperature ratings, K factor, orientation, and RTI*

Roof/ceiling storage sprinklers for categorised commodities shall have a nominal temperature rating of 68°C unless indicated otherwise in this section. Use 93°C nominal temperature rated sprinklers when the ambient temperature will exceed 38°C and treat them the same as 68°C rated sprinklers for design purposes.

Temperature ratings for special commodities shall be in accordance with the requirements for the particular special commodity.

Use 141°C nominal temperature rated ceiling-level sprinklers in dry-pipe and refrigerated area systems.

9.4.1.3 *Location and orientation*

For categorised commodities, sprinklers shall be located in accordance with the requirements of Part 5.

For special commodities, sprinklers shall be located in accordance with the requirements of Part 5 unless otherwise specified for the particular commodity.

Install upright storage sprinklers so their frame arms are parallel to the range pipes.

Install storage sprinklers so their deflector is parallel to the floor except in the following circumstances:

(a) The deflector of the sprinkler can be installed parallel to the ceiling if the ceiling slope is 10° or less; and
(b) For slopes > 10° if installation parallel to the floor results in an obstructed umbrella pattern, install sprinklers parallel to the ceiling and provide protection as if there was excessive clearance (building height greater than tables allow) or choose a design that incorporates in rack sprinklers (see 9.4.1.4).

9.4.1.4 *Ceiling slope*

Storage sprinklers shall be installed under sloped ceilings as indicated in Table 9.4.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

For ceiling slopes that exceed the maximum indicated in Table 9.4, do one of the following:

(a) Install a flat, continuous false ceiling (see 9.2.14 for definition) over the affected area and for 4.6 m beyond in all directions. Provide sprinkler protection beneath the false ceiling based on the occupancy or commodity hazard;

(b) Install a flat, continuous false ceiling (see 9.2.14 for definition) over the affected area and for 1.2 m beyond in all directions terminating at a draft curtain. Provide sprinkler protection beneath the false ceiling based on the occupancy or commodity hazard; or

(c) Protect the storage racks based on the presence of excessive clearance as outlined in 9.5.4, if the affected occupancy is rack storage.

For ceilings with a slope greater than 5°, locate sprinklers within 900 mm of a ceiling's peak, measured horizontally along the slope of the ceiling.

Table 9.4 – Storage sprinklers under sloped ceilings

Sprinkler type	IRS provided?	Acceptable ceiling slope
Quick response	Yes or No	Up to 10°
Standard response	No	Up to 10°
	Yes	Up to 20°

If existing buildings are being retrofitted with sprinklers, and it is not possible to meet the requirements of Table 9.4, a specific design shall be submitted to the SSC, who may accept this, based on an 'as nearly as is reasonably practicable' approach.

9.4.1.5 *Linear and area spacing requirements for categorised commodities*

For categorised commodities ceiling-level 'storage' sprinklers shall be installed in accordance with the linear and area spacing requirements in Table 9.5, unless indicated otherwise in this section.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.5 – Spacing of ceiling-level storage sprinklers

Ceiling height (m)	Sprinkler *K* factor	Sprinkler orientation	Sprinkler response	Sprinkler linear spacing (m)		Sprinkler area spacing (m^2)	
				Min.	Max.	Min.	Max.
Up to 9.1	16	Pendent or upright	Quick or standard	2.4	3.7	7.4	9.3
	20 24 28 32 36	Pendent	Quick or standard	2.4	3.7	6.0	9.3
		Upright	Quick	2.4	3.7	6.0	9.3
			Standard	2.4	3.7	7.4	9.3
	36EC	Pendent or upright	Quick	3.1	4.3	9.3	18.2
Over 9.1	16	Pendent or Upright	Quick or standard	2.4	3.1	7.4	9.3
	20 24 28 32 36	Pendent or upright	Quick	2.4	3.1	6.0	9.3
			Standard	2.4	3.1	7.4	9.3
	36EC*	Pendent or upright	Quick	3.1	3.7	9.3	13.4

NOTE –

(1) * If the *K*36EC sprinkler is supplemented with in-rack sprinklers in accordance with this standard, then the maximum linear spacing can be increased to 4.3 m and the maximum area spacing can be increased to 18.2 m^2.

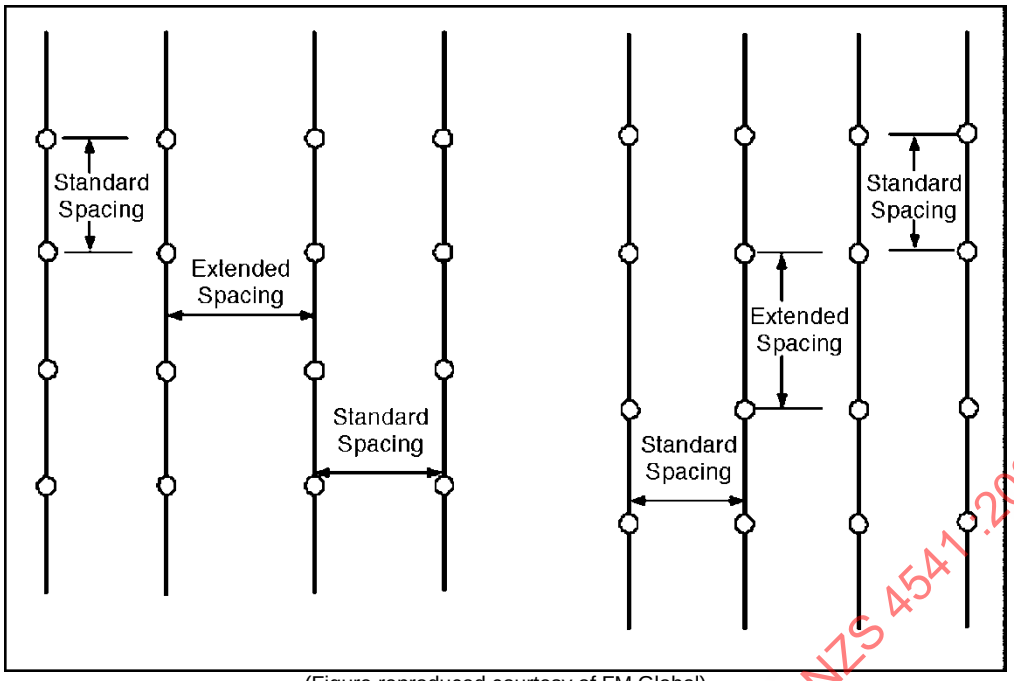
(2) Linear sprinkler spacing is measured horizontally.

The maximum linear spacing of a storage sprinkler, as well as its maximum area spacing, can be increased by 0.3 m and 1.4 m^2, respectively, to avoid obstructing sprinkler discharge as required by 9.4.1.18 (also see Figure 9.9).

NOTE – The extension in storage sprinkler spacing outlined above applies only to a maximum of two adjacent sprinklers on the same range pipe, or a maximum of two adjacent range pipe.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



(Figure reproduced courtesy of FM Global)

Figure 9.9 – Maximum increase in linear and area spacing to avoid obstructing sprinkler discharge

9.4.1.6 *Horizontal distance from walls to storage sprinklers*

Install storage sprinklers horizontally from walls, measured perpendicular to the wall, as follows:
(a) Minimum horizontal distance – 100 mm; and
(b) Maximum horizontal distance – 50% of the recommended maximum linear spacing of the sprinkler.

9.4.1.7 *Vertical distance from the ceiling to storage sprinklers*

Vertical distance is measured perpendicular to the floor, between the centre line of the sprinkler's thermal element to the underside of the roof or ceiling. Install storage sprinklers so the centre line of the sprinkler's thermal sensing element is positioned vertically as follows.

The minimum vertical distance below ceiling shall be:
(a) Smooth ceiling – 50 mm; or
(b) Non-smooth ceiling –100 mm.

The maximum vertical distance below ceiling shall be:
(c) Standard response sprinklers or extended-coverage sprinklers – 300 mm;
(d) Quick response sprinkler less than or equal to *K*24 – 330 mm; or
(e) Quick response sprinkler greater than or equal to *K*32 – 425 mm.

Exception for quick response or standard response storage sprinklers: Quick response storage sprinklers are not necessary in every channel bay formed by obstructed ceiling construction and can have a maximum spacing of 9.3 m² when the following criteria are met:
(f) Combustible and non-combustible solid structural members extend up to a maximum of -300 mm from the underside of the ceiling; and
(g) The sprinklers are located below the bottom of the structural members.

Exception for standard response storage sprinklers: Standard response storage sprinklers are not necessary in every channel bay formed by obstructed ceiling construction and can have a maximum spacing of 9.3 m² when one or more of the following criteria are met:
(h) Combustible and non-combustible solid structural members extend more than 300 mm from the underside of the ceiling, form channel bays not exceeding 28 m² in area, and are horizontally separated by less than 900 mm on centre;
(i) Combustible solid structural members extend from more than 300 mm up to 525 mm from the underside of the ceiling and form channel bays not exceeding 28 m² in area;
(j) Non-combustible solid structural members extend from more than 300 mm) up to 525 mm from the underside of the ceiling and form channel bays not exceeding 28 m² in area; or
(k) Non-combustible solid structural members form channel bays that exceed 28 m² in area but have horizontal separation between 900 mm and 2.3 m on centre.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

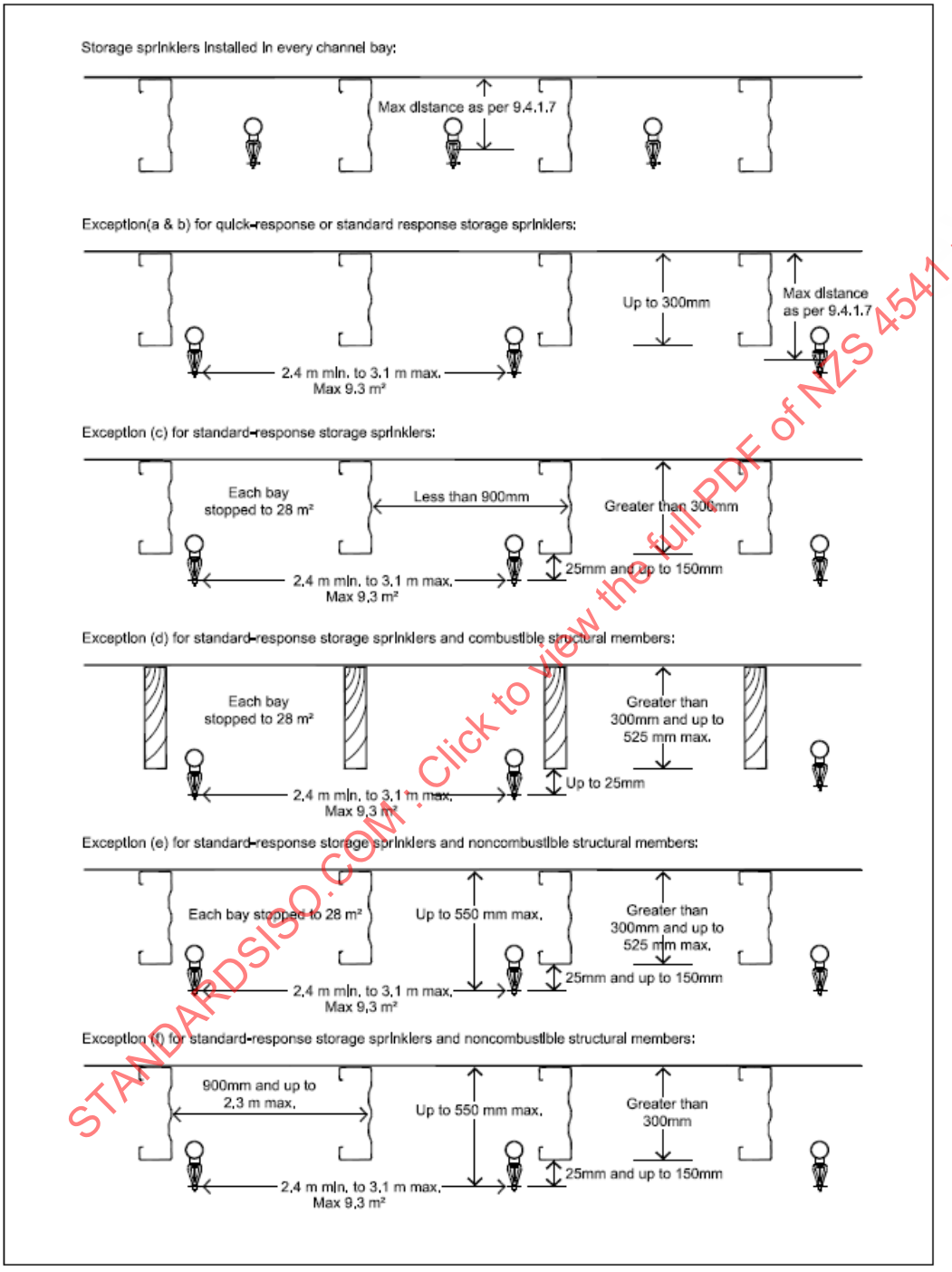
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

For exception (h), vertically install the centre line of the sprinkler's thermal sensing element from 25 mm to a maximum of 150 mm below the underside of the solid structural member.

For exception (i), vertically install the centre line of the sprinkler's thermal sensing element a maximum of 25 mm directly below the underside of the solid structural member.

For exceptions (j) and (k), vertically install the centre line of the sprinkler's thermal sensing element a maximum of 550 mm below the underside of the ceiling as well as on a horizontal plane from 25 mm to a maximum of 150 mm below the bottom of the solid structural member.



(Figure reproduced courtesy of FM Global)

Figure 9.10 – Location of sprinklers under non-smooth ceilings

9.4.1.8 *Minimum pressures for ceiling-level storage sprinklers*

The sprinkler system designs in this part for ceiling-level sprinklers are based on an indicated minimum operating pressure for a given sprinkler *K* factor. As a result, base the minimum required ceiling-level

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

sprinkler pressure on the value indicated in the applicable protection table (Tables 9.14(a) to (j)) for the commodity hazard, storage arrangement, and ceiling height involved.

9.4.1.9 *Mixing different ceiling-level storage sprinklers within the same protected area*

Do not mix the following types of sprinklers on the same sprinkler system protecting the same hazard area:

(a) Storage, non-storage, and special protection sprinklers;
(b) Sprinklers having different *K* factors;
(c) Sprinklers having different orientation;
(d) Sprinklers having different nominal temperature ratings;
(e) Sprinklers having different nominal RTI values; or
(f) Sprinklers having different linear and/or area spacing requirements (for example, extended-coverage and non-extended-coverage sprinklers).

Exception 1: Install individual sprinklers having a higher-temperature rating as needed based on ambient temperature conditions (such as near unit heater outlets). Ensure the higher-temperature sprinklers are of the same make, model, type, *K* factor, RTI, and orientation as the lower-temperature sprinklers.

Exception 2: An upright sprinkler may be substituted for an obstructed pendent sprinkler provided it has the same *K* factor, nominal temperature rating, nominal RTI, and recommended sprinkler spacing as the pendent sprinkler and is compatible for the occupancy hazard.

Exception 3: Sprinklers installed under lower ceilings are not considered 'on the same system'. See requirements in 9.4.1.19 if the lower ceiling is open-grid, or 9.4.1.20 if the lower ceiling is solid.

Exception 4: When two different occupancy hazards are adjacent to each other and are not separated by a wall or draft curtain, extend the design of the sprinkler system protecting the higher-hazard occupancy a minimum of 4.6 m in all directions beyond the perimeter of the higher-hazard occupancy area. For a sprinkler system protecting a storage occupancy, install ceiling-level storage sprinklers having the same *K* factor, orientation, RTI rating, and temperature rating throughout the sprinkler system, whenever possible.

NOTE – See 9.4.1.19.2 for requirements on the mixing of pendent and upright sprinklers on the same ceiling-level sprinkler system for the purpose of eliminating obstruction to sprinkler discharge.

Do not mix sprinklers having different RTI ratings (that is, quick response and standard response) on the same ceiling-level sprinkler system within the same protected area unless a clear delineation between the area protected by quick response sprinklers and the area protected by standard response sprinklers can be provided. When mixing quick response and standard response sprinklers at ceiling-level cannot be avoided, a draft curtain is needed:

(a) When the roofs over the two areas are at the same elevation; or
(b) When the quick response ceiling-level sprinklers are at a higher elevation than the standard response ceiling-level sprinklers.

9.4.1.10 *Steel column protection*

Adhering to the design guidelines in Part 9 eliminates the need for both building column and overhead steel protection.

9.4.1.11 *Draft curtains*

Install draft curtains to:

(a) Separate areas protected by quick response storage sprinklers from areas protected by standard response non-storage or storage sprinklers; or
(b) Required in other areas of Part 9.

Solid beams, girders, or other structural features that meet the criteria in 9.2.10 can be considered the equivalent of a draft curtain. Extend the draft curtain at least 0.6 m below the ceiling and position the sprinklers horizontally from the draft curtain based on the installation guidelines as outlined in 9.4.1.5.

9.4.1.12 *Heat and smoke vents*

If smoke and heat vents are required by the fire engineering design, the preference is for manually operated ones. If the fire engineering design requires the installation of automatic smoke and heat vents, one of the following shall be provided:

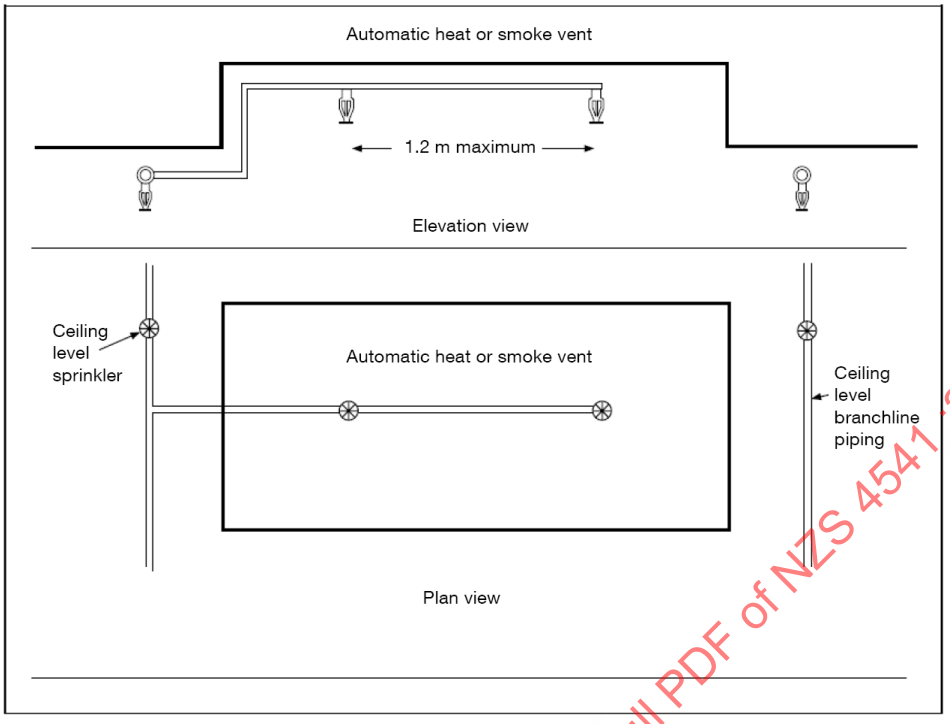
(a) Install vents equipped with a standard response 179°C nominal thermal activating device; or
(b) Install quick response sprinklers directly under the vent opening on a maximum 1.2 m linear and 1.5 m^2 area spacing. Position the centre line of the sprinkler's thermal element in accordance with the guidelines outlined in 9.4.1.7. Ensure these sprinklers have the same *K* factor and orientation as the adjacent ceiling-level sprinklers and are fed by sprinkler piping no smaller than the ceiling-level range pipes. Sprinklers located under the ceiling vent and installed as outlined above do not need to be added

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

to the hydraulic design of the ceiling sprinkler system. See Figure 9.11 for a diagram of this arrangement.



(Figure reproduced courtesy of FM Global)

Figure 9.11 – Quick response sprinklers installed under automatic smoke and heat vents

9.4.1.13 *Exhaust openings at ceiling level*

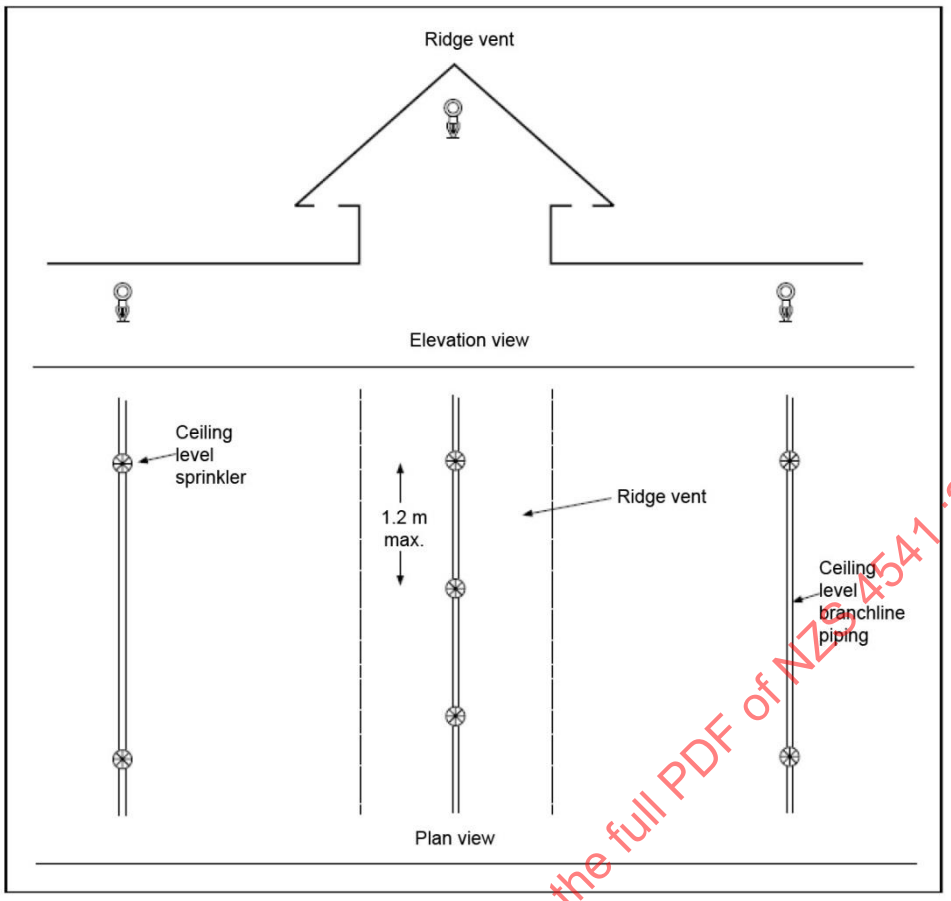
Arrange openings at ceiling level, such as exhaust and ridge vents, to close automatically upon early fire detection (before first sprinkler operation). If this is not possible, do one of the following:

(a) Install a false ceiling (see 9.2.14) under the ceiling opening. Ensure the false ceiling is, at a minimum, the same size as the ceiling opening, and install sprinklers below the false ceiling using the same range pipe size and sprinkler spacing installed at ceiling level. Sprinklers located under the false ceiling and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system; or

(b) Install quick response sprinklers directly under the ceiling opening on a maximum 1.2 m linear and 1.5 m^2 area spacing. Ensure these sprinklers have, at a minimum, the same *K* factor and orientation as the adjacent ceiling-level sprinklers and are fed by sprinkler piping no smaller than the ceiling-levelrange pipes. Sprinklers located under the ceiling opening and installed as outlined above do not need to be added to the hydraulic design of the ceiling sprinkler system. See Figure 9.12 for this arrangement.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



(Figure reproduced courtesy of FM Global)

Figure 9.12 – Quick response sprinklers installed under ceiling-level exhaust devices

9.4.1.14 *Airflow velocities at ceiling-level sprinklers*

Arrange air-handling equipment (and similar devices that discharge air into a protected area) so the multidirectional airflow velocity at any ceiling-level storage sprinkler does not exceed 1.5 m/s.

If it is not possible to avoid airflow velocities in excess of 1.5 m/s at ceiling-level storage sprinklers, choose one of the following two options:

(a) False ceiling under an air vent
If the airflow velocity is due to a ceiling-level air-discharge vent, install a false ceiling under the vent and install storage sprinklers below the false ceiling using the same range pipe size and sprinkler spacing installed at ceiling level. Locate and size the false ceiling so the air velocity at the sprinklers adjacent to the false ceiling does not exceed 1.5 m/s. Sprinklers located under the false ceiling do not need to be added to the hydraulic design of the ceiling sprinkler system; or

(b) Heat/flame detection/aspirated smoke detection
Install either listed flame detection at ceiling level, or line-type heat detection within storage racks and/or at ceiling level. Arrange either type of detection system to automatically shut down the flow of air upon detector actuation.

(i) For flame detection, arrange the detection to monitor the area located within a 3.0 m radius from all affected sprinklers

(ii) For line-type detection, install the detection at the top of the storage rack structure and within all transverse flue spaces that are within a 3.0 m radius of any affected sprinkler. Install ceiling mounted linear detection based on the maximum allowable sprinkler spacing. The nominal temperature rating of the line-type detection should be as low as permissible based on ambient temperature conditions.

Install aspirated smoke detection with the sampling ports not exceeding the heat detection spacing defined in NZS 4512. Where the air handling system has an air return grille or plenum, additional ASD sampling ports shall be installed at these locations. Follow the manufacturer's guidelines for obscuration levels to provide the appropriate settings for initiating shutdown of air flow.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

9.4.1.15 *Automated goods handling systems*

All automated goods handling systems shall stop be stopped immediately on activation of a sprinkler head, manual call point, or other fire protection system that will generate a fire signal, unless approved by the SSC. A risk analysis should be carried out to assess any issues that might result from this requirement, and the risks discussed with the SSC.

9.4.1.16 *Aisle storage*

Maintain aisles located between storage racks free of combustibles.

9.4.1.17 *Maximum floor area per installation control assembly*

The maximum floor area controlled by one installation control assembly shall be in accordance with 3.2.1.4.

9.4.1.18 *Clearance between top of storage and ceiling-level sprinkler deflector*

Maintain a minimum 900 mm clearance between the top of the storage and the ceiling-level sprinkler deflectors.

Concealed spaces shall be protected in accordance with 5.10.1.

9.4.1.19 *Obstructions*

Install storage sprinklers in accordance with 9.4.1.19.1, 9.4.1.19.2, and 9.4.1.19.3 to ensure the water discharged from sprinklers is not significantly obstructed.

The two main factors affecting sprinkler system performance are:

(a) Prompt sprinkler operation; and
(b) Sufficient, unobstructed sprinkler discharge to the fire area.

A facility's construction features have a major impact on both of these critical factors. Ceiling construction has a significant effect on the performance of a sprinkler system.

9.4.1.19.1 Obstruction to umbrella discharge pattern of ceiling-level storage sprinklers

In addition to the requirements in 9.4.1, install pendent and upright storage sprinklers on standard spacing in accordance with Figure 9.13 and Table 9.6 to avoid obstructing the sprinkler's umbrella pattern. Locate objects less than 300 mm horizontally from the sprinkler above the horizontal plane of the sprinkler's deflector.

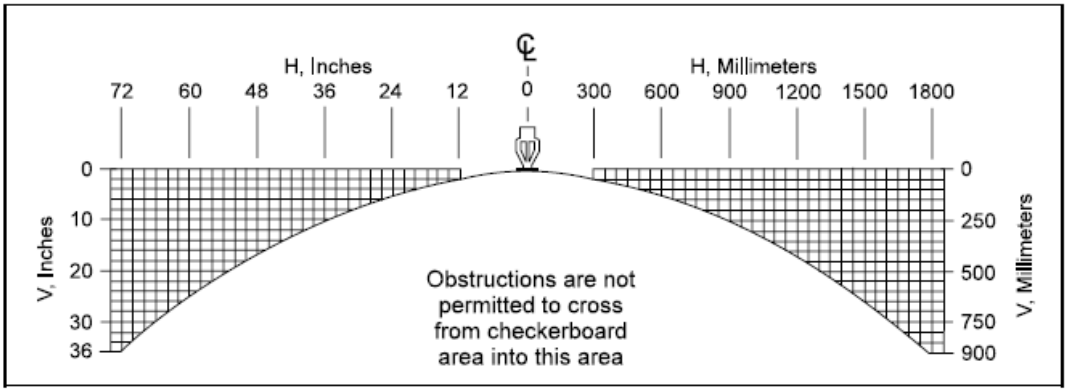
In addition to the requirements in 9.4.1, install pendent and upright extended coverage storage sprinklers in accordance with Figure 9.14 and Table 9.7. Locate objects less than 450 mm horizontally from the sprinkler above the horizontal plane of the sprinkler's deflector.

Table 9.6 – Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of storage sprinklers (not extended coverage)

Maximum vertical distance of ceiling object below sprinkler deflector (mm)	Minimum horizontal distance from sprinkler to avoid obstructing umbrella pattern (mm)
50	300
100	500
150	700
200	800
300	1000
500	1300
900	1800

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

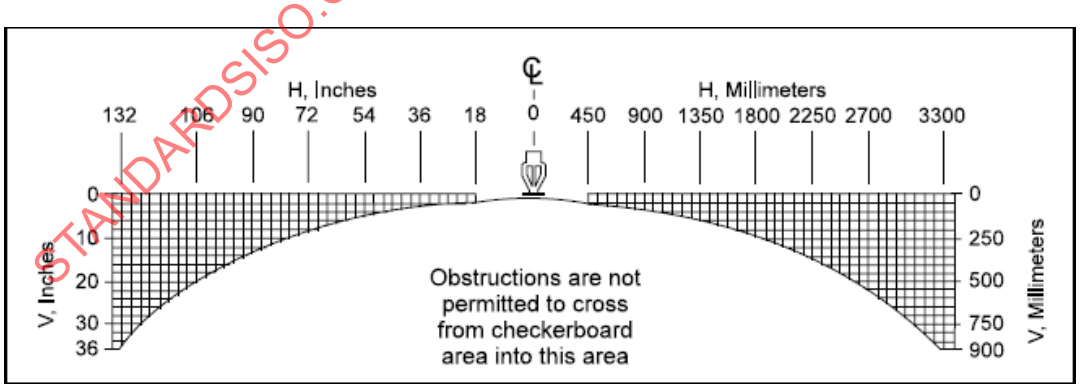


(Figure reproduced courtesy of FM Global)

Figure 9.13 – Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of storage sprinklers (not extended coverage)

Table 9.7 – Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of extended coverage storage sprinklers

Maximum vertical distance of ceiling object below sprinkler deflector (mm)	**Minimum horizontal distance from sprinkler to avoid obstructing umbrella pattern** (mm)
50	450
100	1200
150	1500
200	1800
300	2100
500	2700
900	3300



(Figure reproduced courtesy of FM Global)

Figure 9.14 – Minimum horizontal distance of ceiling objects to avoid obstructing umbrella patterns of extended coverage storage sprinklers

An object located at or near ceiling level that is entirely within the checkerboard pattern shown in Figure 9.13 or Figure 9.14 is not considered an obstruction to the sprinkler's umbrella pattern.

Any object located at or near ceiling level that extends downward into the area below the checkerboard pattern in Figure 9.13 or Figure 9.14 is deemed an obstruction to the sprinkler's umbrella pattern, except under the following conditions:

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

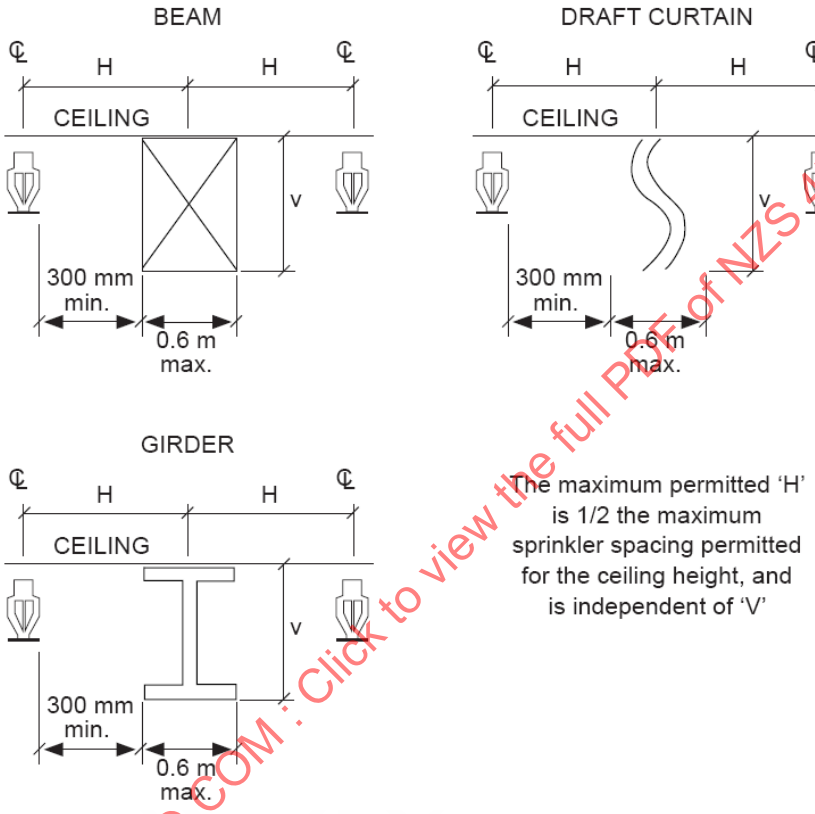
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(a) The object located at or near ceiling level is a structure member or similar that is at least 70% open; or
(b) The object located at or near ceiling level is no wider than 75 mm in its least dimension and is separated from other objects by a minimum of 300 mm.

Account for obstructions by using either of the two following methods:
(c) Relocate the obstructed sprinkler so it complies with the horizontal and vertical distances recommended in Figure 9.13 or Figure 9.14, while still meeting the installation guidelines in 9.4.1.7;
(d) Install sprinklers on both sides of the obstruction as follows (see Figure 9.15 for this arrangement):
    (i) A minimum of 300 mm horizontally from the edge of the obstruction.

For objects wider than 600 mm that would obstruct the spray distribution pattern of the sprinkler, install sprinklers as directed in 9.4.1.18.3.

NOTE – Sprinklers are not required to be at equal horizontal distances from the obstruction if they are less than half the maximum allowable spacing from the obstruction on both sides.



(Figure reproduced courtesy of FM Global)

Figure 9.15 – Obstruction to inner core discharge pattern of ceiling-level storage sprinklers

9.4.1.19.2 Obstruction to inner core discharge pattern of ceiling-level storage sprinklers

In addition to the requirements in 9.4.1 and 9.4.1.18.1, install storage sprinklers as recommended in Table 9.8 and Figures 9.17 through 9.21 to avoid the sprinkler's inner core distribution pattern being obstructed by individual objects located below the sprinklers (see 9.2.21 for a definition of an individual object).

An upright storage sprinkler can be used as a replacement for an obstructed pendent sprinkler, provided all of the following criteria are met:
(a) The upright storage sprinkler has the same *K* factor, nominal temperature rating, nominal RTI, and recommended spacing as the obstructed pendent storage sprinkler;
(b) The upright storage sprinkler is appropriate for the occupancy hazard; and
(c) The upright storage sprinkler is not considered obstructed (see Note 1 of Table 9.8).

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 9.8 – Installation guidelines to avoid obstructions to inner core distribution pattern of storage sprinklers

Width of object in least dimension	Horizontal distance from nearest edge of object to sprinkler deflector	Figure reference
Up to 20 mm	Within 300 mm either side and down to 100 mm below	Figure 9.17
Over 20 mm and up to 32 mm	Within 300 mm either side and down to 400 mm below	Figure 9.18
Over 32 mm and up to 50 mm	Within 300 mm either side and down to 600 mm below	Figure 9.19
Over 50 mm and up to 300 mm[(a)]	Within 300 mm either side and object shall be a below the top of storage and not blocking any flues	
Over 50 mm and up to 300 mm[(a)]	More than 300 mm either side and shall be a minimum 450 mm above any flue space that is parallel and directly under the object	Figure 9.20
Over 300 mm and up to 600 mm[(b)]	Within 600 mm either side and object shall be a below the top of storage and not blocking any flues	
Over 300 mm and up to 600 mm[(b)]	More than 600 mm either side and shall be a minimum 900 mm above any flue space that is parallel and directly under the object	Figure 9.21
Over 600 mm	Sprinklers are needed under the object as specified in 9.4.1.18.3	Figures 9.21 to 9.24

NOTE –

(1) Upright storage sprinklers can tolerate individual objects up to 100 mm wide located directly below them at any vertical distance. This includes 100 mm ID range pipes with 114 mm OD. See Figure 9.16.

(2) If the object is up to 600 mm wide in its maximum dimension the object shall be located a minimum 300 mm horizontally from the nearest sprinkler.

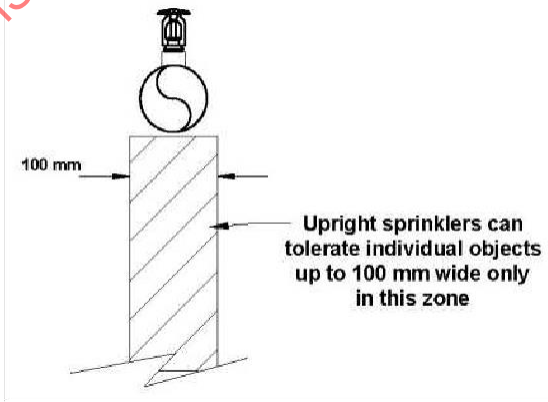
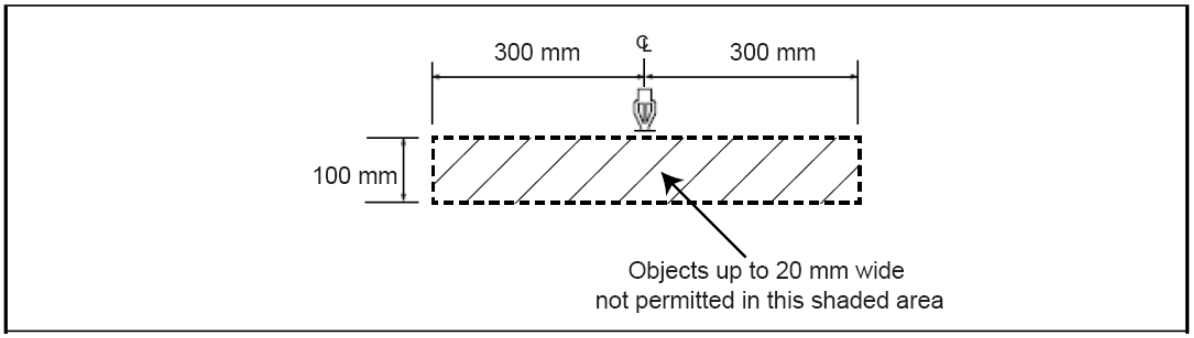


Figure 9.16 – Upright storage sprinklers can tolerate individual objects up to 100 mm wide located directly below them at any vertical distance.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

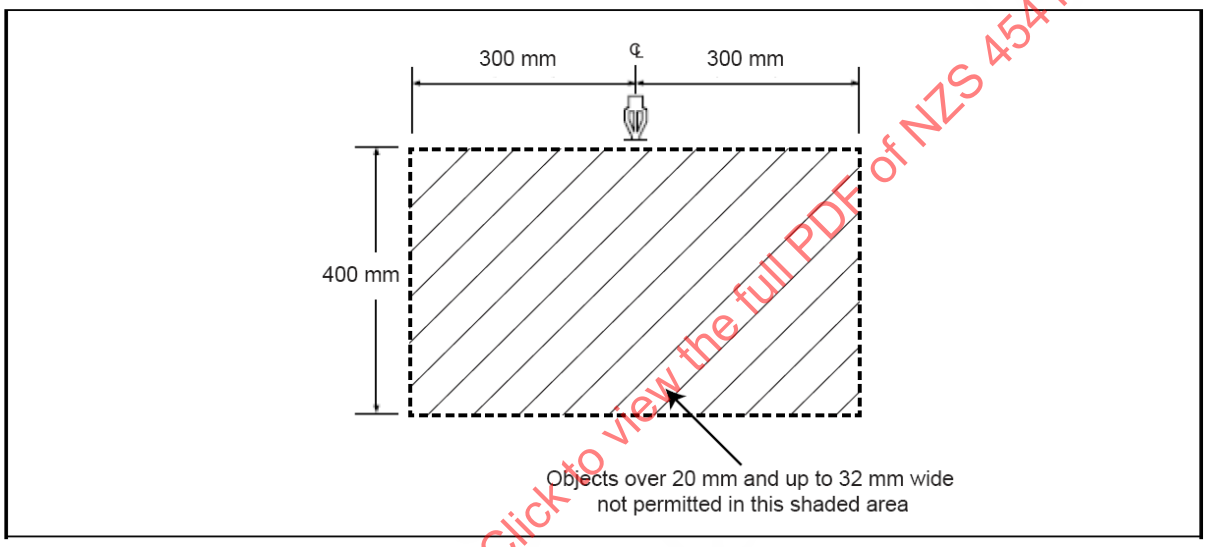
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand



(Figure reproduced courtesy of FM Global)

Figure 9.17 – Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects up to 20 mm wide

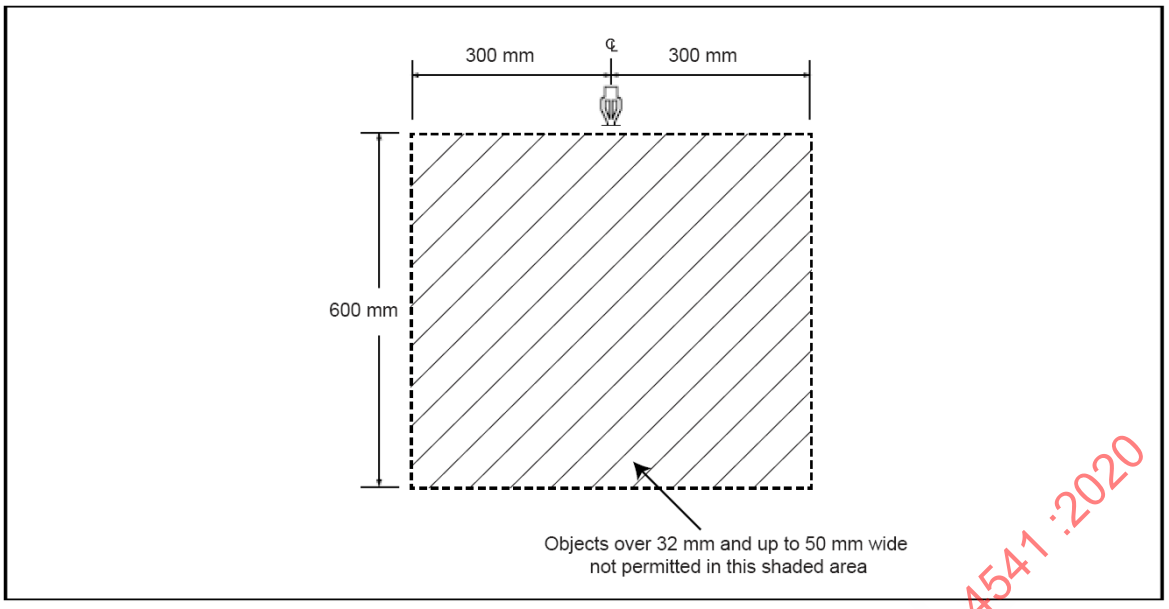


(Figure reproduced courtesy of FM Global)

Figure 9.18 – Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 20 mm and up to 32 mm wide

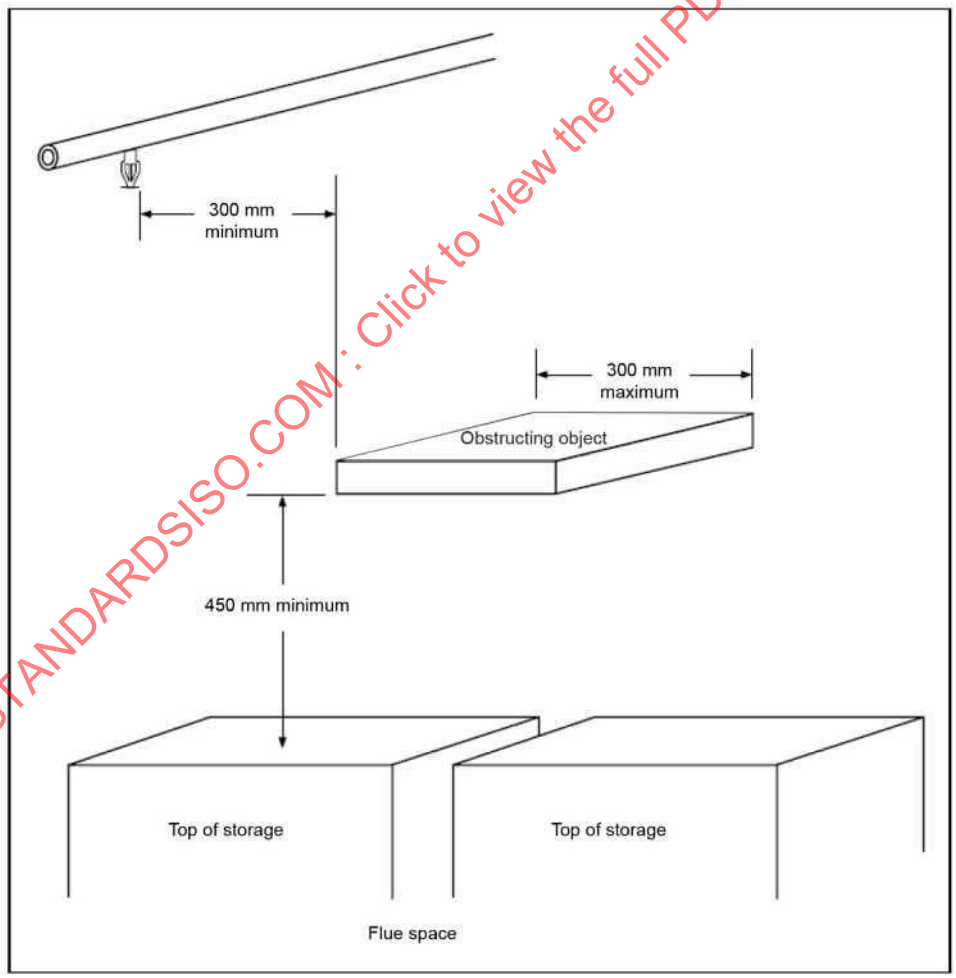
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



(Figure reproduced courtesy of FM Global)

Figure 9.19 – Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 32 mm and up to 50 mm wide



(Figure reproduced courtesy of FM Global)

Figure 9.20 – Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 50 mm and up to 300 mm wide

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

9.4.1.19.3 Additional sprinklers for objects wider than 600 mm in least dimension that obstruct a sprinkler's inner core distribution pattern

For objects wider than 600 mm that obstruct a sprinkler's inner core distribution pattern, install sprinklers in one of the following ways:

(a) For flat, continuous, solid objects up to 1.2 m wide, install a single line of ceiling-level sprinklers centred under the object on a maximum linear spacing of 2.4 m fed by the same range pipe size used at ceiling level. See Figure 9.22 for a diagram of this arrangement;

(b) For flat, continuous, solid objects from 1.2 m wide to 3.0 m wide, install ceiling-level sprinklers under the object on a maximum linear spacing of 2.4 m and area spacing of 6.0 m^2 fed by the same range pipe size used at ceiling-level. Maintain a minimum 900 mm vertical distance between the sprinkler deflector and the top of storage. See Figure 9.22 for a diagram of this arrangement;

(c) For flat, continuous, solid objects over 3.0 m wide, treat the underside of the object as a ceiling and install ceiling-level sprinklers for this area fed by the same range pipe size used at ceiling level and in accordance with the requirements in 9.4.1. Maintain a minimum 0.9 m vertical distance between the sprinkler deflector and the top of storage;

(d) For non-flat, non-continuous, or non-solid objects, install a flat, continuous, solid barrier of equal width under the object and install sprinklers as recommended in options (a), (b), or (c) depending on the width of the object. See Figure 9.23 for a diagram of this arrangement;

(e) As an alternative to option (d), install quick response ceiling-level sprinklers under the object on a maximum 1.2 m linear spacing and a maximum 1.5 m^2 area spacing fed by the same range pipe size used at ceiling-level. Maintain a minimum 900 mm vertical distance between the sprinkler deflector and the top of storage. See Figure 9.24 for a diagram of this arrangement; or

(f) As an alternative to options (a) through (e) when protecting rack storage, install ceiling-level sprinklers at the top of the storage rack at all flue space intersections (face and longitudinal) that are affected in a plan view by the obstructing object; feed these sprinklers using the same range pipe size used at ceiling level. Limit the height of storage above these sprinklers to 1.5 m maximum. See Figure 9.25 for a diagram of this arrangement.

Options (e) and (f) negate the need for a flat, continuous, solid barrier under the obstructing object. Option (f) can also be implemented when a minimum 900 mm clearance cannot be maintained between the deflectors of the additional sprinklers and the top of storage.

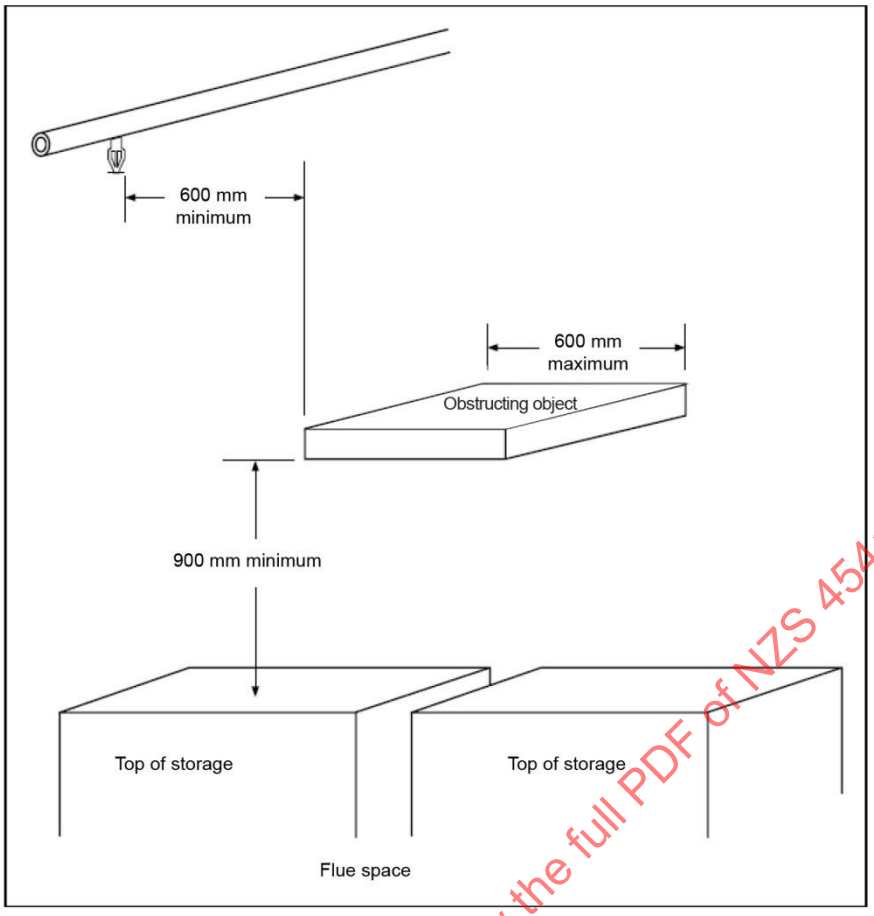
For options (a) through (e), maintain a minimum 900 mm vertical distance between the deflector of the additional sprinklers and the top of storage. This is not required for option (f) because the additional sprinklers are installed as in-rack sprinklers.

For options (a) through (f), the additional sprinklers installed under the obstruction as required above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

NOTE – Where this clause requires sprinklers beneath an object they shall be the same exact sprinkler head as those used at ceiling level.

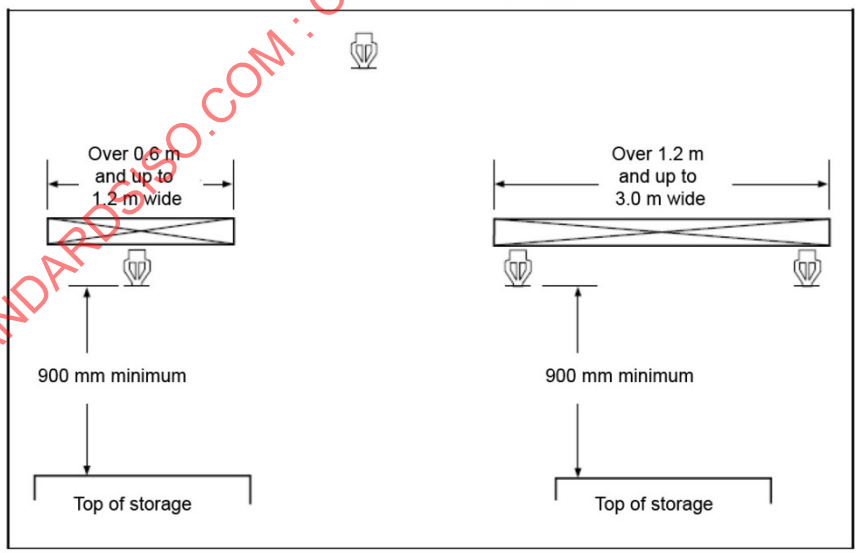
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



(Figure reproduced courtesy of FM Global)

Figure 9.21 – Obstruction area to inner core discharge pattern of pendent storage sprinklers for objects over 300 mm and up to 600 mm wide



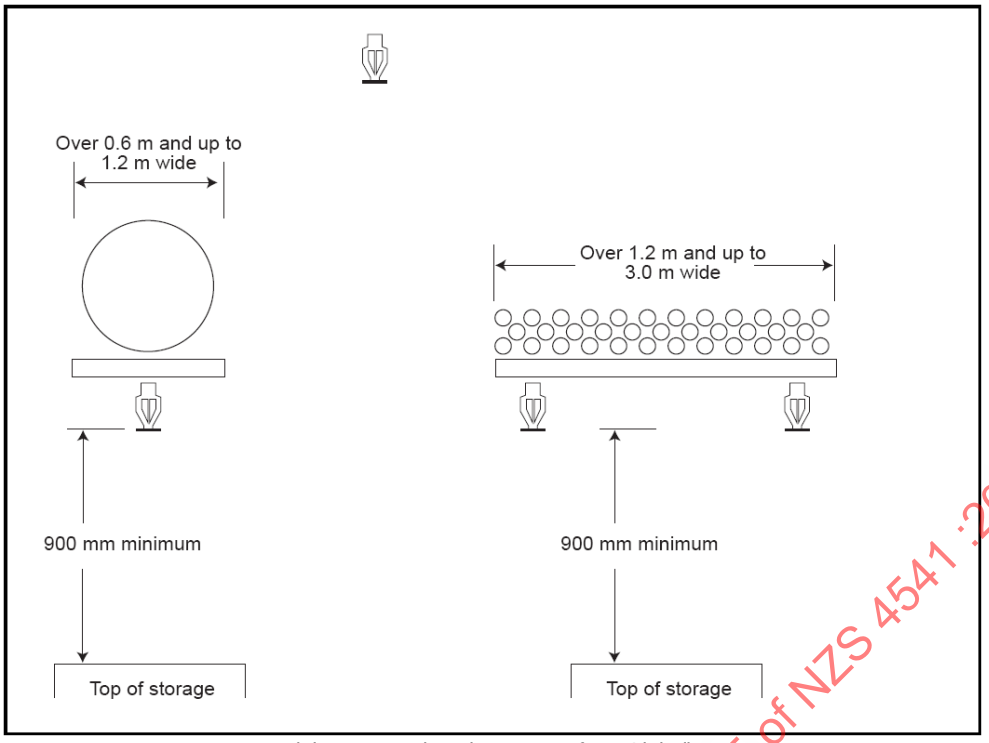
(Figure reproduced courtesy of FM Global)

Figure 9.22 – Additional sprinklers installed below flat, continuous solid obstructions from over 0.6 m wide to 3.0 m wide

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

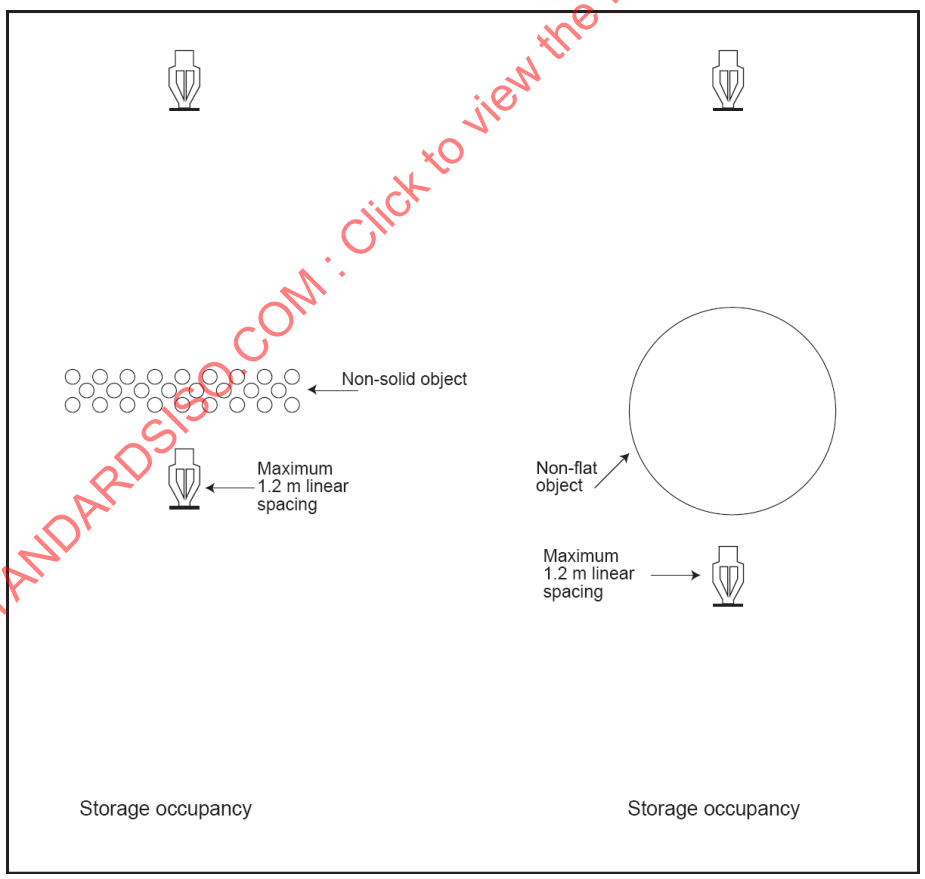
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



(Figure reproduced courtesy of FM Global)

Figure 9.23 – Additional sprinkler installed below non-flat, non-continuous, or non-solid obstructions more than 0.6 m wide up to 3.0 m wide

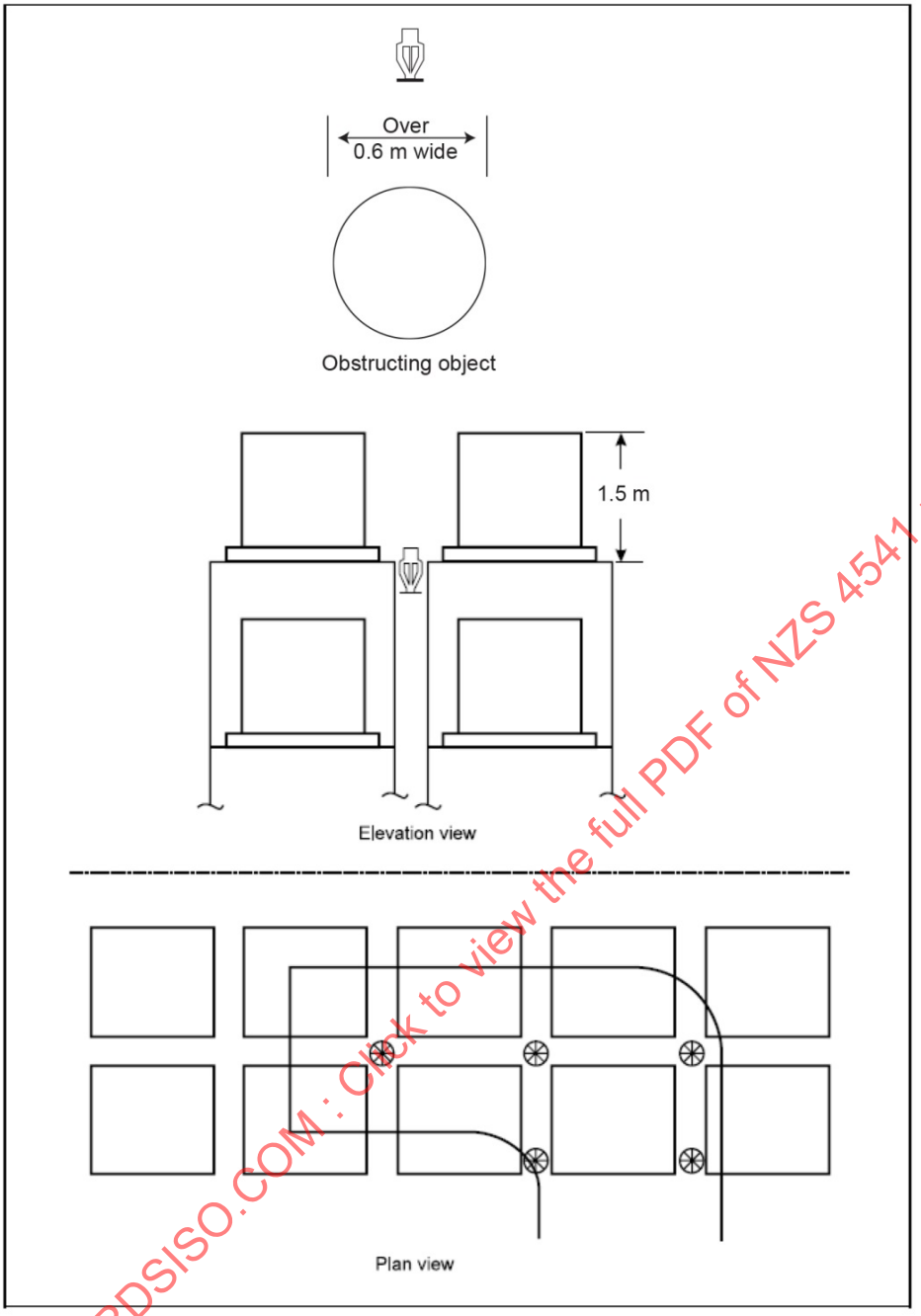


(Figure reproduced courtesy of FM Global)

Figure 9.24 – Additional sprinkler installed below non-flat, non-continuous, or non-solid obstructions over 0.6 m and up to 3.0 m wide without a flat, continuous, solid barrier provided

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020



(Figure reproduced courtesy of FM Global)

Figure 9.25 – Additional sprinklers installed within storage racks to account for obstructions to the inner core distribution pattern of a sprinkler

9.4.1.20 *Open-grid ceilings, mezzanines or walkways (open grids)*

Open grids obstruct ceiling-level sprinkler discharge and solid mezzanines or walkways are preferred.

If open grids cannot be avoided, provide sprinkler protection per the following requirements.

9.4.1.20.1 Ceiling-level sprinklers above open grids

Design ceiling-level sprinklers as required for the relevant occupancy as though no open grid was present.

9.4.1.20.2 Sprinklers under open grids

Install sprinkler protection under open grids using 70°C nominally rated quick response sprinklers having the same:

(a) *K* factor;
(b) Orientation; and
(c) Area spacing as the sprinklers installed at ceiling level.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

COPYRIGHT © Standards New Zealand

Install storage sprinklers under open grids on a maximum linear spacing of 2.4 m and a maximum area spacing of 6 m^2, using the same range pipe sizing installed at ceiling level.

Sprinklers installed under open grids as outlined above do not need to be added to the hydraulic design of the ceiling-level sprinkler system.

9.4.1.20.3 Exception for sprinklers under open-grid ceilings

Storage sprinklers are not required under an open-grid ceiling when the following conditions are met:

(a) The open grid is a minimum of 70% open;
(b) The open grid is a maximum of 6 mm deep;
(c) The open grid is at least 0.9 m vertically below the deflector of the ceiling-level sprinklers;
(d) It is not possible for materials to fall onto the top of the open grid and obstruct sprinkler discharge during a fire;
(e) There is only one open grid ceiling between the solid ceiling and the floor; and
(f) The ceiling sprinkler system can protect the occupancy in the absence of the open grid.

9.4.1.21 *Solid mezzanines*

Base the design of the mezzanine-level sprinkler protection on the height of the mezzanine and the occupancy located underneath it.

Install quick response sprinklers under solid mezzanines; however, standard response sprinklers can be installed under a solid mezzanine when they are installed at ceiling level and the design is appropriate for the occupancy located under the mezzanine, or a draft curtain is provided around the perimeter of the mezzanine.

Install a draft curtain around the perimeter of the solid mezzanine; however, a draft curtain is not required around the perimeter of a solid mezzanine when one of the following is true:

(a) The ceiling sprinkler protection design is appropriate for the occupancy located under the solid mezzanine;
(b) The ceiling-level and mezzanine-level sprinklers are of the same nominal RTI value and the occupancy under the mezzanine is located completely within the sprinklers at the edge of the mezzanine; or
(c) The sprinklers located under the solid mezzanine are quick response and the sprinklers located at ceiling level are standard response.

9.4.1.22 *Solid walkways*

Install quick response sprinklers under solid walkways and under solid walkways located between storage racks or similar structures.

For solid walkways up to 1.2 m wide, install a single line of quick response sprinklers down the centre of the walkway on maximum 3.0 m linear spacing.

For solid walkways over 1.2 m wide, install a line of quick response sprinklers within 300 mm horizontally of the perimeter of the walkway on maximum 3.0 m linear spacing and 9.0 m^2 area spacing.

Treat the walkway sprinklers as in-rack sprinklers and design in accordance 9.4.2 based on the commodity hazard located either under or adjacent to the solid walkway.

9.4.1.23 *Conveyors*

Provide sprinkler protection under belt-type or other solid-type conveyor systems having combustible construction or a combustible occupancy below them as follows.

9.4.1.23.1 Belt or similar solid-type conveyors

Treat belt-type and similar solid-type conveyor systems the same as a solid walkway and provide sprinkler protection in accordance with 9.4.1.21.

9.4.1.23.2 Roller and similar open-type conveyors

Sprinklers are not required below conveyor systems that are a minimum of 70% open, or below roller-type conveyors that are at least 50% open. If these conditions cannot be met, treat conveyors as open-grid ceilings and adhere to the recommendations in 9.4.1.19.3.

9.4.1.23.3 Automatic shutdown of conveyor systems

Arrange conveyor systems to automatically shut down in the event of sprinkler water discharge.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.4.2 *In-rack sprinklers*

9.4.2.1 *General*

In-rack sprinklers shall be installed in open-frame racks if the ceiling-level protection tables (Tables 9.14(a) to (j)) do not provide a design option for the ceiling height.

When in-rack sprinklers are needed, they can be used in combination with any of the ceiling sprinklers listed in Tables 9.14(a) to 9.14(j).

Extensions and upgrades to existing buildings provided with ceiling-level protection meeting high hazard requirements in previous versions of this standard, that do not meet the requirements in Tables 9.14(a) to 9.14(j), do not need to be upgraded provided in-rack sprinkler protection is installed meeting the following requirements:

(a) Provide in-rack sprinklers above the top level of storage;
(b) Limit the top tier of storage to a maximum height of 1.5 m. A row of fire sprinklers is required beneath the uppermost pallet load; and
(c) The roof level density shall be concurrent with the in-rack design and a minimum of 7.5 mm/min x 260 m^2.

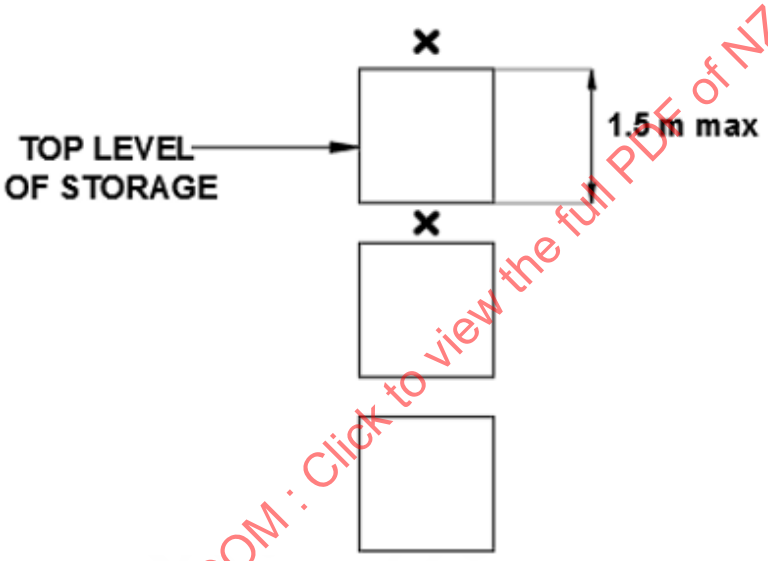


Figure 9.26 – Elevation view of in-rack sprinkler locations with roof level to previous editions of the standard

In-rack sprinklers shall be provided within storage racks having solid shelves 2.0 to 6.0 m^2 in surface area under the following conditions:

(a) Categories 1 through 4 commodities and cartoned plastics commodities stored higher than 4.5 m under a ceiling up to 9.0 m high;
(b) Uncartoned plastics commodities stored higher than 3.0 m under a ceiling up to 9.0 m high; or
(c) The ceiling height exceeds 9.0 m;

The vertical and horizontal in rack sprinkler arrangement for solid shelves 2.0 to 6.0 m^2 shall be as follows:

(d) Horizontal in-rack sprinkler arrangement – single-row racks:

  (i) Shelf area > 6.0 m^2 – Figure 9.27(a)
  (ii) Shelf area > 2.0 up to 6.0 m^2 and storage height < 7.5 m – Figure 9.27(a)
  (iii) Shelf area > 2.0 up to 6.0 m^2 and storage height > 7.5 m – Figure 9.28(a);

(e) Horizontal in-rack sprinkler arrangement – double-row racks:

  (i) Shelf area > 6.0 m^2 and storage height < 7.5 m – Figure 9.27(b)
  (ii) Shelf area > 6.0 m^2 and storage height > 7.5 m and < 9.0 m – Figure 9.28(b)
  (iii) Shelf area > 2.0 up to 6.0 m^2 and storage height < 7.5 m – Figure 9.27(b)
  (iv) Shelf area > 2.0 up to 6.0 m^2 and storage height > 7.5 m and < 9.0 m – Figure 9.28(b)
  (v) Shelf area > 2.0 up to 6.0 m^2 and storage height > 9.0 m – Figure 9.28(c);

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

(f) Horizontal in-rack sprinkler arrangement – multiple-row racks:

(i) Shelf area > 6.0 m^2 – Figure 9.36(c)
(ii) Shelf area > 2.0 up to 6.0 m^2 and storage up to 7.5 m – Figure 9.36(c)
(iii) Shelf area > 2.0 up to 6.0 m^2 and storage height > 7.5 m – Figure 9.28(d);

(g) Vertical in-rack sprinkler spacing – All rack types:

(i) Shelf area > 6.0 m^2 – every shelf level
(ii) Shelf area > 2.0 up to 6.0 m^2 Categories 1 to 4 and cartoned Categories 5 and 6 plastics – approximately 4.5 m
(iii) Shelf area > 2.0 up to 6.0 m^2 Categories 5 and 6 uncartoned plastics – approximately 3.0 m.

In-rack sprinklers are needed within storage racks at all tier levels equipped with solid shelves greater than 6.0 m^2 in area.

NOTE –

(1) In rack sprinklers are an alternative option when the available water supply cannot provide the flow and pressure needed for any ceiling-only protection option.

(2) In-rack sprinklers may also be needed if open-top containers are present (see 9.5.5.1).

9.4.2.2 *Design procedure for in-rack sprinklers*

Use the following procedure to determine the design requirements for both the ceiling and in-rack sprinkler systems:

(a) The available horizontal in-rack sprinkler arrangements shall be determined as per 9.4.2.5;
(b) The available vertical increments between in-rack sprinkler levels shall be determined as per 9.4.2.6;
(c) The in-rack sprinkler system design guidelines shall be determined as per 9.4.2.7.1;
(d) The ceiling-level sprinkler system design guidelines when supplemented with in-rack sprinklers shall be determined as per 9.4.2.7; and
(e) The duration for the combined ceiling and in-rack demand shall be as required by Table 6.1 (which is based on the number of sprinklers designed to be operating at roof level).

9.4.2.3 *Temperature rating, K factor, and RTI*

Sprinklers within racking shall have a nominal temperature rating of 68°C. Where design flows are greater than 115 L/min, a minimum *K* factor of *K*11.5 is required. Sprinklers with a *K* factor of *K*20 or less shall be quick response. If sprinklers with larger orifices than *K*20 are used, the sprinklers can be either quick response or standard response.

9.4.2.4 *Location and orientation*

(a) Sprinklers within racking shall be positioned so that there is not less than 150 mm clearance between the deflectors and the top of the storage immediately below the line of sprinklers. Where this is not achievable, more stringent in rack sprinkler spacing shall be provided (see 9.4.2.5.4).
(b) At each tier level where in-rack sprinklers are provided, position the in-rack sprinkler deflector at, or just below, the bottom of the rack's horizontal support member when it is under full load conditions.
(c) Except as detailed in (d), locate all in-rack sprinklers within the rack storage array. Position the in-rack sprinklers so they are not directly behind rack uprights and are no more than 75 mm horizontally away from the transverse flue space intersection they are intended to protect.
(d) In-rack sprinklers may be located outside the rack storage structure of a single-row rack that is located within 300 mm horizontally of a wall. The in-rack sprinklers shall be no more than 150 mm horizontally away from the rack structure as well as no more than 75 mm offset from the transverse flue space intersection they are intended to protect.
(e) When solid shelves are present and in-rack sprinklers are needed using horizontal layouts as per 9.4.2.5.1 and 9.4.2.5.4, position the in-rack sprinklers as close to the shelf openings as possible.

NOTE – Arrange sprinkler piping and in-rack sprinklers to avoid mechanical damage but ensure proper distribution from the in-rack sprinkler can be achieved. Before installing in-rack sprinklers, check the proposed in-rack sprinkler locations to ensure both adequate protection against mechanical damage and proper sprinkler discharge are provided.

9.4.2.5 *Horizontal lay-outs of in-rack sprinklers*

There are two basic horizontal layouts for in-rack automatic sprinklers (IRAS). They are as follows:

(a) IRS(EO), which represents in-rack sprinklers spaced horizontally at every other transverse flue space intersection between pallet loads; and
(b) IRS(E), which represents in-rack sprinklers spaced horizontally at every transverse flue space intersection between pallet loads.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

9.4.2.5.1 Horizontal lay-outs for IRS(EO) in-rack sprinkler arrangements

Figures 9.27(a), (b), and (c) represent IRS(EO) in-rack sprinkler arrangements for single-row, double-row, and multiple-row rack storage arrangements, respectively. These types of in-rack sprinkler arrangements canbe used when a minimum 150 mm vertical clearance is provided between the in-rack sprinkler deflector and the top of storage in combination with any of the following additional conditions:

(a) Categories 1, 2, or 3 commodities in closed-top packaging are maintained in open-framed racks, the storage height does not exceed 7.6 m, and the ceiling height does not exceed 13.7 m;
(b) Category 4 or cartoned Category 5 plastic commodities in closed-top packaging are maintained in open-framed racks, the storage height does not exceed 7.6 m and the ceiling height does not exceed 10.7 m;
(c) Closed-top uncartoned Category 5 plastic commodities are maintained in open-framed racks and the ceiling height does not exceed 7.6 m;
(d) Storage racks are equipped with solid shelves not exceeding 6.0 m^2 in area and the ceiling height does not exceed 7.6 m; or
(e) Closed-top packaged storage maintained in racks equipped with horizontal barriers (see 9.4.2.5.7).

NOTE – The minimum 150 mm vertical clearance between the deflector of the in-rack sprinkler and the top of storage is not required for multi-row racks.

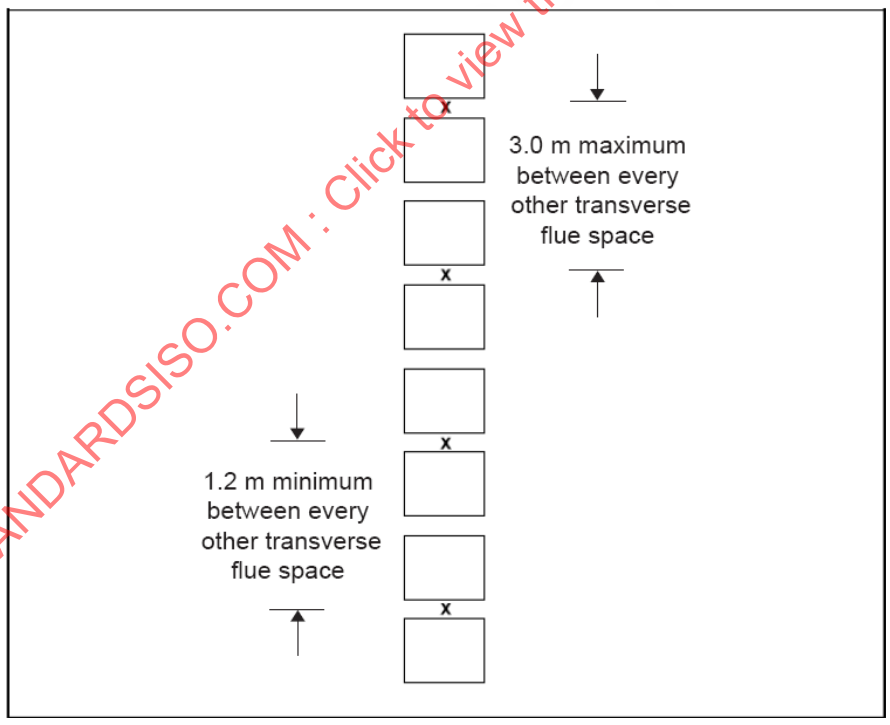
Storage arrangements and conditions that do not meet the above requirements shall have IRS(E) horizontal layout.

9.4.2.5.2 Maximum horizontal distance between (EO) transverse flues

When designing in-rack sprinklers in accordance with an IRS(EO) arrangement, ensure the maximum horizontal distance between every other transverse flue space is 3.0 m. If the horizontal distance between every other transverse flue space is greater than 3.0 m, follow the guidelines in 9.4.2.5.4 for installing an IRS(E) arrangement.

9.4.2.5.3 Minimum horizontal distance between (EO) transverse flue

Ensure the minimum distance between every other transverse flue space is 1.2 m; otherwise, in-rack sprinklers can be installed at every fourth transverse flue space.



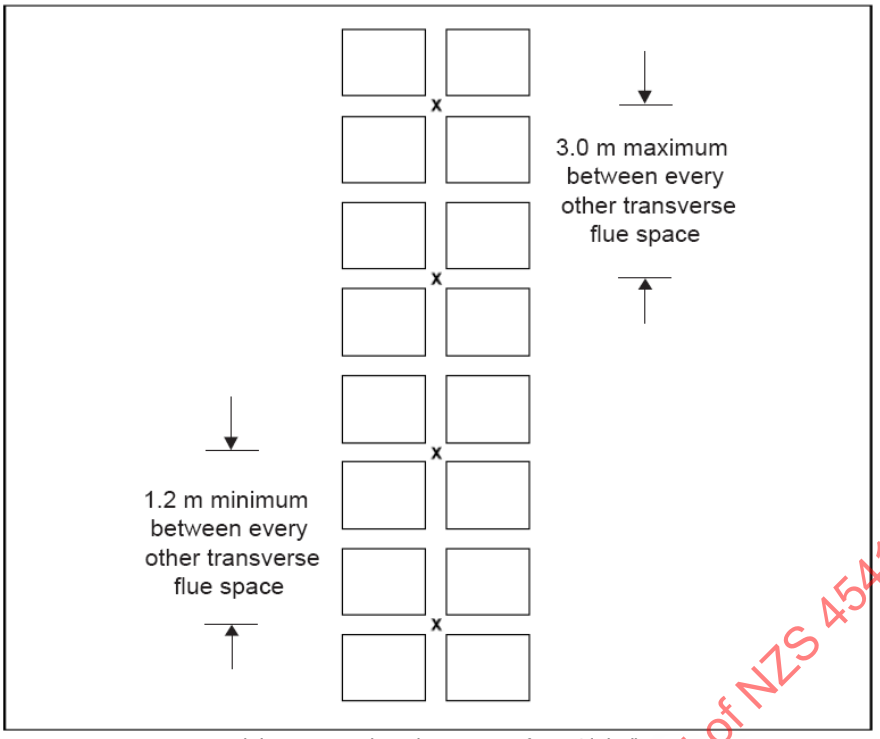
(Figure reproduced courtesy of FM Global)

Figure 9.27(a) – Plan view of IRS(EO) in-rack sprinkler arrangement for single-row racks

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

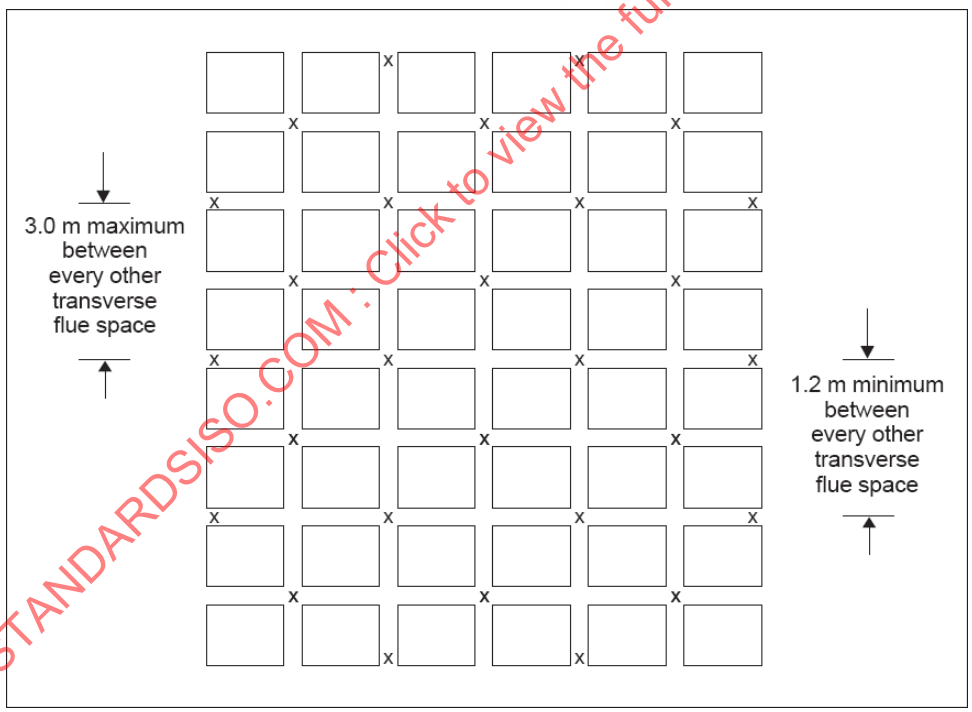
STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand



(Figure reproduced courtesy of FM Global)

Figure 9.27(b) – Plan view of IRS(EO) in-rack sprinkler arrangement for double-row racks



(Figure reproduced courtesy of FM Global)

Figure 9.27(c) – Plan view of IRS(EO) in-rack sprinkler arrangement for multiple-row racks

9.4.2.5.4 Horizontal lay-outs for IRS(E) in-rack sprinkler arrangements

Figures 9.28(a) to (d) represent IRS(E) arrangements for single-row, double-row, and multiple-row rack storage arrangements. IRS(E) horizontal in-rack arrangements shall be used whenever conditions areunacceptable for IRS(EO) arrangements and when a minimum 150 mm clearance cannot be or is not provided between the in-rack sprinkler deflector and the top of storage other than for multiple-row racks.

The in-rack sprinkler arrangement indicated in Figure 9.28(b) is for double-row racks up to 2.7 m deep. It is also for double-row racks up to 3.6 m deep for ceiling heights not exceeding 9.0 m. For open-frame

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

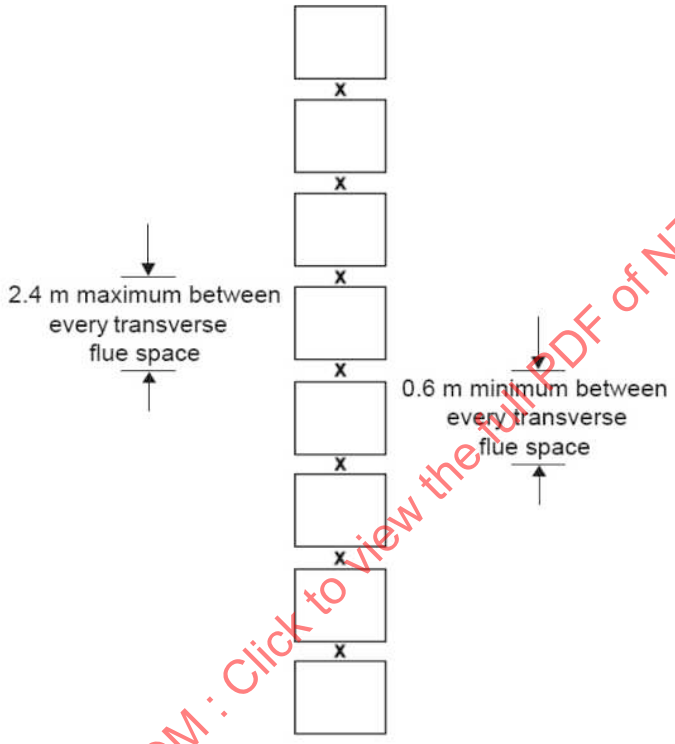
double-row racks over 2.7 m deep and up to 3.6 m deep, not equipped with horizontal barriers under ceilings higher than 9.0 m, use the in-rack arrangement indicated in Figure 9.28(c).

9.4.2.5.5 Maximum horizontal distance between IRS(E) transverse flues

When designing protection in accordance with an IRS(E) arrangement, the maximum horizontal distance between transverse flue spaces is 2.4 m. If the horizontal distance between every transverse flue space is greater than 2.4 m, install in-rack sprinklers horizontally at the midpoints between transverse flue spaces so that the horizontal distance between in-rack sprinklers does not exceed 2.4 m.

9.4.2.5.6 Minimum horizontal distance between IRS(E) transverse flue

The minimum distance between transverse flue spaces is 0.6 m, otherwise in-rack sprinklers can be installed at every other transverse flue space.

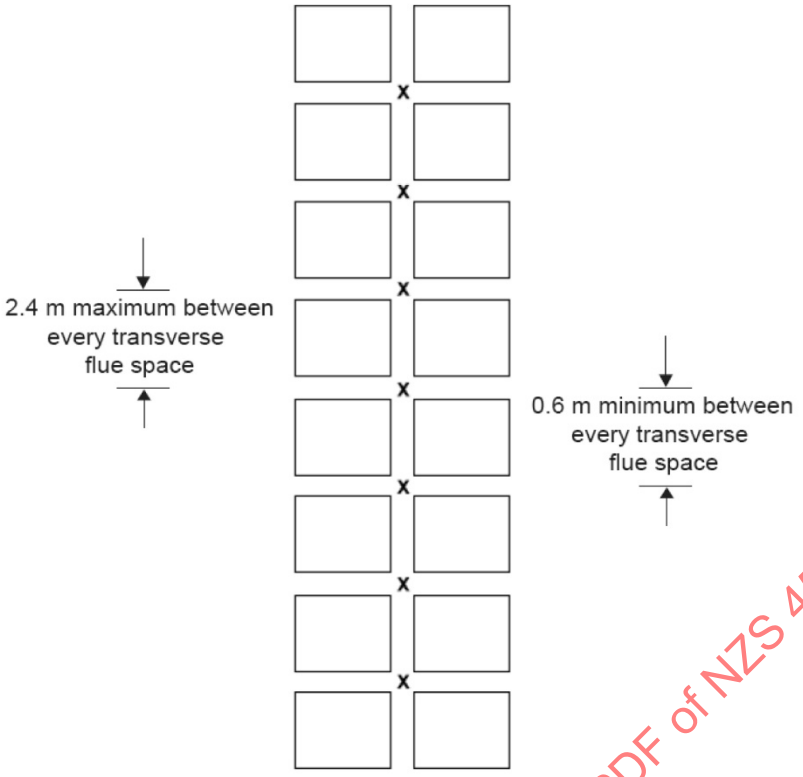


(Figure reproduced courtesy of FM Global)

Figure 9.28(a) – Plan view of IRS(E) in-rack sprinkler arrangement for single-row racks

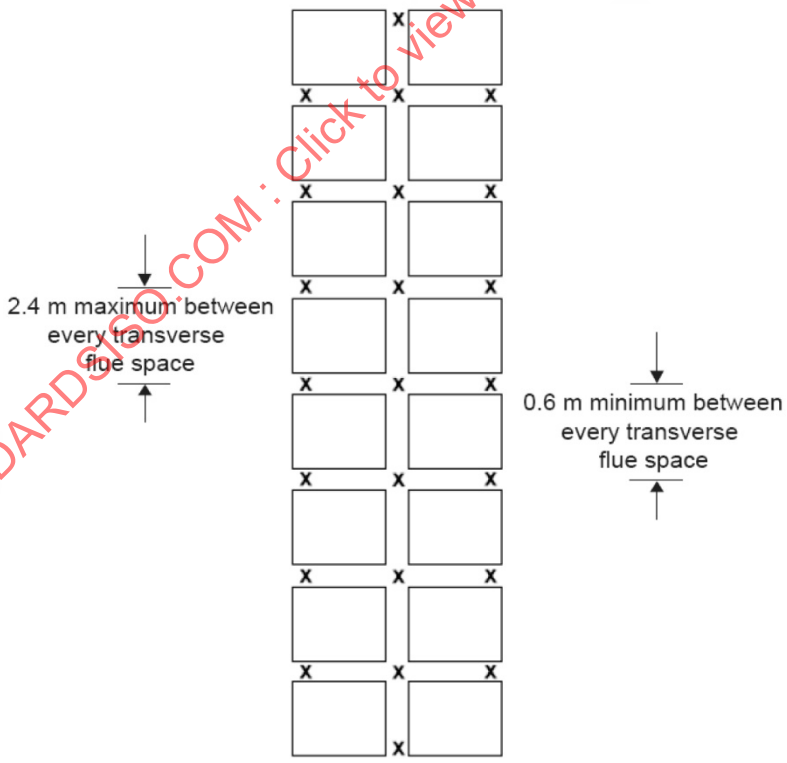
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution
STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020
Standards

COPYRIGHT © Standards New Zealand



(Figure reproduced courtesy of FM Global)

Figure 9.28(b) – Plan view of IRS(E) in-rack sprinkler arrangement in longitude flue only double-row racks

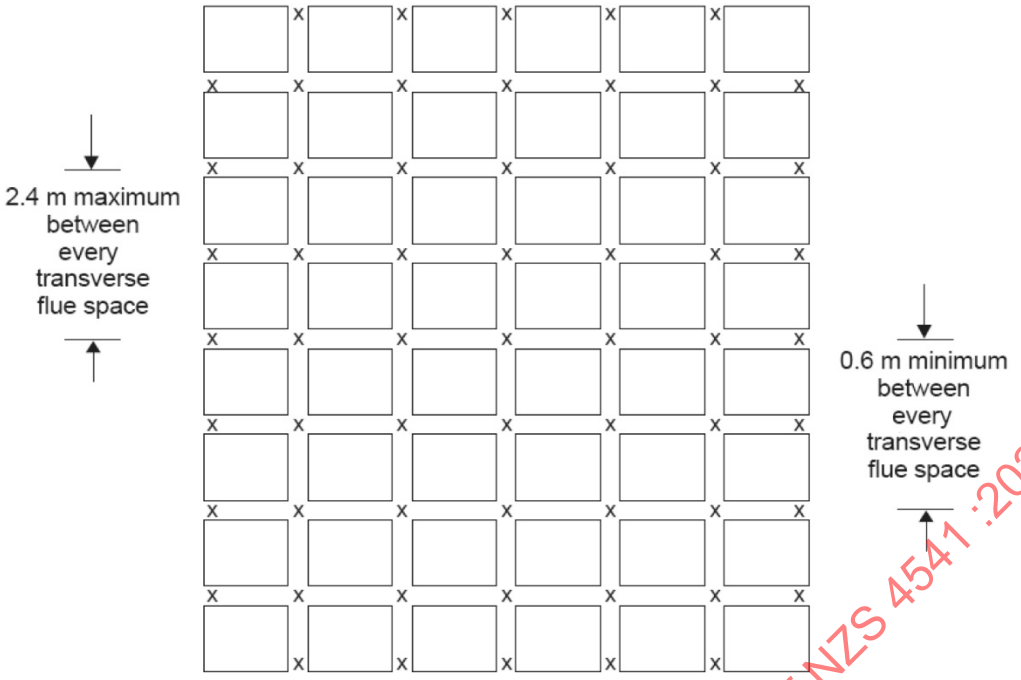


(Figure reproduced courtesy of FM Global)

Figure 9.28(c) – Plan view of IRS(E) in-rack sprinkler arrangement for double-row racks

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



(Figure reproduced courtesy of FM Global)

Figure 9.28(d) – Plan view of IRS(E) in-rack sprinkler arrangement for multiple-row racks

9.4.2.5.7 Horizontal lay-outs for in-rack sprinklers in combination with horizontal barriers

The use of a horizontal barrier generally reduces the number of in-rack sprinklers required per level; however, it does not reduce the number of in-rack levels required.

Use the following figures when installing horizontal barriers in combination with in-rack sprinklers:

Figure 9.27(a): Single-row racks that contain storage in closed-top containers and have a minimum 150 mm vertical clearance between the deflector of the in-rack sprinkler and the top of storage.

Figure 9.27(b): Double-row racks that contain storage in closed-top containers and have a minimum 150 mm vertical clearance between the deflector of the in-rack sprinkler and the top of storage.

Figure 9.27(c): All multiple-row racks arrangements.

Figure 9.28(a): Single-row racks that contain open-top containers or do not have a minimum150 mm vertical clearance between the deflector of the in-rack sprinkler and thetop of storage.

Figure 9.28(b): Double-row racks that contain open-top containers or do not have a minimum 150 mm vertical clearance between the deflector of the in-rack sprinkler and the top of storage.

When installed in combination with a horizontal barrier, in-rack sprinklers do not have to be positioned relative to the proximity of the transverse flue spaces unless there is less than 150 mm clearance between the top of storage and deflector of the in-rack sprinkler or there are open-top containers present within the storage rack.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

9.4.2.6 *Vertical increments of in-rack sprinklers*

The maximum vertical increments at which in-rack sprinklers can be installed are dependent mainly on the commodity classification and, if present, the size of solid shelves.

In addition to the maximum vertical increments described in 9.4.2.6.1, the storage height above the top level of in-rack sprinklers shall be limited to a maximum of 3.0 m.

9.4.2.6.1 Vertical increments of in-rack sprinklers in open-frame racks

The following maximum vertical increments can be applied to the horizontal in-rack sprinkler layouts indicated in Figures 9.27(a), (b), (c), and 9.33(a) as well as Figures 9.28(c) and (d); however, they do not apply to the horizontal in-rack sprinkler layout shown in Figure 9.28(b) when the ceiling height exceeds 9.0 m:

(a) Categories 1 to 3 commodities – 7.5 m;
(b) Category 4 and cartoned unexpanded plastics – 6.0 m;
(c) Cartoned expanded plastics – 4.5 m; or
(d) Uncartoned plastics – 3.0 m.

See 904.2.6.2 and 904.2.6.3 for possible exceptions when the ceiling height exceeds 9.0 m high.

9.4.2.6.2 Exception 1 for ceiling height exceeding 9.0 m

Categories 1, 2, 3, 4, and cartoned plastic commodities maintained in single-row and double-row open-frame racks can be protected by in-rack sprinklers in only the longitudinal flue space under the following conditions:

(a) The depth (aisle-to-aisle) of the double-racks does not exceed 2.7 m;
(b) The in-rack sprinklers are installed horizontally at every transverse flue space intersection as outlined in Figure 9.28(a) for single-row racks and Figure 9.28(b) for double-row racks; and
(c) The IRS are installed on vertical increments not exceeding 3.6 m.

9.4.2.6.3 Exception 2 for ceiling height exceeding 9.0 m

Categories 1, 2, 3, 4, and cartoned plastic commodities maintained in single-row and double-row open-frame racks can also be protected by in-rack sprinklers in only the longitudinal flue space under the following conditions:

(a) The depth (aisle-to-aisle) of the double-row racks does not exceed 2.7 m;
(b) The in-rack sprinklers are quick response;
(c) The in-rack sprinklers are installed horizontally at every other transverse flue space intersection, as outlined in Figure 9.27(a) for single-row racks and Figure 9.27(b) for double-row racks, and staggered vertically;
(d) The in-rack sprinklers are installed on vertical increments not exceeding 3.6 m; and
(e) All transverse/longitudinal flue space intersections are protected with in-rack sprinklers at vertical increments not exceeding 7.2 m.

9.4.2.6.4 Vertical increments of in-rack sprinklers in racks having solid shelves 2.0 m^2 to 6.0 m^2 in area

The following vertical increments of in-rack sprinklers in racks having solid shelves 2.0 m^2 to 6.0 m^2 in area apply:

(a) Categories 1 to 4 and cartoned plastic commodities – 4.5 m; and
(b) Uncartoned plastics – 3.0 m.

9.4.2.6.5 Vertical increments of in-rack sprinklers in racks having solid shelves greater than 6.0 m^2 in area

In-rack sprinklers are needed directly under every tier level where these types of shelves are provided.

9.4.2.7 *Design requirements for ceiling-level and in-rack sprinklers*

The design guidelines for in-rack sprinklers are dependent on the commodity being protected, the number of in-rack sprinkler levels installed, and the height of storage above the top level of in-rack sprinklers.

The design guidelines for ceiling-level sprinklers that are supplemented with in-rack sprinklers are dependent on the commodity being protected, the horizontal in-rack sprinkler layout provided, and the height of storage above the top level of in-rack sprinklers.

9.4.2.7.1 Design of in-rack sprinklers

Design in-rack sprinkler systems as per Table 9.9.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.9 – Hydraulic design for in-rack sprinkler systems

Commodity hazard	Storage height above top level of IRS (m)	No. of installed IRS levels	IRS design, no. of sprinklers	IRS design, min. flow per sprinkler (L/min)
Categories 1 – 3	≤ 3.0	1	6	85
		2 or more	10 (5 on 2 levels)	85
Categories 4 – 6	≤ 3.0	1	8	115
		2 or more	14 (7 on 2 levels)	115

Balance the in-rack sprinkler system water demand with the ceiling-level sprinkler water demand at the point where the two systems are connected.

Unless indicated otherwise, ensure the minimum operating pressure of the in-rack sprinklers is 50 kPa.

For dry pipe systems, the maximum water delivery time for any dry-type in-rack sprinkler system shall be no more than 60 seconds and based on the operation of the hydraulically most remote in-rack sprinkler.

9.4.2.7.2 Design for ceiling-level sprinklers in combination with in-rack sprinklers

Design ceiling-level sprinkler systems that are supplemented with in-rack sprinklers as per Table 9.10. The last column of this table indicates the ceiling height to be used from Tables 9.14(a) to (j) that is applicable to the commodity hazard being protected and the in-rack sprinkler arrangement that is being installed.

Table 9.10 – Hydraulic design for ceiling-level sprinkler systems supplemented with in-rack sprinklers

Commodity hazard	IRS arrangement	Storage height above top IRS level (m)	Clearance between top of storage and ceiling[1]	Ceiling height for applicable protection table (m)
Categories 1 to 3	IRS(EO)	Up to 3.0	Up to 6.0	6.0
	IRS(E)	Up to 3.0	Up to 6.0	6.0
Category 4 cartoned unexpanded plastic and cartoned expanded plastic	IRS(EO) IRS(E)	Up to 1.5	Up to 6.0	4.5
		Over 1.5, up to 3.0	Up to 1.5	4.5
			Over 1.5, up to 3.0	6.0
			Over 3.0, up to 6.0	7.5
Uncartoned unexpanded plastic	IRS(EO)	Up to 1.5	Up to 1.5	1.5
			Over 1.5, up to 3.0	2.4
			Over 3.0, up to 6.0	3.0
		Over 1.5, up to 3.0	Up to 1.5	3.0
			Over 1.5, up to 3.0	3.6
			Over 3.0, up to 6.0	4.5

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Commodity hazard	IRS arrangement	Storage height above top IRS level (m)	Clearance between top of storage and ceiling[1]	Ceiling height for applicable protection table (m)
	IRS(E)	Up to 1.5	Up to 3.0	1.5
			Over 3.0, up to 6.0	2.4
		Over 1.5, up to 3.0	Up to 1.5	2.4
			Over 1.5, up to 3.0	3.0
			Over 3.0, up to 6.0	4.5
Uncartoned expanded plastic	IRS(EO)	Up to 1.5	Up to 1.5	1.5
			Over 1.5, up to 3.0	2.4
			Over 3.0, up to 6.0	3.0
		Over 1.5, up to 3.0	Up to 1.5	3.0
			Over 1.5, up to 3.0	3.6
			Over 3.0, up to 6.0	6.0
	IRS(E)	Up to 1.5	Up to 3.0	1.5
			Over 3.0, up to 6.0	2.4
		Over 1.5, up to 3.0	Up to 1.5	3.0
			Over 1.5, up to 3.0	3.6
			Over 3.0, up to 6.0	4.5
NOTE – When this distance is greater than 6.0 m, see 9.5.4.1.2 for guidance.				

Use the ceiling height indicated for an IRS(E) arrangement when in-rack sprinklers are used in combination with horizontal barriers or when in-rack sprinklers are installed under solid shelves.

Balance the ceiling-level sprinkler system water demand with the in-rack sprinkler system water demand at the point where the two systems are connected.

9.4.2.7.3 Design guidelines for Scheme A

Fire Protection Scheme A as shown in Figures 9.29(a) to (c) is a specific combination of horizontal barriers and quick response, in-rack sprinklers within a storage rack that allows for high-challenge commodities to be treated as if they have been removed from the warehouse area. The in-rack sprinkler system design is independent of the ceiling-level sprinkler system in that it does not have to be hydraulically balanced with it.

Scheme A sprinklers must be supplied from a wet pipe installation. Dry pipe or pre-action systems are not acceptable with a Scheme A sprinkler installation.

The intent of Scheme A is to allow the use of a particular ceiling-only protection option in the presence of non-compatible commodity hazards. This is accomplished by segregating the non-compatible commodity hazards into a dedicated storage rack that is equipped with Scheme A protection, thus allowing for the ceiling-level sprinkler system to protect the next highest (compatible) commodity.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

Establish a dedicated storage rack (or racks) where all of the high-challenge commodities will be maintained. If this storage rack will not be solely dedicated to the storage of high-challenge commodities then either extend the Fire Protection Scheme A protection horizontally one pallet load in all directions beyond the designated high-challenge commodities storage area or install a vertical barrier to segregate the high- challenge commodities from any adjacent commodities.

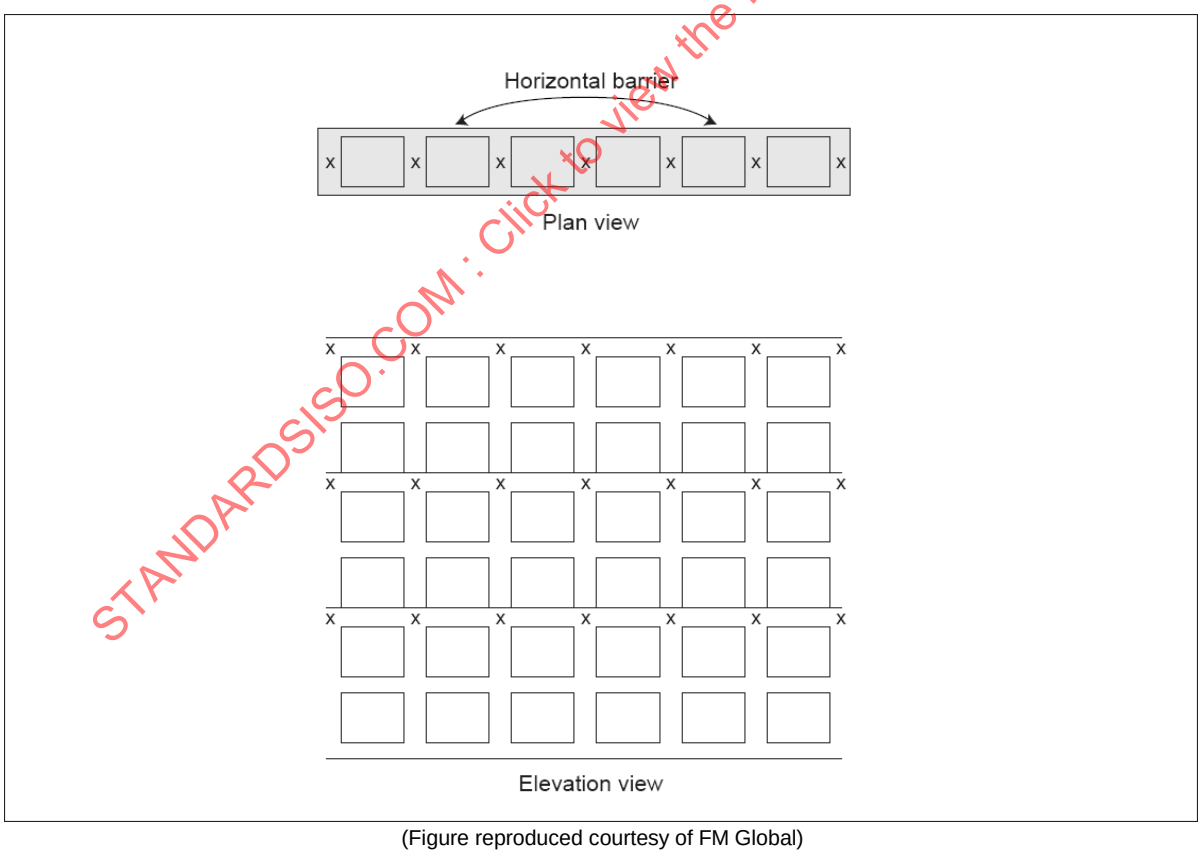
Commodities that can be protected by the ceiling-level sprinkler system can be stored vertically above, as well as horizontally adjacent to the portions of the storage rack equipped with Scheme A protection.

Where ignitable liquids are involved, additional measures are required. Refer to NFPA 30 or FM Global Data Sheet 7-29.

Storage sprinkler system design example

The majority of a proposed 12.2 m high warehouse will contain commodity hazards ranging up to and including cartoned unexpanded plastics; however, it will also contain a small but significant amount of uncartoned expanded plastics. The existing water supply has the flow and pressure needed to support several ceiling-only protection options for cartoned unexpanded plastics; however, it is not sufficient to support any ceiling-only protection options for uncartoned expanded plastics. By segregating all of the uncartoned expanded plastics into a storage rack that is equipped with Scheme A protection, the ceiling- level sprinkler system can be designed based on the next highest commodity hazard; in this case cartoned unexpanded plastics.

When Tables 9.14(a) to (j) indicate a ceiling-only protection option is not available for a given commodity hazard, Scheme A is a potential alternative option, provided the large majority of the warehouse commodity hazards can be protected by a ceiling-only protection option. Other, less-stringent, in-rack options may be available as an alternative to Scheme A. Another potential option could be changing the storage arrangement from rack to on-floor.



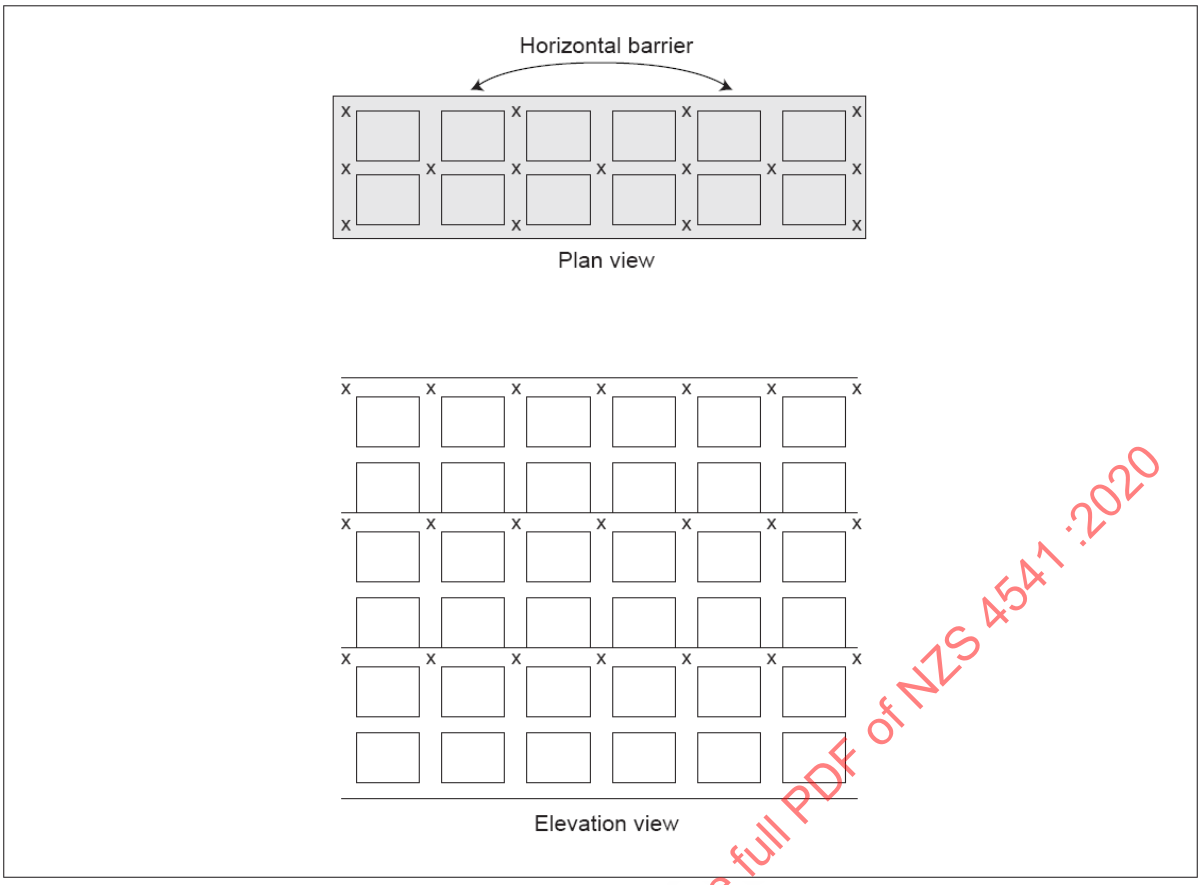
(Figure reproduced courtesy of FM Global)

Figure 9.29(a) – Fire Protection Scheme A within single-row racks

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

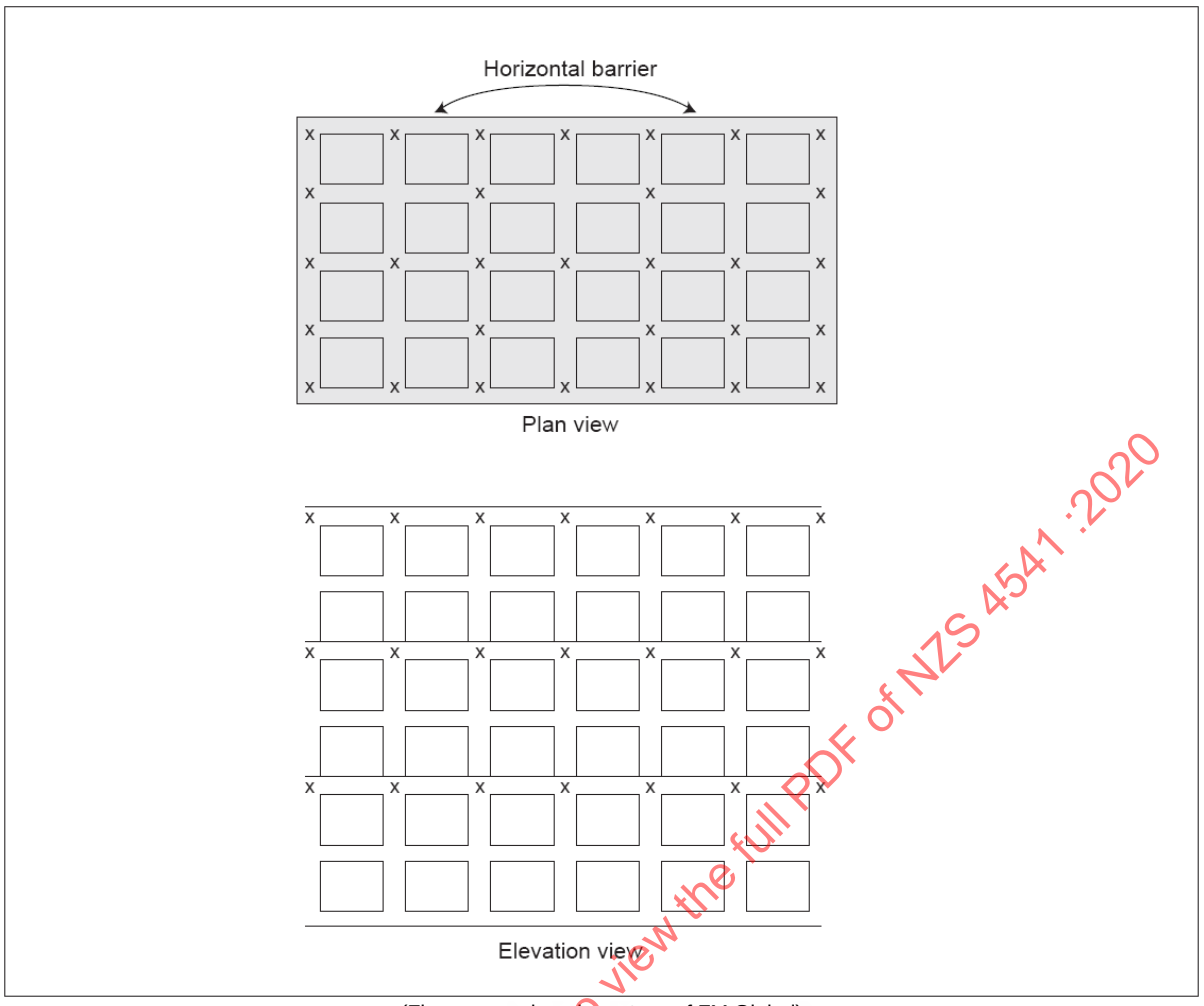


(Figure reproduced courtesy of FM Global)

Figure 9.29(b) – Fire Protection Scheme A within double-row racks

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



(Figure reproduced courtesy of FM Global)

Figure 9.29(c) – Fire Protection Scheme A within multiple-row racks

9.4.2.7.4 Horizontal barriers

Install horizontal barriers for Scheme A using minimum 0.7 mm sheet metal whenever possible; however, minimum 10 mm plywood can also be used. Install horizontal barriers at every tier level of the dedicated storage rack if the rack is equipped with solid shelves. If the dedicated storage rack is open-frame, install horizontal barriers at vertical increments not exceeding 3.7 m. Span the barriers horizontally so that all flue spaces within the rack bay are covered. A maximum 75 mm wide gap is acceptable at rack uprights.

9.4.2.7.5 In-rack sprinklers

Install minimum *K*11.5, quick response sprinklers (ceiling-level or in-rack) beneath each horizontal barrier. Locate the deflector of the sprinkler as close to the underside of the horizontal barrier as possible. If the in-rack sprinklers do not align with the transverse flue spaces between pallet loads, locate the sprinkler deflector a minimum of 150 mm above the top of storage.

For single-row racks, install sprinklers at each rack upright as well as at each rack mid-bay as shown in Figure 9.29(a). The maximum linear spacing between sprinklers is 1.5 m.

For double-row racks, install sprinklers at each rack upright within the longitudinal flue space as well as at the face of the rack. In addition, install sprinklers at the mid-bay longitudinal flue space of each rack bay as shown in Figure 9.29(b). The maximum linear spacing between sprinklers is 3.0 m at the rack face and 1.5 m within the longitudinal flue space.

For multiple-row racks, install an alternating IRS(E)/IRS(EO) sprinkler arrangement within adjacent transverse flue spaces as shown in Figure 9.29(c). Sprinklers are needed at the face of each flue space. The maximum linear spacing between sprinklers using an IRS(E) sprinkler arrangement is 1.5 m and 3.0 m between sprinklers using an IRS(EO) sprinkler arrangement.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

9.4.2.7.6 In-rack sprinkler design and duration

Single-row racks: A minimum flow of 230 L/min from each of the most hydraulically remote six sprinklers.

Double-row and multiple-row racks: A minimum flow of 230 L/min from each of the most hydraulically remote eight sprinklers.

Provide the in-rack water demand for at least 60 minutes. The in-rack sprinkler demand does not have to be hydraulically balanced with the ceiling-level sprinkler system and does not have to be accounted for operating simultaneously with the ceiling-level sprinkler system. The ceiling sprinkler system shall be capable of providing the required protection for the surrounding occupancy.

9.4.2.7.7 In-rack sprinkler installation control assemblies

A supervised subsidiary stop valve may be provided to allow the rack sprinklers to be isolated without isolating roof level protection.

9.4.3 *In-rack sprinkler protection for Category 1 through Category 6 commodities that are independent of the ceiling sprinkler design, Option 1.*

9.4.3.1 *General*

The in-rack sprinkler designs provided in this section are alternatives to the in-rack sprinkler designs recommended in section 9.4.2 of this standard.

9.4.3.2 *Occupancy*

The designs in this section can be used to protect all commodities (both cartoned and uncartoned) addressed in this data sheet.

Do not use the in-rack sprinkler designs in this section to protect open-top containers, unless they are located on the bottom tier level.

Storage racks must be considered 'open-frame' as defined in 9.2.20.

9.4.3.3 *Protection*

9.4.3.3.1 In-rack sprinkler system

The alternative in-rack sprinkler designs in this section are for wet-pipe systems only.

9.4.3.3.2 In-rack sprinklers

Use storage (ceiling) sprinklers that are standard coverage, quick response, pendent, and have a nominal temperature rating of 70°C. Use minimum *K*32 sprinklers; however, minimum *K*20 sprinklers can be used when the required flow for the commodity being protected is 380 L/min or less.

9.4.3.3.3 Horizontal location of in-rack sprinklers

See Figures 9.30(a) to 9.30(f) for the recommended horizontal location of in-rack sprinklers, depending on the type of storage rack being protected. The minimum and maximum horizontal distances between in-rack sprinklers is 700 mm and 1.4 m, respectively, except as shown in the applicable figures. The maximum horizontal distance between face sprinklers and either (1) the face of the storage rack, or (2) the outer edge of the pallet load if it protrudes into the aisle, is 450 mm. Locate all in-rack sprinklers within the footprint of the rack structure they are intended to protect. In-rack sprinklers protecting the flue space created between a single-row rack structure and a wall located within 300 mm horizontally of the rack structure can be positioned outside the footprint of the single-row rack structure as shown in Figure 9.30(c).

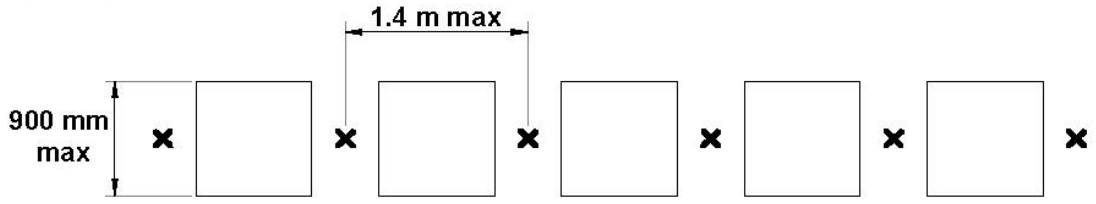


Figure 9.30(a) – Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 0.9 m deep

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

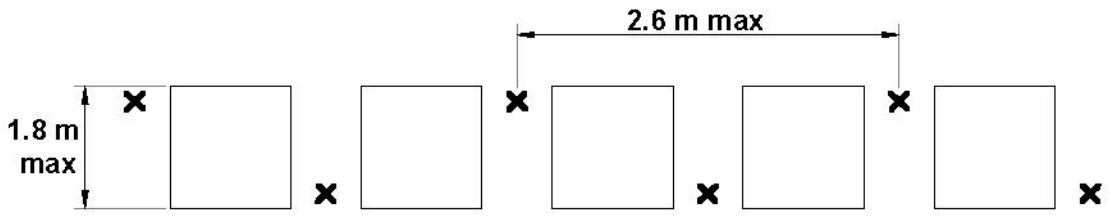


Figure 9.30(b) – Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 1.8 m deep

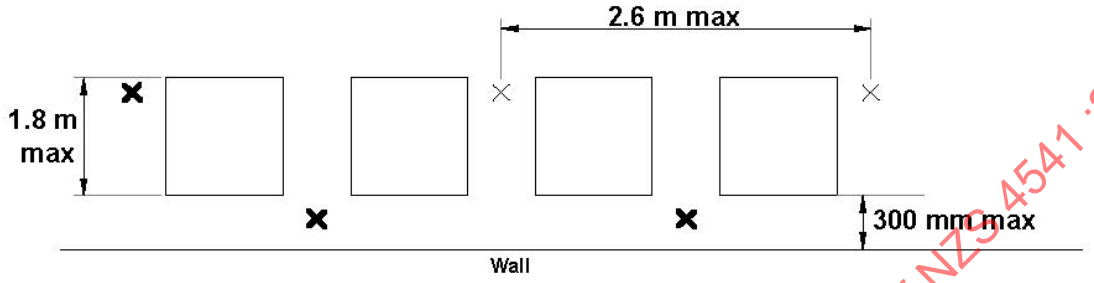


Figure 9.30(c) – Plan view of alternative in-rack sprinkler arrangement for single-row racks up to 1.8 m deep located against wall

Arrange sprinkler piping and in-rack sprinklers to avoid mechanical damage but ensure proper distribution from the in-rack sprinkler can be achieved. Before installing in-rack sprinklers, check the proposed in-rack sprinkler locations to ensure both adequate protection against mechanical damage and proper sprinkler discharge are provided.

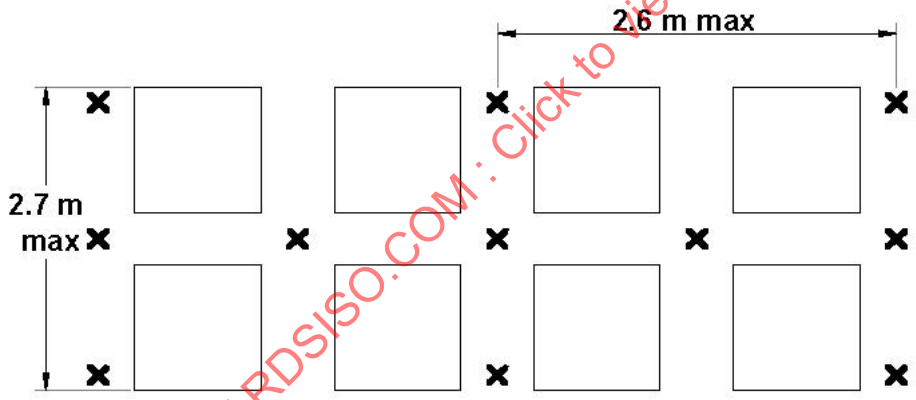


Figure 9.30(d) – Plan view of alternative in-rack sprinkler arrangement for double-row racks up to 2.7 m deep

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

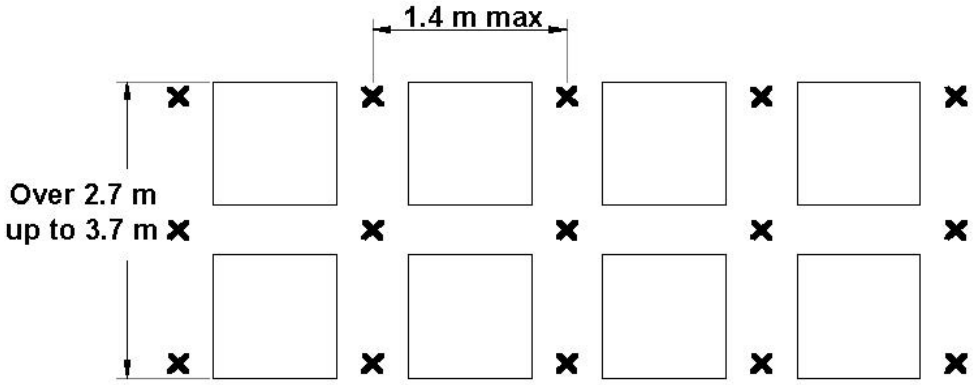


Figure 9.30(e) – Plan view of alternative in-rack sprinkler arrangement for double-row racks up to 3.7 m deep

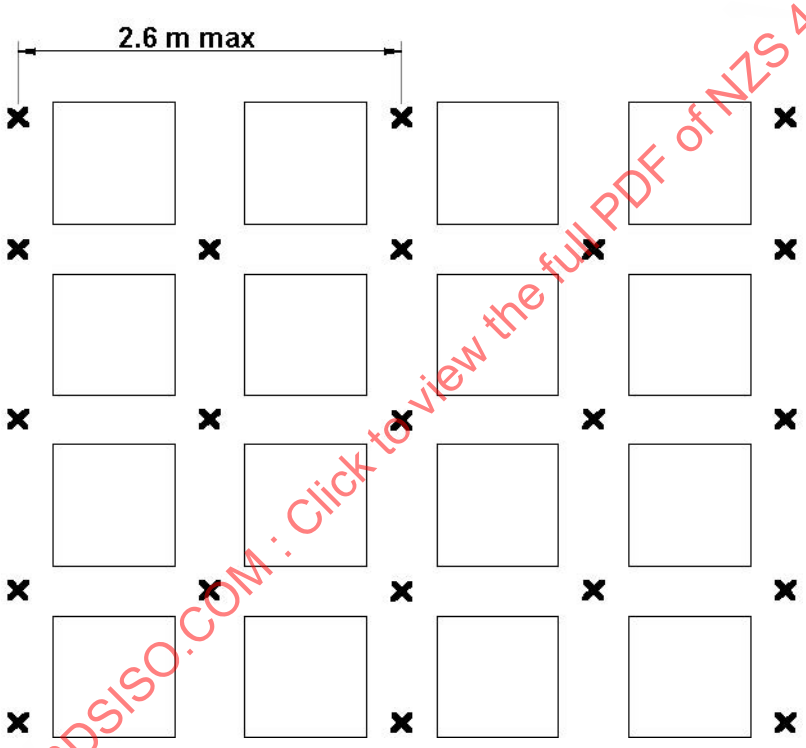


Figure 9.30(f) – Plan view of alternative in-rack sprinkler arrangement for multiple-row racks

9.4.3.3.4 Vertical location of in-rack sprinklers

The maximum vertical distance between in-rack sprinkler levels is 9.1 m for cartoned Category 6 plastics as well as uncartoned Category 5 and Category 6 plastics. The maximum vertical distance for Category 1 through 4 and cartoned Category 5 plastics is 12.2 m. Provide a minimum vertical clearance of 150 mm between the top of storage and the sprinkler deflector.

At each tier level where in-rack sprinklers are needed, position the in-rack sprinkler deflector at or just below the bottom of the rack's horizontal support member when it is under full load conditions.

9.4.3.3.5 In-rack sprinkler system design

Regardless of the number of in-rack sprinkler levels installed, base the in-rack sprinkler system design on the single most hydraulically remote in-rack sprinkler level. Base the minimum number of in-rack sprinklers in the system design per Table 9.11.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.11 – Number of sprinklers in the in-rack design

	Number of sprinklers in the in-rack design	
	Categories 1 through 4 and Cartoned Category 5 and Category 6 plastics	Uncartoned Category 5 and Category 6 plastics
Single-row racks up to 900 mm deep	4	4
Single-row racks up to 1.8 m deep	5	5
Single-row racks up to 1.8 m deep against wall	5	5
Double-row racks up to 2.7 m deep	6	5 & 5*
Double-row racks up to 3.6 m deep	6	5 & 5*
Multiple-row racks	6	5 & 5*
* The number of sprinklers is based on the most remote five in-rack sprinklers in the most remote storage rack as well as the most remote five in-rack sprinklers in the adjacent storage rack.		

Base the minimum flow required in the system design from the most remote in-rack sprinkler per Table 9.12.

Table 9.12 – Minimum flow in the in-rack design

Max. vertical IRAS installation	Commodity hazard	Min. *K* factor	Min. flow, from most remote in-rack sprinkler, L/min
9.1 m	Categories 1 through 4 and cartoned Category 5 plastic	20	250
	Cartoned expanded plastic	20	380
	Uncartoned Plastics	32	455
12.2 m	Categories 1 through 4 and cartoned Category 5 plastic	32	455

Arrange the water supply to provide the required in-rack sprinkler system demand for a minimum of 60 minutes.

The water supply must be capable of providing the required design for the in-rack sprinkler system independent of the design requirements of the ceiling sprinkler system. It is not necessary to hydraulically balance the in-rack sprinkler system with the ceiling-level sprinkler system, nor account for them flowing simultaneously.

9.4.3.3.6 Ceiling sprinkler system design

Design and install the ceiling-level sprinkler system in accordance with the requirements of 9.5 except as modified in this section. When the in-rack sprinkler system is designed and installed in accordance with sections 9.4.3.1, 9.4.3.2, and 9.4.3.3.1 through 9.4.3.3.5, the ceiling sprinkler system can be designed using the applicable protection table (such as Tables 9.14(a) to (j)), depending on the commodity hazard being protected) based on a ceiling height that is obtained by taking the vertical distance between the top level of in-rack sprinklers and the actual ceiling above. In other words, the top level of in-rack sprinklers can be considered a floor for design purposes. See Figure 9.31 for a visual representation of this guidance.

The maximum storage height of 3 m above the top level of in-rack sprinklers outlined in 9.4.2 does not apply to this in-rack sprinkler arrangement. If no storage is to be located above the top level of in-rack sprinklers, base the ceiling sprinkler system design on the minimum ceiling height indicated within the applicable protection table for the commodity hazard being protected.

The water supply must be capable of providing the required design for the ceiling sprinkler system independent of the design requirements of the in-rack sprinkler system. It is not necessary to hydraulically

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

balance the ceiling sprinkler system with the in-rack sprinkler system, nor account for them flowing simultaneously.

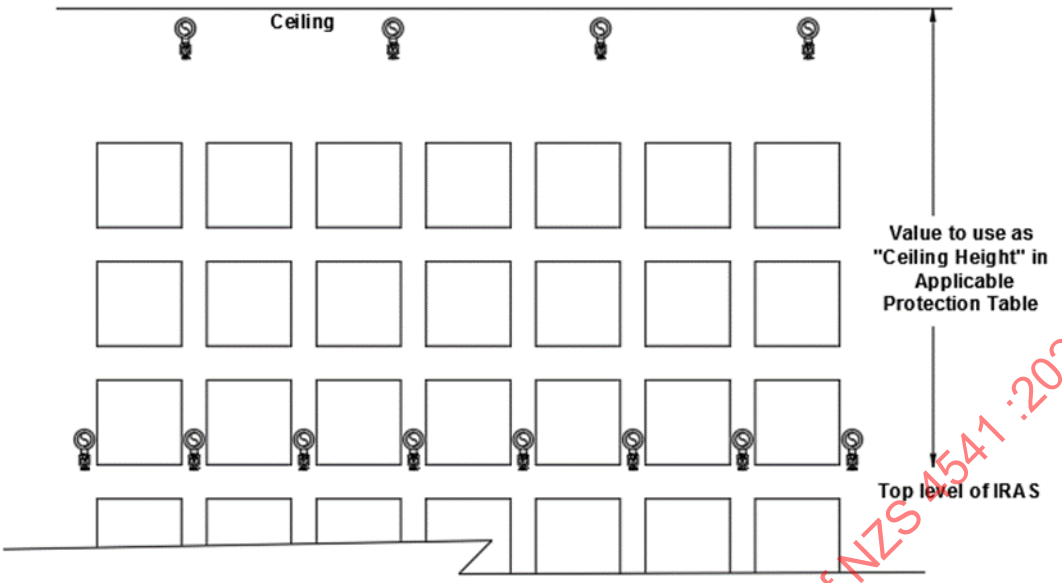


Figure 9.31 – Determining ceiling height in applicable protection table

9.4.4 *In-rack sprinkler protection for Category 1 through Category 6 commodities that are independent of the ceiling sprinkler design, Option 2*

9.4.4.1 *General*

Category 1 through Category 6 commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with this section.

9.4.4.2 *Occupancy*

Where the storage rack will not be solely dedicated to the storage of commodities requiring a greater level of protection than is available from the overhead sprinkler system, either of the following shall apply:

(a) Extend the protection prescribed by this section horizontally one pallet load in all directions beyond the commodity storage area requiring the higher level of protection; and
(b) Install a vertical barrier to segregate the commodities requiring the higher level of protection from any adjacent commodities.

Commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack equipped as prescribed by this section.

9.4.4.3 *Horizontal barriers*

(a) Horizontal barriers shall be installed at every tier level of the dedicated storage rack where the rack is equipped with solid shelves.
(b) Where dedicated storage of Categories 1 through 4 and cartoned Categories 5 and 6 plastic commodity is in open racks, horizontal barriers shall be installed at vertical increments not exceeding 9.1 m.
(c) Where dedicated storage of uncartoned Categories 5 and 6 plastic commodity is in open racks, horizontal barriers shall be installed at vertical increments not exceeding 6.1 m.

The barriers shall span horizontally so that all flue spaces within the rack bay are covered.

A maximum 75 mm wide gap shall be permitted at rack uprights.

The solid barrier shall be installed on a horizontal plane within a rack, beneath which in-rack sprinklers shall be installed, as follows:

(a) The barrier shall be constructed of minimum 0.8 mm sheet metal or 10 mm minimum plywood;
(b) The barrier shall extend to both ends and both aisle faces of the racks covering up both the longitudinal and transverse flue spaces of the rack bays in which they are installed; and

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

(c) The barrier shall be fitted to within 75 mm of any vertical rack member or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

9.4.4.4 *In-rack sprinklers*

Intermediate temperature extended coverage pendent storage sprinklers with a nominal *K* factor of *K*36 shall be installed beneath each horizontal barrier. The deflector of the sprinkler shall be located as close to the underside of the horizontal barrier as possible with the deflector a minimum 150 mm above the top of the commodity.

The design of the in-rack sprinkler system shall be based on a minimum flow of 520 L/min from each of the most remote four sprinklers for single-row and double-row racks or each of the most remote eight in-rack sprinklers (three at each face and two in-between) for multiple-row racks.

The in-rack sprinkler demand shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the criteria prescribed by this section.

9.4.4.4.1 Single-row racks

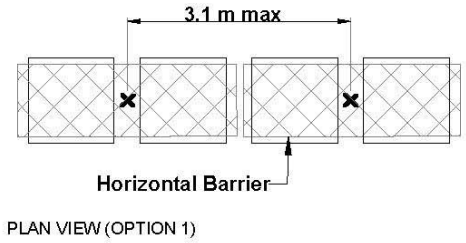
For single-row racks, sprinklers shall be installed at each rack mid-bay as shown in Figure 9.32(a) for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodity and Figure 9.32(b) for uncartoned Category 5 and Category 6 plastic commodity.

The maximum linear spacing between sprinklers shall not exceed 3.1 m.

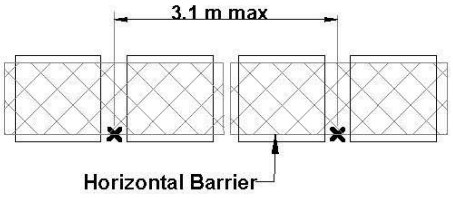
This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

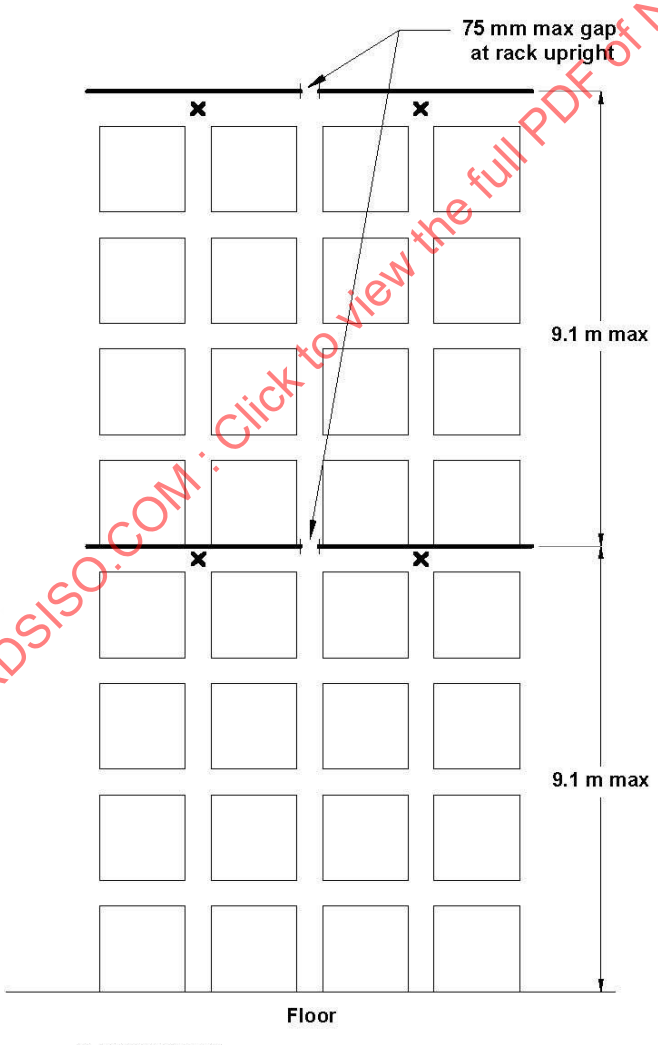
COPYRIGHT © Standards New Zealand



PLAN VIEW (OPTION 1)



PLAN VIEW (OPTION 2)

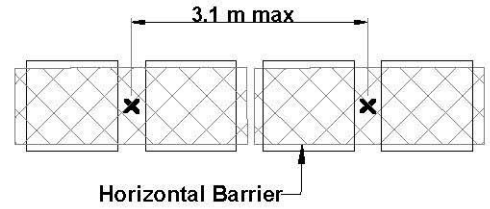


ELEVATION VIEW

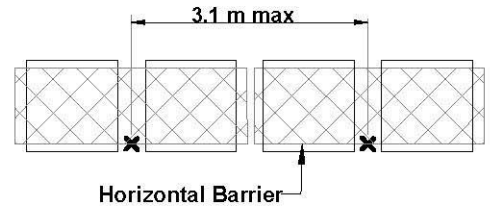
Figure 9.32(a) – Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in single-row racks, Option 3

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

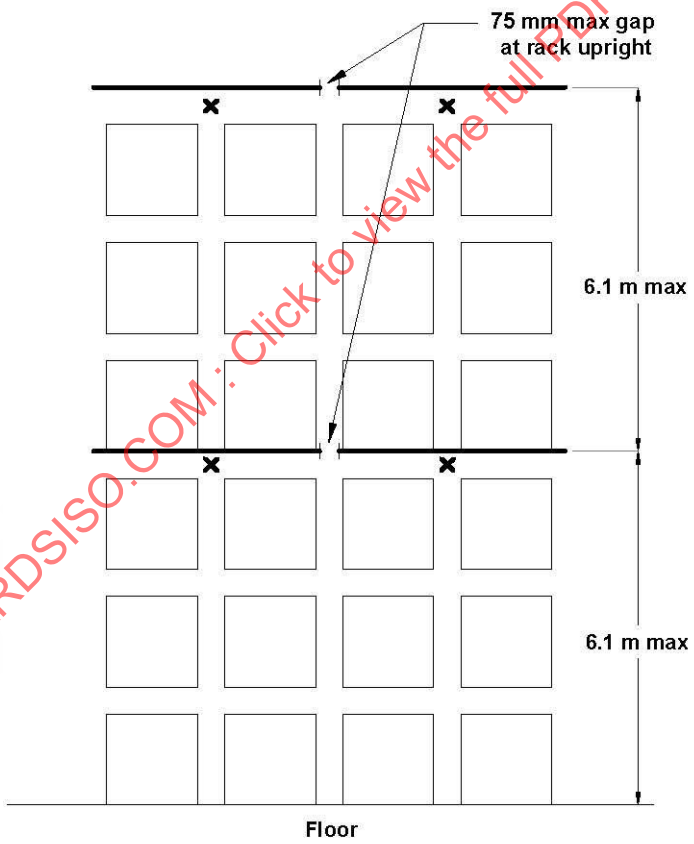
STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



PLAN VIEW (OPTION 1)



PLAN VIEW (OPTION 2)



ELEVATION VIEW

Figure 9.32(b) – Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in single-row racks, Option 2

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

9.4.4.4.2 Double-row racks

For double-row racks, sprinklers shall be installed within the longitudinal flue space at each rack mid-bay as shown in Figure 9.32(c) for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodity and Figure 9.32(d) for uncartoned Category 5 and Category 6 plastic commodity.

The maximum linear spacing between sprinklers shall not exceed 3.1 m.

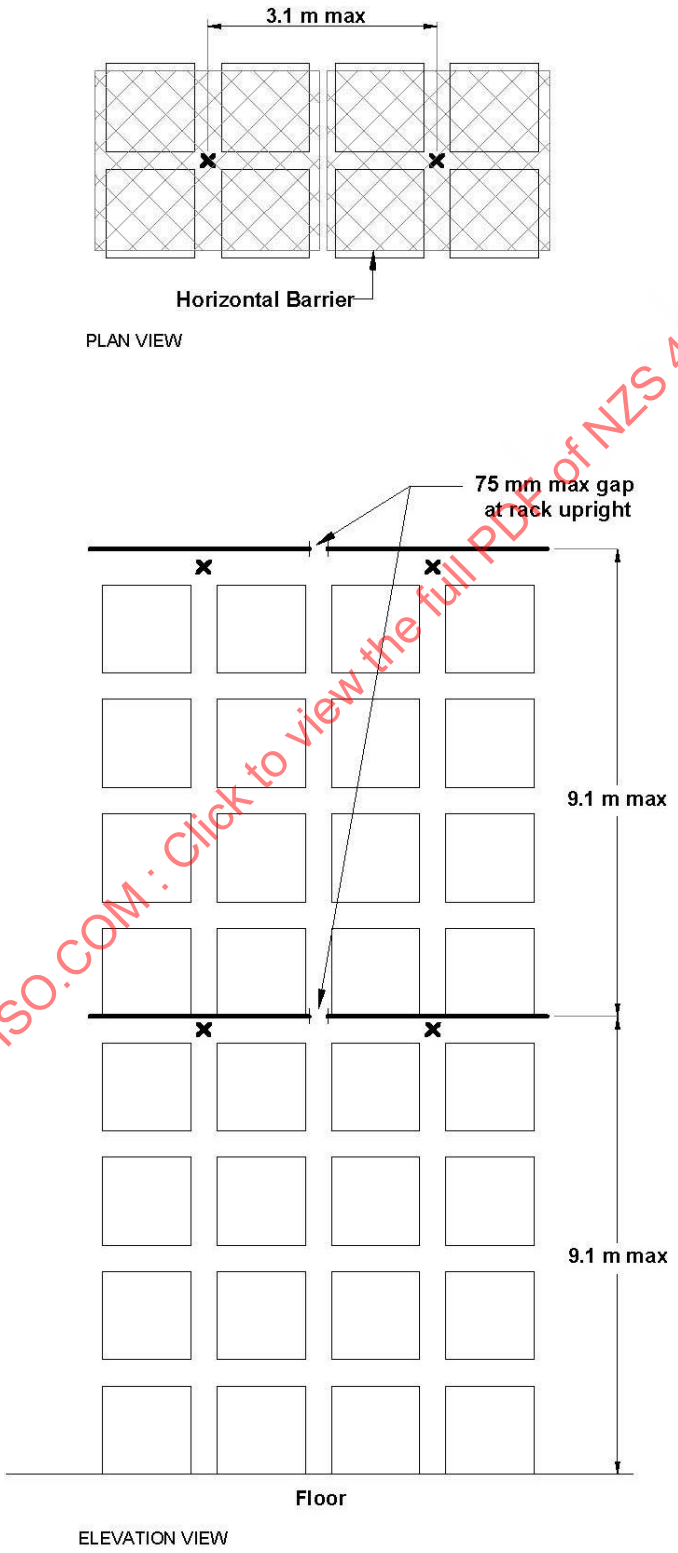
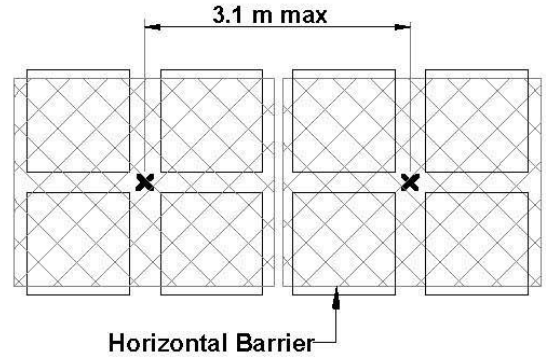


Figure 9.32(c) – Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in double-row racks, Option 2

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020



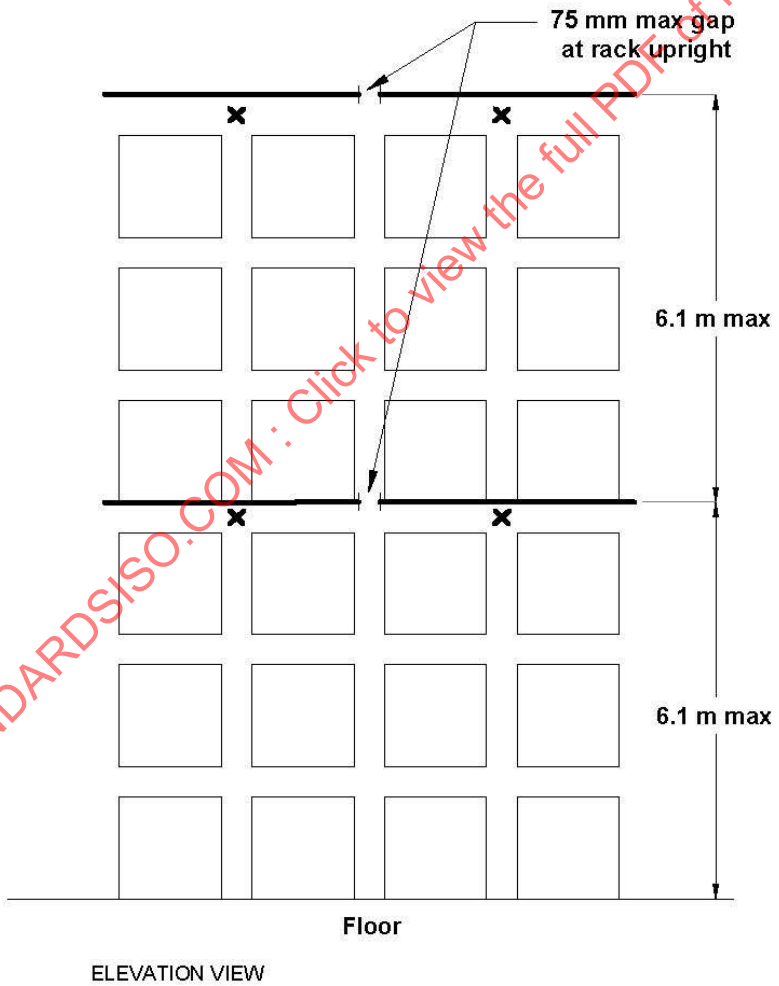


Figure 9.32(d) – Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in double-row racks, Option 2

9.4.4.4.3 Multiple-row racks

For multiple-row racks with an overall depth between aisles not exceeding 4.7 m, an alternating sprinkler arrangement shall be installed within adjacent transverse flue spaces as shown in Figure 9.32(e) Category 1

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

through Category 4 and cartoned Category 5 and Category 6 plastic commodity and Figure 9.32(f) for uncartoned Category 5 and Category 6 plastic commodity.

The maximum linear spacing between sprinklers at the face shall not exceed 3.1 m and shall not exceed 3.1 m between sprinklers at every other bay.

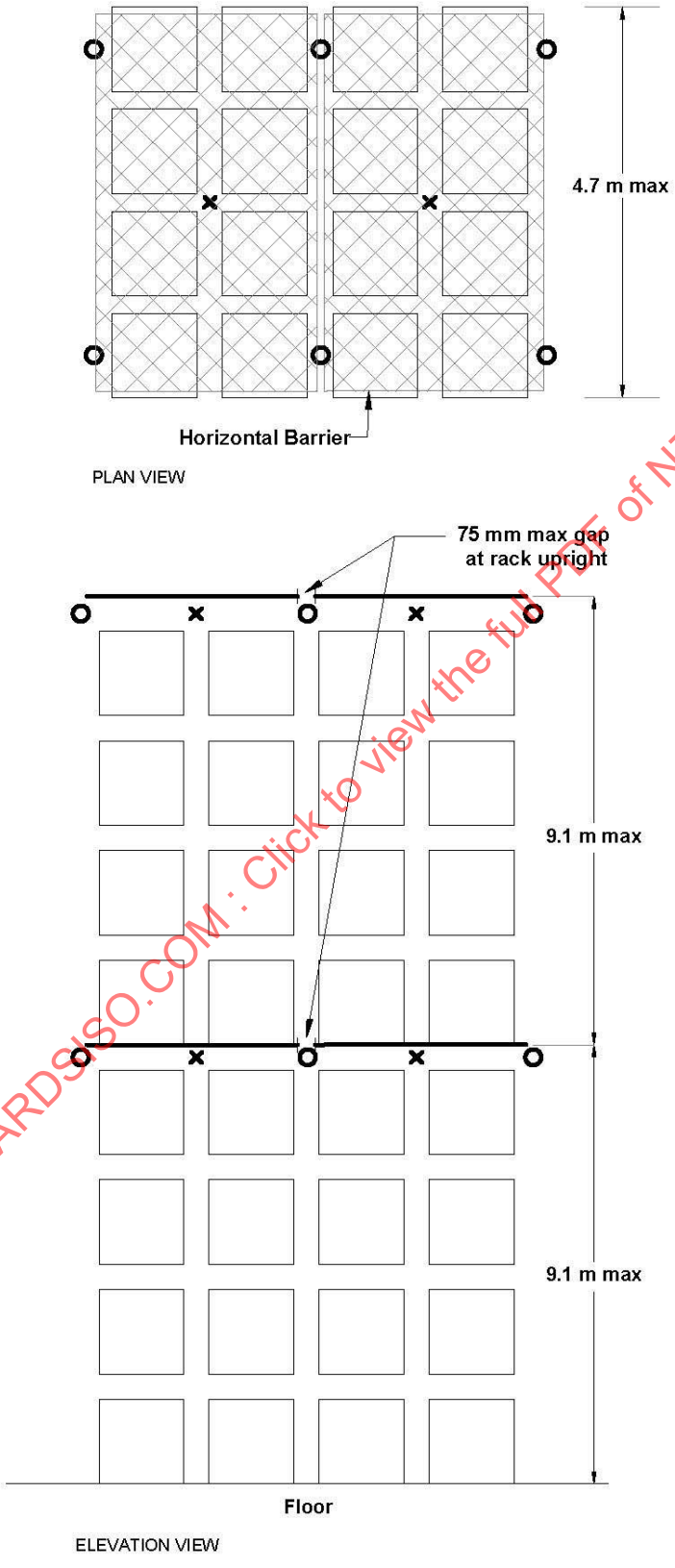


Figure 9.32(e) – Alternative in-rack sprinkler protection for Category 1 through Category 4 and cartoned Category 5 and Category 6 plastic commodities in multiple-row racks, Option 2

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

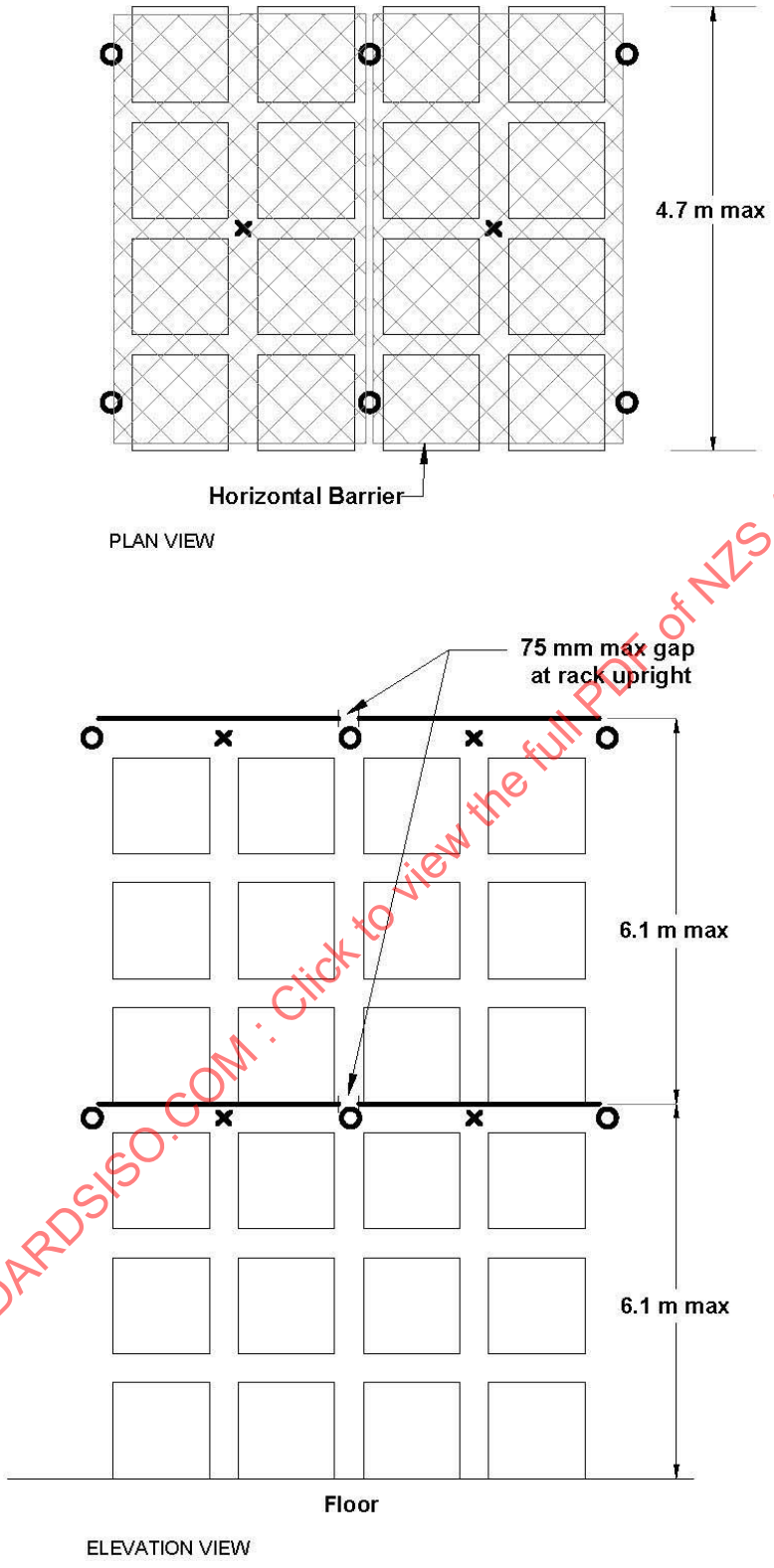


Figure 9.32(f) – Alternative in-rack sprinkler protection for uncartoned Category 5 and Category 6 plastic commodities in multiple-row racks, Option 2

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

9.4.4.4.4 Flammable liquids in retail areas and other ordinary hazard occupancies

9.4.4.4.4.1.

Flammable liquids in retail glass, plastic, and metal containers may be stored and displayed in OH3 retail areas protected by a minimum of an OH 3 or OH4 sprinkler system, subject to the following limitations:

(a) The maximum allowable storage height is 2.4 m;
(b) Class 3.1A and B flammable liquids in containers of greater than 1 litre capacity shall not be stored in retail areas designed to OH3 or OH4;
(c) Class 3.1C and D flammable liquids in containers of greater than 10 litres capacity shall not be stored in retail areas designed to OH3 or OH4; and
(d) Adjacent storage areas (see 9.4.4.4.4.2) of flammable liquids in retail areas shall be separated by a horizontal distance of at least 15 m or be in an adjacent firecell.

For the purposes of this clause, a firecell is defined as providing an FRR of at least –/60/60.

9.4.4.4.4.2.

The maximum volumes of flammable liquids allowed to be stored in OH3 retail occupancies protected to a minimum of OH3 occupancy are as follows:

(a) The maximum volume of Class 3.1A and B flammable liquids in any one storage area is 100 litres; and
(b) The maximum aggregate volume of other classes of flammable liquids in any one storage area is 1000 litres.

Storage or display of Class 3.1A, B, or C flammable liquids is not permitted in basements.

If the required storage criteria exceed the limits specified in these clauses, alternative design criteria may be found in Part 9, or NFPA 30.

9.5 Categorised commodities design requirements

9.5.1 *General*

Ceiling-level protection options for various storage arrangements and commodity classifications are provided in Tables 9.14(a) to (j) as shown in Table 9.13. See Appendix J for commodity classifications.

The design guidelines for ceiling-level storage sprinklers are based on five main attributes assigned to a sprinkler. They are:

(a) *K* factor (orifice size);
(b) Orientation (pendent or upright);
(c) Response time index rating (quick response or standard response);
(d) Nominal temperature rating; and
(e) Sprinkler spacing (standard or extended-coverage).

NOTE –

(1) Base the design for the storage area on the most severe commodity classification present anywhere within that storage area. The commodity classifications in the following table are ranked from the lowest hazard (Category 1) to the highest (Category 6 uncartoned expanded plastic). The design protection criteria may be somewhat different for solid pile or palletised arrangements as compared to rack storage because of the stability that is provided by the rack structure versus the instability and collapse of solid pile or palletised storage arrangements.

(2) See 9.4.2.7.3 for Scheme A if the most severe commodity exists in relatively small amounts throughout the storage area and designing protection creates a challenge.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.13 – Summary of ceiling-level protection tables

Storage arrangement	Commodity	Protection table
Solid-piled, palletised, shelf, or bin box	Categories 1, 2, and 3	9.14(a)
	Category 4 and cartoned Category 5 unexpanded plastic	9.14(b)
	Cartoned Category 6 expanded plastic	9.14(c)
	Uncartoned Category 5 unexpanded plastic	9.14(d)
	Uncartoned Category 6 expanded plastic	9.14(e)
Open-frame racks	Categories 1, 2, and 3	9.14(f)
	Category 4 and cartoned Category 5 unexpanded plastic	9.14(g)
	Cartoned Category 6 expanded plastic	9.14(h)
	Uncartoned Category 5 unexpanded plastic	9.14(i)
	Uncartoned Category 6 expanded plastic	9.14(j)

9.5.2 *Flue spaces*

Flue spaces within storage configurations that are arranged as outlined in this clause will promptly vent heat from a fire vertically. This allows for the sprinklers to operate as quickly as possible and reduced horizontal fire spread within the storage array. Flue spaces arranged as outlined in this clause will also allow sprinkler water penetration down through the storage arrangement. Without sufficient water penetration to burning commodities throughout the storage array, fire control may not be achieved.

9.5.2.1 *Flue spaces for rack storage protected by ceiling-level sprinklers only*

Maintain all transverse flue spaces at a minimum net width of 75 mm throughout the vertical height of the rack. Provide transverse flue spaces a maximum of every 1.4 m horizontally when their net width is less than 150 mm or when their vertical alignment cannot be maintained. The maximum horizontal distance between well-maintained, vertically aligned transverse flue spaces can be increased to 2.7 m when their net width is 150 mm or greater.

9.5.2.1.1 Longitudinal flues in double-row and multiple-row racks

Longitudinal flue spaces are not required in double-row racks; however, if they are provided, maintain a minimum net width of 75 mm throughout the vertical height of the rack. Provide net 150 mm wide longitudinal flue spaces within multiple-row racks a maximum of every 4.8 m horizontally.

9.5.2.1.2 Rolled and bulging commodities

Ensure rolled or similar types of commodities stored in racks are arranged so they cannot bulge into or encroach over flue spaces. If adequate flue spaces are difficult to maintain (for example, loading of racks becomes haphazard during peak production), provide wire mesh and/or other physical means to ensure adequate flue spaces are always maintained.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

9.5.2.1.3 Non-conforming flue spaces

Treat storage racks that do not have flue spaces as described in 9.5.2.1 through 9.5.2.2.3 as racks with solid shelves. Base the size of the shelf area on the presence of well-maintained, vertically aligned flue spaces having a minimum net width of 75 mm. If well maintained, vertically aligned flue spaces having a minimum net width of 75 mm cannot be provided, protect the racks based on the presence of solid shelves greaterthan 6.0 m^2 in area.

9.5.2.2 *Flue spaces for rack storage protected by both ceiling-level and in-rack sprinklers*

Maintain all transverse flue spaces at a minimum net width of 75 mm throughout the vertical height of the rack. However, transverse flue spaces are not required for the storage tier located directly above in-rack sprinklers or when in-rack sprinklers are provided at every tier level.

9.5.2.2.1 Longitudinal flues in double-row racks

Longitudinal flue spaces are not required in double-row racks; however, if they are provided, maintain a minimum net width of 75 mm throughout the vertical height of the rack. Longitudinal flue spaces are not required for the storage tier located directly above in-rack sprinklers or when in-rack sprinklers are provided at every tier level.

9.5.2.2.2 Rolled or bulging commodities

Arrange rolled or similar types of commodities stored in racks so they cannot bulge into or encroach over flue spaces located directly below in-rack sprinklers. The exception to this is storage located directly above a level of in-rack sprinklers. If adequate flue spaces are difficult to maintain (for example, loading of racks becomes haphazard during peak production), provide wire mesh and/or other physical means to ensure adequate flue spaces are always maintained.

9.5.2.2.3 Non-conforming flue spaces

Treat storage racks that do not have flue spaces as described above in 9.5.2.2 through 9.5.2.2.2 as racks with solid shelves greater than 6.0 m^2 in area.

9.5.2.3 *Solid-piled, palletised, shelf, and bin-box storage*

There are no specific requirements for the minimum size and horizontal distance between flue spaces for this type of storage; however, arrange storage such that flue spaces that are provided are not blocked from water penetration.

9.5.3 *Ceiling-level design guidelines and tables*

The ceiling-level protection design guidelines listed in the following tables use a design format based on an indicated number of operating sprinklers at a given minimum sprinkler operating pressure. No interpolation or adjustment shall be made for the values listed in these tables.

To determine the protection options available, find the appropriate protection table (Table 9.14(a) to (j)) based on the commodity and storage arrangements in Table 9.13. If the storage arrangement is racks with solid shelves or racks that shall be protected as if they have solid shelves, see 9.4.2.1 to determine the protection options available.

Once the appropriate table has been chosen, the available protection options shall be determined based on the maximum ceiling height of the protected area and the type of sprinkler system (wet or dry) to be installed.

The ceiling-level designs listed within these tables are provided to either achieve suppression like performance or when suppression-like performance is not available, offer the lowest allowable pressure for design purposes. If a design listed for a higher ceiling height hydraulically offers a better option than for the design indicated for the ceiling height of the storage area, the design for the higher ceiling height may be used.

Although Tables 9.14(a) to (j) use the number of sprinklers as a design format, ensure the size of the design area (number of sprinklers times sprinkler area spacing) does not drop below 71 m^2. If the size of the design area would be less than 71 m^2 based on the number of sprinklers indicated in Tables 9.14(a) to (j), increase the number of sprinklers to make the design area a minimum of 71 m^2.

The units for *K* factor values given in Tables 9.14(a) to (j) are Lpm/$kPa^{0.5}$.

NOTE – Storage arrangements vary among locations. In general, most storage arrangements can be classified as solid-piled, palletised, shelf, bin-box, or single-row, double-row, or multiple-row racks for the purpose of determining fire protection requirements. Within Part 9 the design guidelines for solid-piled, palletised, shelf, or bin-box storage arrangements are consolidated into the same table for a given commodity hazard. Similarly, the design guidelines for single-row, double-row, and multiple-row storage racks are consolidated into the same table for a given commodity hazard.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

Table 9.14(a) – Ceiling-level protection guidelines for Categories 1, 2, and 3 commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement

Protection of Categories 1, 2, and 3 commodities in solid-piled, palletised, shelf, or bin-box arrangements No. of sprinklers @ kPa																				
Ceiling height (m)[1]	**Wet system, pendent sprinklers, 70°C[2]**										**Wet system, upright sprinklers, 70°C**							**Dry system, upright sprinklers, 140°C**			
	Quick response						**Standard response**				**Quick response**				**Standard response**			**Standard response**			
	***K*16**	***K*20**	***K*24**	***K*32**	***K*36**	***K*36 EC**	***K*16**	***K*20**	***K*28**	***K*36**	***K*16**	***K*20**	***K*24**	***K*36 EC**	***K*16**	***K*24**	***K*36**	***K*16**	***K*24**	***K*28**	***K*36**
6.1	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	12 @ 110	12 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
7.6	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	12 @ 110	12 @ 70	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
9.1	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	20 @ 50	20 @ 50	12 @ 110	12 @ 70	20 @ 50	12 @ 350	12 @ 240	6 @ 170	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
10.7	15 @ 170	12 @ 520	12 @ 350	12 @ 210	12 @ 210	6 @ 410	15 @ 170	15 @ 100	15 @ 110	12 @ 100	15 @ 170	12 @ 520	12 @ 350	8 @ 280[3]	15 @ 170	15 @ 70	15 @ 50	See 9.5.6			
12.2		12 @ 520	12 @ 350	12 @ 280	12 @ 280					12 @ 210											
13.7		12 @ 620	12 @ 450	12 @ 350	12 @ 350																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table can be based on any ceiling height equal to or higher than the actual maximum ceiling height of the protected area.

(2) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

(3) The design of 8 @ 280 kPa has a duration of 60 minutes when the maximum linear spacing is up to 3.6 m; for a linear spacing over 3.6 m the duration is 120 minutes. An acceptable alternative design is 10 @ 70 kPa using a duration of 120 minutes.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.14(b) – Ceiling-level protection guidelines for Category 4 and Category 5 cartoned unexpanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement

Protection of Category 4 and Category 5 cartoned unexpanded plastic commodities in solid-piled, palletised, shelf, or bin-box arrangements No. of sprinklers @ kPa																					
Ceiling height (m)[1]	**Wet system, pendent sprinklers, 70°C[2]**										**Wet system, upright sprinklers, 70°C**							**Dry system, upright sprinklers, 140°C**			
	Quick response						**Standard response**				**Quick response**				**Standard response**			**Standard response**			
	***K*16**	***K*20**	***K*24**	***K*32**	***K*36**	***K*36 EC**	***K*16**	***K*20**	***K*28**	***K*36**	***K*16**	***K*20**	***K*24**	***K*36 EC**	***K*16**	***K*24**	***K*36**	***K*16**	***K*24**	***K*28**	***K*36**
4.6	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	12 @ 110	12 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
6.1	15 @ 170	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	15 @ 170	15 @ 100	12 @ 110	12 @ 50	15 @ 170	12 @ 350	12 @ 240	6 @ 140	15 @ 170	15 @ 100	12 @ 140	20 @ 170	20 @ 100	20 @ 210	20 @ 50
7.6	15 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	15 @ 350	15 @ 240	12 @ 110	12 @ 70	15 @ 350	12 @ 350	12 @ 240	6 @ 140	15 @ 350	15 @ 150	12 @ 140	20 @ 350	20 @ 150	20 @ 210	20 @ 70
9.1	20 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	20 @ 350	20 @ 240	12 @ 110	12 @ 70	20 @ 350	12 @ 350	12 @ 240	6 @ 170	20 @ 350	20 @ 150	12 @ 140	25 @ 350	25 @ 150	25 @ 210	25 @ 70
10.7		12 @ 520	12 @ 350	12 @ 210	12 @ 210	6 @ 410[3]			15 @ 170	12 @ 210		12 @ 520	12 @ 350	8 @ 280[4]							
12.2		12 @ 520	12 @ 350	12 @ 280	12 @ 280					12 @ 210											
13.7		12 @ 620	12 @ 450	12 @ 350	12 @ 350																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table can be based on any ceiling height equal to or higher than the actual maximum ceiling height of the protected area.

(2) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

(3) An acceptable alternative design is 8 @ 280 kPa when a 3.6 m maximum linear spacing is used.

(4) The design of 8 @ 280 kPa has a duration of 60 minutes when the maximum linear spacing is up to 3.6 m; for a linear spacing over 3.6 m the duration is 120 minutes.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.14(c) – Ceiling-level protection guidelines for cartoned Category 6 expanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement

Protection of cartoned Category 6 expanded plastic commodities in solid-piled, palletised, shelf, or bin-box arrangements No. of sprinklers @ kPa																					
Ceiling height (m)[1]	Wet system, pendent sprinklers, 70°C[2]										Wet system, upright sprinklers, 70°C							Dry system, upright sprinklers, 140°C			
	Quick response						Standard response				Quick response				Standard response			Standard response			
	*K*16	*K*20	*K*24	*K*32	*K*36	*K*36 EC	*K*16	*K*20	*K*28	*K*36	*K*16	*K*20	*K*24	*K*36 EC	*K*16	*K*24	*K*36	*K*16	*K*24	*K*28	*K*36
3.0	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	15 @ 110	15 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	15 @ 50	25 @ 50	25 @ 50	20 @ 210	20 @ 50
4.6	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	15 @ 110	15 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	15 @ 50	25 @ 50	25 @ 50	20 @ 210	20 @ 50
6.1	15 @ 170	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	15 @ 170	15 @ 100	15 @ 110	15 @ 50	15 @ 170	12 @ 350	12 @ 240	6 @ 140	15 @ 170	15 @ 100	15 @ 50	20 @ 170	20 @ 100	20 @ 210	20 @ 50
7.6	15 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	15 @ 350	15 @ 240	15 @ 140	15 @ 70	15 @ 350	12 @ 350	12 @ 240	6 @ 140	15 @ 350	15 @ 150	15 @ 70	20 @ 350	20 @ 150	20 @ 210	20 @ 70
9.1	20 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 280	20 @ 350	20 @ 240	20 @ 140	20 @ 70	20 @ 350	12 @ 350	12 @ 240	10 @ 280	20 @ 350	20 @ 150	20 @ 70	25 @ 350	25 @ 150	25 @ 210	25 @ 70
10.7					12 @ 410																
12.2					12 @ 410																

NOTE –

The data in this table has been reproduced courtesy of FM Global.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.14(d) – Ceiling-level protection guidelines for uncartoned Category 5 unexpanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement

Protection of uncartoned Category 5 unexpanded plastic commodities in solid-piled, palletised, shelf, or bin-box arrangements No. of sprinklers @ kPa																					
Ceiling height (m)[1]	Wet system, pendent sprinklers, 70°C[2]										Wet system, upright sprinklers, 70°C							Dry system, upright sprinklers, 140°C			
	Quick response						Standard response				Quick response				Standard response			Standard response			
	*K*16	*K*20	*K*24	*K*32	*K*36	*K*36 EC	*K*16	*K*20	*K*28	*K*36	*K*16	*K*20	*K*24	*K*36 EC	*K*16	*K*24	*K*36	*K*16	*K*24	*K*28	*K*36
3.0	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 50	20 @ 50	20 @ 50	15 @ 110	15 @ 50	20 @ 50	12 @ 350	12 @ 240	10 @ 50	20 @ 50	20 @ 50	15 @ 50	25 @ 50	25 @ 50	20 @ 210	20 @ 50
4.6	25 @ 50	12 @ 350	12 @ 240	12 @ 240	12 @ 240	12 @ 50	25 @ 50	25 @ 50	15 @ 110	15 @ 50	25 @ 50	12 @ 350	12 @ 240	12 @ 50	25 @ 50	25 @ 50	15 @ 50	35 @ 50	35 @ 50	20 @ 210	20 @ 50
6.1	15 @ 170	12 @ 350	12 @ 240	12 @ 240	12 @ 240	8 @ 140	15 @ 170	15 @ 140	15 @ 110	15 @ 50	15 @ 170	12 @ 350	12 @ 240	8 @ 140	15 @ 170	15 @ 100	15 @ 50	20 @ 170	20 @ 100	20 @ 210	20 @ 50
7.6	15 @ 350	12 @ 350	12 @ 240	12 @ 240	12 @ 240	8 @ 280	15 @ 350	15 @ 240	15 @ 140	15 @ 70	15 @ 350	12 @ 350	12 @ 240	8 @ 280	15 @ 350	15 @ 150	15 @ 70	20 @ 350	20 @ 150	20 @ 210	20 @ 70
9.1	20 @ 350	12 @ 350	12 @ 240	12 @ 240	12 @ 240	10 @ 280	20 @ 350	20 @ 240	20 @ 140	20 @ 70	20 @ 350	12 @ 350	12 @ 240	10 @ 280	20 @ 350	20 @ 150	20 @ 70	25 @ 350	25 @ 150	25 @ 210	25 @ 70
10.7		12 @ 520	12 @ 350	12 @ 350	12 @ 350																
12.2		12 @ 520	12 @ 350	12 @ 350	12 @ 350																
13.7				12 @ 450	12 @ 410																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.14(e) – Ceiling-level protection guidelines for uncartoned Category 6 expanded plastic commodities in a solid-piled, palletised, shelf, or bin-box storage arrangement

Protection of uncartoned expanded plastic commodities in solid-piled, palletised, shelf, or bin-box arrangements No. of sprinklers @ kPa																				
Ceiling height (m)[1]	Wet system, pendent sprinklers, 70°C[2]										Wet system, upright sprinklers, 70°C							Dry system, upright sprinklers, 140°C			
	Quick response						Standard response				Quick response				Standard response			Standard response			
	*K*16	*K*20	*K*24	*K*32	*K*36	*K*36 EC	*K*16	*K*20	*K*28	*K*36	*K*16	*K*20	*K*24	*K*36 EC	*K*16	*K*24	*K*36	*K*16	*K*24	*K*28	*K*36
3.0	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 50	20 @ 50	20 @ 50	15 @ 110	15 @ 50	20 @ 50	20 @ 50	12 @ 50	10 @ 50	20 @ 50	20 @ 50	15 @ 50	25 @ 50	25 @ 50	20 @ 210	20 @ 50
4.6	15 @ 170	12 @ 350	12 @ 240	12 @ 170	12 @ 170	8 @ 140	15 @ 170	15 @ 140	15 @ 110	15 @ 50	15 @ 170	15 @ 110	15 @ 80	8 @ 140	15 @ 170	15 @ 100	15 @ 50	20 @ 170	20 @ 100	20 @ 210	20 @ 50
6.1	15 @ 350	12 @ 350	12 @ 240	12 @ 170	12 @ 170	8 @ 280	15 @ 350	15 @ 240	15 @ 110	15 @ 70	15 @ 350	15 @ 220	15 @ 150	8 @ 280	15 @ 150	15 @ 150	15 @ 70	20 @ 350	20 @ 150	20 @ 210	20 @ 70
7.6	25 @ 350	12 @ 350	12 @ 240	12 @ 170	12 @ 170	12 @ 280	25 @ 350	25 @ 240	25 @ 110	25 @ 70	25 @ 350	25 @ 220	25 @ 150	12 @ 280	25 @ 350	25 @ 150	25 @ 70	35 @ 350	35 @ 150	35 @ 210	35 @ 70
9.1		12 @ 690	12 @ 480	10 @ 280	10 @ 280																
10.7					20 @ 520																
12.2					20 @ 520																
The data in this table has been reproduced courtesy of FM Global.																					

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.14(f) – Ceiling-level protection guidelines for Categories 1, 2, and 3 commodities in open-frame rack storage arrangements

Protection of Categories 1, 2, and 3 commodities in open-frame storage racks No. of sprinklers @ kPa																				
Ceiling height (m)[1]	Wet system, pendent sprinklers, 70°C[2]										Wet system, upright sprinklers, 70°C							Dry system, upright sprinklers, 140°C			
	Quick response						Standard response				Quick response				Standard response			Standard response			
	*K*16	*K*20	*K*24	*K*32	*K*36	*K*36 EC	*K*16	*K*20	*K*28	*K*36	*K*16	*K*20	*K*24	*K*36 EC	*K*16	*K*24	*K*36	*K*16	*K*24	*K*28	*K*36
6.1	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	20 @ 50	20 @ 50	12 @ 110	12 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 140	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
7.6	15 @ 210	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 140	15 @ 210	15 @ 140	12 @ 110	12 @ 70	15 @ 210	12 @ 350	12 @ 240	6 @ 140	15 @ 210	15 @ 100	12 @ 140	20 @ 210	20 @ 100	20 @ 210	20 @ 50
9.1	20 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 210	20 @ 350	20 @ 240	12 @ 110	12 @ 70	20 @ 350	12 @ 350	12 @ 240	6 @ 210	20 @ 350	20 @ 150	12 @ 140	25 @ 350	25 @ 150	25 @ 210	25 @ 70
10.7		12 @ 520	12 @ 350	12 @ 210	12 @ 210	6 @ 410[2]			15 @ 170	12 @ 210		12 @ 520	12 @ 350	8 @ 280				See 9.5.6			
12.2		12 @ 520	12 @ 350	12 @ 280	12 @ 280					12 @ 210											
13.7				12 @ 350	12 @ 350																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

(2) An acceptable alternative design is 8 @ 280 kPa when a 3.6 m maximum linear spacing is used.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.14(g) – Ceiling-level protection guidelines for Category 4 and cartoned Category 5 unexpanded plastic commodities in open-frame rack storage arrangements

Protection of Category 4 and cartoned Category 5 unexpanded plastic commodities in open-frame storage racks No. of sprinklers @ kPa																					
Ceiling height (m)[1]	**Wet system, pendent sprinklers, 70°C[2]**										**Wet system, upright sprinklers, 70°C**							**Dry system, upright sprinklers, 140°C**			
	Quick response						**Standard response**				**Quick response**				**Standard response**			**Standard response**			
	***K*16**	***K*20**	***K*24**	***K*32**	***K*36**	***K*36 EC**	***K*16**	***K*20**	***K*28**	***K*36**	***K*16**	***K*20**	***K*24**	***K*36 EC**	***K*16**	***K*24**	***K*36**	***K*16**	***K*24**	***K*28**	***K*36**
4.6	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	20 @ 50	20 @ 50	12 @ 110	12 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 170	20 @ 50	20 @ 50	12 @ 140	25 @ 50	25 @ 50	20 @ 210	20 @ 50
6.1	15 @ 140	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	15 @ 170	15 @ 100	12 @ 110	12 @ 50TE –	15 @ 170	12 @ 350	12 @ 240	6 @ 170	15 @ 170	15 @ 100	12 @ 140	20 @ 170	20 @ 100	20 @ 210	20 @ 50
7.6	15 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	15 @ 350	15 @ 240	12 @ 110	12 @ 70	15 @ 350	12 @ 350	12 @ 240	6 @ 170	15 @ 350	15 @ 150	12 @ 140	20 @ 350	20 @ 150	20 @ 210	20 @ 70
9.1		12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 210			12 @ 110	12 @ 70		12 @ 350	12 @ 240	6 @ 210			12 @ 140			25 @ 210	25 @ 100
10.7		12 @ 520	12 @ 350	12 @ 210	12 @ 210	6 @ 410[2]			15 @ 170	12 @ 210		12 @ 520	12 @ 350	8 @ 280							
12.2		12 @ 520	12 @ 350	12 @ 280	12 @ 280					12 @ 210											
13.7				12 @ 350	12 @ 350																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) An acceptable alternative design is 8 @ 280 kPa when a 3.6 m maximum linear spacing is used.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.14(h) – Ceiling-level protection guidelines for cartoned Category 6 expanded plastic commodities in open-frame rack storage arrangements

Protection of cartoned Category 6 expanded plastic commodities in open-frame storage racks No. of sprinklers @ kPa																					
Ceiling height (m)[1]	Wet system, pendent sprinklers, 70°C[2]										Wet system, upright sprinklers, 70°C							Dry system, upright sprinklers, 140°C			
	Quick response						Standard response				Quick response				Standard response			Standard response			
	*K*16	*K*20	*K*24	*K*32	*K*36	*K*36 EC	*K*16	*K*20	*K*28	*K*36	*K*16	*K*20	*K*24	*K*36 EC	*K*16	*K*24	*K*36	*K*16	*K*24	*K*28	*K*36
4.6	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	20 @ 50	20 @ 50	15 @ 110	15 @ 50	20 @ 50	12 @ 350	12 @ 240	6 @ 170	20 @ 50	20 @ 50	15 @ 50	25 @ 50	25 @ 50	20 @ 210	20 @ 50
6.1	15 @ 170	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	15 @ 170	15 @ 100	15 @ 110	15 @ 50	15 @ 170	12 @ 350	12 @ 240	6 @ 170	15 @ 170	15 @ 100	15 @ 50	20 @ 170	20 @ 100	20 @ 210	20 @ 50
7.6	15 @ 350	12 @ 350	12 @ 240	12 @ 140	12 @ 140	6 @ 170	15 @ 350	15 @ 240	15 @ 140	15 @ 70	15 @ 350	12 @ 350	12 @ 240	6 @ 170	15 @ 350	15 @ 150	15 @ 70	20 @ 350	20 @ 150	20 @ 210	20 @ 70
9.1		12 @ 350	12 @ 240	12 @ 140	12 @ 140							12 @ 350	12 @ 240								
10.7					12 @ 410																
12.2					12 @ 410																
The data in this table has been reproduced courtesy of FM Global.																					

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

© STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 9.14(i) – Ceiling-level protection guidelines for uncartoned Category 5 unexpanded plastic commodities in open-frame rack storage arrangements

Protection of uncartoned Category 5 unexpanded plastic commodities in open-frame storage racks No. of sprinklers @ kPa																					
Ceiling height (m)[1]	**Wet system, pendent sprinklers, 70°C**										**Wet system, upright sprinklers, 70°C**							**Dry system, upright sprinklers, 140°C**			
	Quick response						**Standard response**				**Quick response**				**Standard response**			**Standard response**			
	***K*16**	***K*20**	***K*24**	***K*32**	***K*36**	***K*36 EC**	***K*16**	***K*20**	***K*28**	***K*36**	***K*16**	***K*20**	***K*24**	***K*36 EC**	***K*16**	***K*24**	***K*36**	***K*16**	***K*24**	***K*28**	***K*36**
1.5	20 @ 50	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 50	20 @ 50	20 @ 50	20 @ 110	20 @ 50	20 @ 50	20 @ 50	20 @ 50	10 @ 50	20 @ 50	20 @ 50	20 @ 50	25 @ 50	25 @ 50	25 @ 210	25 @ 50
2.4	20 @ 110	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 80	20 @ 110	20 @ 70	20 @ 110	20 @ 50	20 @ 110	20 @ 70	20 @ 50	10 @ 80	20 @ 110	20 @ 50	20 @ 50	25 @ 110	25 @ 50	25 @ 210	25 @ 50
3.0	20 @ 210	12 @ 350	12 @ 240	12 @ 140	12 @ 140	10 @ 150	20 @ 210	20 @ 140	20 @ 110	20 @ 50	20 @ 210	20 @ 140	20 @ 90	10 @ 150	20 @ 210	20 @ 90	20 @ 50	25 @ 210	25 @ 90	25 @ 210	25 @ 50
3.6	20 @ 350	12 @ 350	12 @ 240	12 @ 170	12 @ 170	10 @ 280	20 @ 350	20 @ 240	20 @ 110	20 @ 70	20 @ 350	20 @ 240	20 @ 170	10 @ 280	20 @ 350	20 @ 150	20 @ 70	25 @ 350	25 @ 150	25 @ 210	25 @ 70
4.6	25 @ 350	12 @ 350	12 @ 240	12 @ 170	12 @ 170	12 @ 280	25 @ 350	25 @ 240	25 @ 110	25 @ 70	25 @ 350	25 @ 240	25 @ 170	12 @ 280	25 @ 350	25 @ 150	25 @ 70	30 @ 350	30 @ 150	30 @ 210	30 @ 70
6.1		12 @ 350	12 @ 240	12 @ 170	12 @ 170	6 @ 620		12 @ 520	12 @ 280	12 @ 170											
7.6		12 @ 350	12 @ 240	12 @ 210	12 @ 210																
9.1		12 @ 520	12 @ 350	10 @ 280	10 @ 280																
10.7					12 @ 410																
12.2					12 @ 410																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 9.14(j) – Ceiling-level protection guidelines for uncartoned Category 6 expanded plastic commodities in open-frame rack storage arrangements

Protection of uncartoned Category 6 expanded plastic commodities in open-frame storage racks No. of sprinklers @ kPa																					
Ceiling height (m)[1]	**Wet system, pendent sprinklers, 70°C[2]**										**Wet system, upright sprinklers, 70°C**							**Dry system, upright sprinklers,140°C**			
	Quick response						**Standard response**				**Quick response**				**Standard response**			**Standard response**			
	***K*16**	***K*20**	***K*24**	***K*32**	***K*36**	***K*36 EC**	***K*16**	***K*20**	***K*28**	***K*36**	***K*16**	***K*20**	***K*24**	***K*36 EC**	***K*16**	***K*24**	***K*36**	***K*16**	***K*24**	***K*28**	***K*36**
1.5	20 @ 50	12 @ 520	12 @ 350	12 @ 140	12 @ 140	10 @ 50	20 @ 50	20 @ 50	20 @ 110	20 @ 50	20 @ 50	20 @ 50	20 @ 50	10 @ 50	20 @ 50	20 @ 50	20 @ 50	25 @ 50	25 @ 50	25 @ 210	25 @ 50
2.4	20 @ 110	12 @ 520	12 @ 350	12 @ 140	12 @ 140	10 @ 80	20 @ 110	20 @ 70	20 @ 110	20 @ 50	20 @ 110	20 @ 70	20 @ 50	10 @ 80	20 @ 110	20 @ 50	20 @ 50	25 @ 110	25 @ 50	25 @ 210	25 @ 50
3.0	20 @ 210	12 @ 520	12 @ 350	12 @ 140	12 @ 140	10 @ 150	20 @ 210	20 @ 140	20 @ 110	20 @ 50	20 @ 210	20 @ 140	20 @ 90	10 @ 150	20 @ 210	20 @ 90	20 @ 50	25 @ 210	25 @ 90	25 @ 210	25 @ 50
3.6	20 @ 350	12 @ 520	12 @ 350	12 @ 170	12 @ 170	10 @ 280	20 @ 350	20 @ 240	20 @ 110	20 @ 70	20 @ 350	20 @ 240	20 @ 170	10 @ 280	20 @ 350	20 @ 150	20 @ 70	25 @ 350	25 @ 150	25 @ 210	25 @ 70
4.6	25 @ 350	12 @ 520	12 @ 350	12 @ 170	12 @ 170	12 @ 280	25 @ 350	25 @ 240	25 @ 110	25 @ 70	25 @ 350	25 @ 240	25 @ 170	12 @ 280	25 @ 350	25 @ 150	25 @ 70	35 @ 350	35 @ 150	35 @ 210	35 @ 70
6.1		12 @ 520	12 @ 350	12 @ 170	12 @ 170																
7.6		12 @ 520	12 @ 350	12 @ 210	12 @ 210																
9.1		12 @ 690	12 @ 480	12 @ 280	12 @ 280																
10.7					20 @ 520																
12.2					20 @ 520																

The data in this table has been reproduced courtesy of FM Global.

NOTE –

(1) The protection options indicated in the protection table for upright sprinklers can also be used as an alternative option for pendent sprinklers having the same *K* factor, RTI rating, nominal temperature rating and spacing requirements as the upright sprinkler.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.5.4 *Ceiling heights in excess of those indicated in protection tables for ceiling-level storage sprinklers*

When ceiling heights are in excess of those indicated in the applicable protection table from 9.5.3 (Table 9.14(a) to (j)), follow the requirements of 9.5.4.1 for storage arrangements involving racks, or 9.5.4.2 for solid-piled, palletised, shelf, and bin-box storage arrangements.

9.5.4.1 *Ceiling heights in excess of those indicated in protection tables for ceiling-level storage sprinklers protecting rack storage*

Implement one of the two options listed below (see 9.5.4.1.1 and 9.5.4.1.2) when ceiling-only options are not available.

9.5.4.1.1 Option 1: Installation of a false ceiling

Install a non-combustible false ceiling directly over and at least 4.6 m beyond the storage area. Design a non-combustible false ceiling (for example steel sheet, plasterboard), designed to ensure it can withstand a minimum uplift pressure of 14.4 kg/m^2. Provide sprinklers under the false ceiling and design them based on the guidelines indicated in the applicable protection table (Table 9.14(a) to (j) for the height above the floor over which the false ceiling has been installed. If, however, in-racks sprinklers are still needed, even in the presence of a false ceiling, design the sprinklers under the false ceiling in accordance with Table 9.9.

9.5.4.1.2 Option 2: Installation of in-rack sprinklers

Follow the guidelines in 9.4.2.5 to determine the acceptable horizontal layout of the in-rack sprinklers, and 9.4.2.6 for the vertical increments in which the in-rack sprinklers can be installed.

If there are more than 6.0 m of vertical clearance between the top of storage and the ceiling above, supplement the existing in-rack sprinkler arrangement obtained from 9.4.2.5 and 9.4.2.6 by installing in-rack sprinklers at the top tier level of the storage rack. Use an in-rack arrangement in accordance with Figures 9.28(a), (c), and (d), depending on the rack type. If a horizontal barrier is provided above this top level of in- rack sprinklers, Figure 9.28(b) can be used as an alternative for double-row racks, and Figure 9.27(c) can beused as an alternative for multiple-row racks. Design the ceiling-level sprinklers in accordance with Table 9.9. Limit the storage on the top tier to a maximum of 1.5 m.

9.5.4.2 *Ceiling heights in excess of those indicated in protection tables for ceiling-level storage sprinklers protecting solid-piled, palletised, shelf, or binbox storage arrangements*

Implement one of the two options listed below (see 9.5.4.2.1 and 9.5.4.2.2) when ceiling-only options are not available.

9.5.4.2.1 Option 1: Installation of a false ceiling

Install a false ceiling (see 9.2.14), directly over and at least 4.5 m beyond the storage area. Provide sprinklers under the false ceiling and design them based on the guidelines indicated in the applicable protection table (Table 9.14(a) to (j)) for the height above the floor over which the false ceiling has been installed.

9.5.4.2.2 Option 2: Conversion to rack storage

If a false ceiling as indicated in 9.5.4.2.1 cannot be installed, the storage arrangement shall be converted to a rack storage arrangement protected by ceiling with in-rack sprinklers. Follow the guidelines in 9.5.3 for the appropriate design requirements.

9.5.5 *Special storage considerations*

9.5.5.1 *Open-top, five-sided containers maintained in storage racks*

Open-top, five-sided containers will collect sprinkler water, keeping it from running across the top of storage and down the flues. This will prevent water penetration to the fire in the lower levels where it is needed. Rack collapse may also occur if too much water is collected.

9.5.5.1.1 Exceptions for non-combustible open-top, five-sided containers

Open-top, five-sided non-combustible containers shall not need special consideration when:

(a) They are located on the top tier of the storage rack and all storage located below them is also in non-combustible containers;
(b) They are all located on the bottom tier of the storage rack;
(c) They are provided with either wire mesh siding or large uniform openings along the bottom perimeter of each container, such that all water that enters the container will leave the container at the same flow rate and discharge evenly into the flue spaces. For this option to apply, storage within the container shall not be water absorbent nor be capable of blocking any of the container holes; or

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(d) They are intermixed with storage in combustible containers, they are not located on the top tier of the storage rack, and they do not extend into the transverse flue spaces.

If none of these conditions is met, see 9.5.5.1.3 and 9.5.5.1.4 to determine how to account for the presence of these containers within storage racks.

9.5.5.1.2 Exceptions for combustible open-top, five-sided containers

Open-top, five-sided, combustible containers shall not need special consideration when:

(a) They are all located on the bottom tier of the rack storage;
(b) They are not located on the top tier of the storage rack and they do not extend into the transverse flue spaces;
(c) They are provided with either wire mesh siding or large uniform openings along the bottom perimeter of each container, such that all water that enters the container will leave the container at the same flow rate and discharge evenly into the flue spaces. For this option to apply, storage within the container shall not be water absorbent nor be capable of blocking any of the container holes; or
(d) The storage racks are equipped with flat or domed-shaped fixed-in-place lids that are provided directly above the open-top containers and will prevent water from entering the open-top container, as well as distribute water equally into all flue spaces (this only applies for pallet loads that are fixed-in-place within a rack structure).

If none of these conditions is met, see 9.5.5.1.3 and 9.5.5.1.4 to determine how to account for the presence of these containers within storage racks.

9.5.5.1.3 Open-top containers in open-frame racks or with solid shelves up to 6.0 m^2

When the open-top container hazard cannot be eliminated, and the storage racks are either open-frame or have solid shelves up to 6.0 m^2 in area, provide protection for the racks as though 2.0 to 6.0 m^2 solid shelves are present. In addition, at least one level of in-rack sprinklers is needed for any storage in excess of 3.0 m high. Install in-rack sprinklers at every transverse flue space intersection (IRS(E) arrangement) at the vertical tier heights where in-rack sprinklers are recommended as per 9.4.2.6.

9.5.5.1.4 Open-top containers in storage racks with solid shelves greater than 6.0 m^2

When the open-top container hazard cannot be eliminated, and the storage racks have solid shelves greater than 6.0 m^2 in area, protect the rack storage based on presence of solid shelves greater than 6.0 m^2 in area and install in-rack sprinklers at every transverse flue spaces intersection (IRS(E) arrangement).

9.5.5.2 *Portable racks*

Portable racks are designed to be transported with fork-lift trucks. They are typically found to have wire mesh siding with solid bottoms; however, they can be arranged in various configurations of solid or non-solid sides and bottoms. Commodities stored in portable racks burn differently than cartoned commodities maintained in storage racks, as the initial fire within a portable rack does not involve a surface fire on the outside of a cardboard box, but rather the actual commodity stored inside the portable rack. This generally results in a more challenging fire when compared to fires in open-frame storage racks.

If the portable racks are not provided with proper flue spaces between them (or with another means of allowing heat from a fire to vent vertically while at the same time water from sprinklers to penetrate down through them), fire control will not be possible.

9.5.5.2.1 Portable racks with bottoms at least 70% open

Treat portable racks with bottoms at least 70% open as open-frame rack storage as long as the storage within the portable rack allows heat from a fire to vent vertically up through the portable rack and allows water to penetrate down through the portable rack and does not absorb water. Otherwise, treat the portable rack as having a solid bottom.

9.5.5.2.2 Portable racks with solid bottoms or bottoms less than 70% open

For portable racks with solid bottoms or bottoms less than 70% open limit the footprint size of a portable rack to a maximum of 2.0 m^2 and provide minimum 75 mm wide flue spaces around all sides of the portable rack. Protect such a portable rack arrangement in accordance with the guidelines for open-frame rack storage as outlined in 9.5.3. As an alternative, limit the footprint size of a portable rack to a maximum of 4.0 m^2 and equip the portable rack with three full-height, fixed-in-place, solid wooden, or non-combustible sides that will inhibit horizontal fire spread. Protect such a portable rack arrangement in accordance with the guidelines for solid-piled storage as outlined in 9.4.2.6.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

9.5.5.2.3 Non-conforming portable racks

Treat portable racks that do not meet the guidelines in 9.5.5.2.1 and 9.5.5.2.2 as rack storage having solid shelves. Size the shelf area using the guidelines for rack storage.

If ceiling-only protection options are not available from the applicable protection table (Tables 9.14(a) to (j)), limit the storage area of the portable racks to a maximum of 9.3 m^2, as defined by a minimum 2.4 m wide clear space on all sides of the storage area, and limit the storage height to a maximum of 3.0 m for cartoned commodities or 1.5 m if the commodity hazard is uncartoned plastics. Base the automatic sprinkler system design requirements on the occupancy surrounding the portable storage instead of the portable storage itself.

9.5.5.3 *Moveable racks*

Movable racks are designed to use as much of the available storage space as possible. Usually, racks are on tracks and are butted against one another in the aisle-face direction. Loading and unloading takes place in the aisle that is open. Loaded racks are located on one or both sides of the aisles, and empty racks may be located anywhere.

Protect rack storage in movable racks as multiple-row rack storage. Supply in-rack sprinklers (when required) via flexible in-rack sprinkler system connections, or other arrangements that provide sufficient water to the in-rack sprinklers.

9.5.6 *Ceiling-only dry-pipe sprinkler systems*

In addition to the protection design guidelines for the protection of Categories 1, 2, and 3 commodities by ceiling-level sprinklers on dry-pipe and similar sprinkler systems in storage areas having a maximum ceiling height of 9.1 m in Tables 9.14(a) and 9.14(f), ceiling-level protection without the need for in-rack sprinklers is also available for these commodities for ceiling heights over 9.1 m and up to 16.7 m high in accordance with this section.

Acceptable storage arrangements include solid-piled, palletised, shelf, bin-box, and open-framed racks.

NOTE –

(1) Push-back type flow-through racks do not qualify as open-frame racks for this protection guidance.

(2) Use upright, standard-response ceiling-level storage sprinklers having a nominal temperature rating of 140°C on a tree-type dry-pipe or similar sprinkler system.

(3) See Table 9.14(k) to determine the available ceiling-level sprinkler system design options for Categories 1 and 2 commodities or Table 9.14(l)Category 3 commodities.

Table 9.14(k) – Ceiling-level sprinkler system designs for Categories 1 and 2 commodities protected by dry-pipe and similar sprinkler systems

Max. ceiling height (m)	Storage arrangement	Ceiling-level sprinkler	Min. rack aisle width, (m)	Sprinkler system design, no. of AS at min. pressure, kPa	Max. water delivery time	System duration, (minutes)
10.7	Solid-piled, palletised, shelf, and bin-box	*K*16	DNA	20 @ 170	40	120
		*K*24	DNA	20 @ 70		
		*K*36	DNA	20 @ 50		
		*K*48	DNA	20 @ 350		
12.2	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row racks	*K*160	2.4	36 @ 380	30	120
		*K*24	2.4	36 @ 150	30	120
		*K*36	1.2	24 @ 100	25	120
			1.8	12 @ 350	20	90
		*K*48	1.8	12 @ 350	20	90

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Max. ceiling height (m)	Storage arrangement	Ceiling-level sprinkler	Min. rack aisle width, (m)	Sprinkler system design, no. of AS at min. pressure, kPa	Max. water delivery time	System duration, (minutes)
13.7	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row racks	*K*36	1.8	12 @ 350	20	90
		*K*48	1.8	12 @ 350	20	90
15.2	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row racks	*K*48	2.4	15 @ 350	20	90
16.7	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row racks	*K*48	2.4	16 @ 350	20	120

Table 9.14(l) – Ceiling-level sprinkler system designs for Category 3 commodities protected by dry-pipe and similar sprinkler systems

Max. ceiling height (m)	Storage arrangement	Ceiling-level sprinkler	Min. rack aisle width (m)	Sprinkler system design, no. of AS at min. pressure, kPa	Max. water delivery time	System duration, (minutes)
10.7	Solid-piled, palletised, shelf, and bin-box	*K*16	DNA	20 @ 170	40	120
		*K*24	DNA	20 @ 70		
		*K*36	DNA	20 @ 50		
		*K*48	DNA	20 @ 350		
12.2	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row racks	*K*36	1.2	24 @ 100	25	120
			1.8	12 @ 350	20	90
		*K*48	2.4	15 @ 350	20	90
13.7	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row	*K*36	1.8	12 @ 350	20	90
		*K*48	1.8	12 @ 350	20	90
15.2	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row	*K*48	2.4	15 @ 350	20	90
16.7	Solid-piled, palletised, shelf, bin-box, and open-frame single-row and double-row	*K*48	2.4	16 @ 350	20	120

The maximum water delivery time is 40 seconds. For unobstructed ceiling construction, this maximum water delivery time is based on the operation of four sprinklers (two sprinklers on two ranges). For obstructed construction, it is based on the most remote two sprinklers on one range. For cut off areas protected by a single sprinkle, the maximum water delivery time is 60 seconds.

To achieve the maximum water delivery time indicated above in Tables 9.14 (k) and 9.14(l), experience to date has demonstrated that the size of the sprinkler system will need to be limited to approximately 1100 m². Validate the maximum water delivery time before the start of any work by submitting copies of all plans,

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

calculations, water supply details, and equipment details to the SSC. Specific details needed for thisevaluation include:

(a) Manufacturer and model designation for the dry-pipe or pre-action valve;
(b) Manufacturer and model designation for the dry-pilot actuator, as well as response characteristics, including performance criteria that relates actuation time to air pressure setting and static water pressure; and
(c) Air pressure to be maintained within the sprinkler piping.

NOTE – All pre-action and refrigerated-area sprinkler systems must be provided with all trim and accessories included as part of the approval package.

9.5.7 *Retail warehouse occupancies*

9.5.7.1 *General*

Retail/big-box warehouse occupancies typically have full or partial pallet loads in the top tiers of the racks. These pallet loads are broken down as needed to replenish individual stock items in the lower tiers. Lower tiers have slatted or solid shelving, while upper tiers may have slatted, wire mesh, or open shelving. Rack arrangements with certain combinations of slatted, wire mesh, or open shelves that do not qualify as rack storage with open shelves as described in 9.2.34 can nevertheless be protected as rack storage with open shelves if they meet the conditions described in 9.5.6.1.

9.5.7.2 *Requirements for treating retail display as open-frame racking*

Protect rack storage up to 6.0 m high as rack storage with open shelves when all of the following conditions are met:

(a) If slatted shelves are provided, they are fixed-in-place and provide a minimum 75 mm wide transverse flue space;
(b) There are no solid shelf levels above the 3.7 m height in the rack (although there may be other open shelf or wire mesh shelf levels above;
(c) Transverse flue spaces at least 75 mm wide are provided at least every 3.0 m horizontally; and
(d) The storage commodity does not consist of uncartoned plastics or higher hazard.

NOTE – During full-scale fire testing to develop the above conditions for retail warehousing, when solid shelves were tested, the fire spread to the ends of the racking in the test array and significant rack structure damage was sustained. While allowed in the conditions above, grated followed by slatted shelving, should be the preferred option.

9.5.7.3 *Exception for obstructed transverse flues*

Provide longitudinal flue spaces if slatted shelf openings and transverse flue spaces do not run completely through the racks vertically.

9.5.7.4 *Aerosols, flammable or combustible liquids*

If the stored commodities include aerosols or flammable or combustible liquids, refer to NFPA 30 or FM Global Data Sheets 7-31 and 7-29 respectively.

9.5.7.5

Where a retail occupancy has been designed to protect uncartoned unexpanded plastics, a limited volume of uncartoned expanded plastics may be scattered throughout the store.

NOTE –

(1) In such cases, this type of goods should be scattered through the store and not be consolidated in one area.

(2) This clause should not be used to allow bulk storage of such goods in retail stock rooms, timber trade areas, and the like. In such areas, the protection shall be appropriate to the commodity, noting the provisions of 9.3.4.2.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

10 Fully hydraulically calculated design

10.1 General

10.1.1 *Application*

10.1.1.1

Where permitted by this standard, the pipework of the entire installation may be sized, using hydraulic calculation of pressure losses, according to the available water supply pressure and the design requirements for the particular installation.

These requirements concern:
(a) Assumed maximum area of operation;
(b) Design density and/or minimum permitted orifice pressure at each sprinkler; and
(c) Evenness (or permitted diversity) of design density over the assumed maximum area of operation.

10.1.1.2

Fully hydraulically calculated design shall be carried out in accordance with the requirements of this part.

10.1.1.3

This method of design may be used to determine the design of either terminal or looped installations but shall be used on gridded installations.

Where fully hydraulically calculated design is to be used for an area of one class of occupancy, it need not be used for any other area protected by the same installation which represents a less hazardous class of occupancy.

10.1.1.4

Generally, gridded methods of design will permit a more economical system. Other parts of this standard specify the additional information that is required for this type of design.

Dry pipe and pre-action installations are not permitted to use gridded design.

10.1.2 *General calculation method*

10.1.2.1

For design purposes, the calculation method may be used to determine the necessary water supply characteristics (for example, to select a pump size), or it may be used to determine an even and economical design that will fit the available water supply (for example, the characteristics of an existing town's main). It may be advantageous for the designer to have the assistance of a computer that has been programmed to bias one or other of the variables.

For checking purposes, calculation will normally start from the area of operation and work back towards the water supply.

10.1.2.2

Generally, the steps to be followed are:
(a) Establish the design density or the minimum end sprinkler flow requirement;
(b) Establish the assumed maximum area of operation, or number of sprinklers to be operated;
(c) Determine the water supply flow and pressure characteristics;
(d) Select sprinkler head spacing and orifice size, and pipe sizes;
(e) Establish the head losses or gains;
(f) Determine the shape and position of the hydraulically most demanding assumed area of operation;
(g) Count the number of sprinklers within that area;
(h) Calculate:
    (i) The flow from each sprinkler in the area of operation, and except where control mode specific application and suppression mode sprinklers are installed, the values are for (ii) and (iii) below
    (ii) The average density over the assumed area of operation
    (iii) The average density over any group of four adjacent sprinklers; and
(i) If the calculated values do not meet the relevant requirements of the standard, the pipe sizes, and/or sprinkler spacing, and/or sprinkler orifice size, and/or water supply characteristics, shall be adjusted.

10.1.2.3

It is not necessary to determine the hydraulically most favourable area of operation or, therefore, the maximum water supply demand.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Ultimately, the value of such information relates only to the time that stored water supplies will last and the maximum demand to which the pumps may be subjected.

Both factors assume that in a worst-case fire, the most favourably placed areas will impose a larger design flow than the hydraulically most remote area. However, this ignores the tendency for the actual area of operation to decrease as the actual density increases. Hence, in practice, maximum flow tends to be no more than design flow irrespective of the position.

It is not permissible to design on the basis of a smaller area of operation because the possibility of a brief flashfire opening an unusually large number of heads cannot be quantified or, therefore, ignored.

Avoidance of pumps overloading due to excessive flow is provided for in Part 6 in the requirements for pump and motor sizing.

Where stored water supplies are used, extremes of diversity of density across the installation should be avoided to ensure, in the case of a flash fire opening additional sprinklers, that there is sufficient time for the fire brigade to arrive and augment supplies or complete extinguishment.

10.2 Design requirements

10.2.1 *Requirement*

10.2.1.1

The design density or minimum end sprinkler condition for each area of the protected building is that specified by the relevant sections of Parts 7, 8, or 9, according to the fire hazard present.

10.2.1.2

The assumed maximum area of operation shall be determined in accordance with 10.3 but shall not be less than that specified by the relevant sections of Parts 7, 8, or 9 as appropriate.

10.2.2 *Determination of density*

The design density shall mean the average density of a group of four adjacent sprinklers within an area of operation.

It shall be calculated from the sum of the flows from the four sprinklers (while all other sprinklers in the assumed maximum area are operating) and dividing by four times the area of the parallelogram formed by joining the four sprinklers. Every such group of four sprinklers shall provide at least the design density.

10.2.3 *Minimum orifice pressure*

10.2.3.1

The minimum pressure at any sprinkler, with all sprinklers within the assumed maximum area of operation simultaneously operating, shall be 50 kPa or greater as required by design criteria or sprinkler listing:

For extended coverage sprinklers ..... as per listing
In ELH occupancy class:
- using 10 mm sprinklers ..... 100 kPa
- using 15 mm sprinklers ..... 50 kPa
- using residential sprinklers ..... as per the listing

In ordinary hazard occupancy class ..... 50 kPa
In EHH occupancy class ..... As required by design tables

10.3 Determination of area of operation

10.3.1 *Requirement*

To determine how many, and which, sprinklers may be operating simultaneously, it is necessary to determine the shape of an area at least the size of the assumed maximum area of operation prescribed by Part 7, 8, or 9. The sprinklers within that area will be considered to be operating simultaneously.

10.3.2 *General procedure*

10.3.2.1

Due to possible variations, across the protected area, in sprinkler spacing and the actual area protected by each sprinkler (which may be affected by spacing changes or the proximity of walls, beams or partitions), the shape of the area varies according to its position in the sprinkler configuration. Ridges and deep roof bays, which have the effect of channelling heat, will also influence the shape of the area.

Generally, because ultimately only the hydraulically least favourable area is to be considered, the shape will be elongated with the long side (L) being to the area (A) as follows:

$$L = 1.2\sqrt{A} \quad \text{(Eq.3)}$$

COPYRIGHT © Standards New Zealand

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

10.3.2.2

For ordinary hazard or EHH occupancies the following steps are required to determine the shape of any assumed maximum area of operation:

(a) Determine an approximate average area of coverage for each sprinkler in the area being considered;
(b) Divide the minimum assumed maximum area of operation (10.2.1.2) by this average area to determine the approximate number of sprinklers likely to operate;
(c) Identify an area, which incorporates that number, of a shape that approximates the ratio $L \square 1.2\sqrt{A}$ (remainder sprinklers will be located just outside the rectangle) where L is the dimension along the ranges;
(d) Where necessary, adjust the shape and its orientation (in relation to the direction of the ranges) to take account of fire channelling factors;
(e) Check that the actual area is at least that specified in Part 8 or Part 9 and, if not, increase the number of sprinklers from the approximate number and locate within the general shape requirement.

10.3.2.3

For ELH situations where the design density is 2.7 mm/min or where residential sprinklers are installed, see the special provisions of 10.3.5.1.

10.3.2.4

Cloud ceilings require definition and guidance on how many sprinklers to operate simultaneously at each level. Design area in roof space to be a minimum of 50% of the below ceiling. Consultation with the SSC is required to confirm that not more than 50% of the roof space sprinklers will be necessary.

10.3.3 *Determining the mean area per sprinkler*

10.3.3.1

A sufficient number of adjacent sprinklers to be statistically typical shall be selected and the actual area covered by those determined (10.3.3.2 and Figure 10.1). Division of that area by the number of sprinklers provides the mean area per sprinkler.

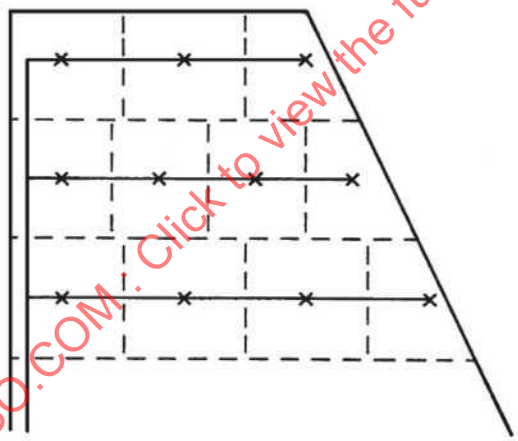


Figure 10.1 – Determination of mean area per sprinkler

10.3.3.2

The area covered by sprinklers that are not against walls or partitions, shall extend from lines midway between the sprinkler and the line of sprinklers on one side, to a line midway between the sprinkler and the line of sprinklers on the opposite side.

10.3.3.3

The area covered by sprinklers that are against walls or partitions shall extend from the wall or partition to lines midway between and parallel to the adjacent lines of sprinklers (or, on the same range, adjacent sprinkler) and the sprinkler under consideration.

10.3.4 *Determining the number of sprinklers within the assumed area of operation*

10.3.4.1

The number of sprinklers (*N*) used to determine the assumed area of operation shall initially be determined by dividing the assumed maximum area of operation (Parts 7, 8, or 9) by the mean area per sprinkler, and rounding that result up to the next whole number.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

If a statistically typical group of sprinklers was considered in determining the mean area per sprinkler, then the number of sprinklers (*N*) is to be recalculated as required by 10.3.6.

10.3.5 *Determining the shape of the area of operation*

10.3.5.1

The assumed maximum area of operation which shall be generally rectangular shall enclose the number of sprinklers (*N*) assumed to be in simultaneous operation and shall be shaped according to the following formulae (and as illustrated in Figure 10.2):

$$N_a = \frac{A}{S^2} \quad \text{(Eq.4)}$$

$$N_b = \frac{N_a}{S} \quad \text{(Eq.5)}$$

$$r = N - N_a \quad \text{(Eq.6)}$$

Where:

N_a = Number of sprinklers on those ranges within the rectangular portion of the area of operation
N_b= Number of ranges within the rectangular portion of the area of operation
A = Assumed maximum area of operation
r = Remainder sprinklers not within the rectangular portion
S = Mean spacing of sprinklers on the ranges under consideration

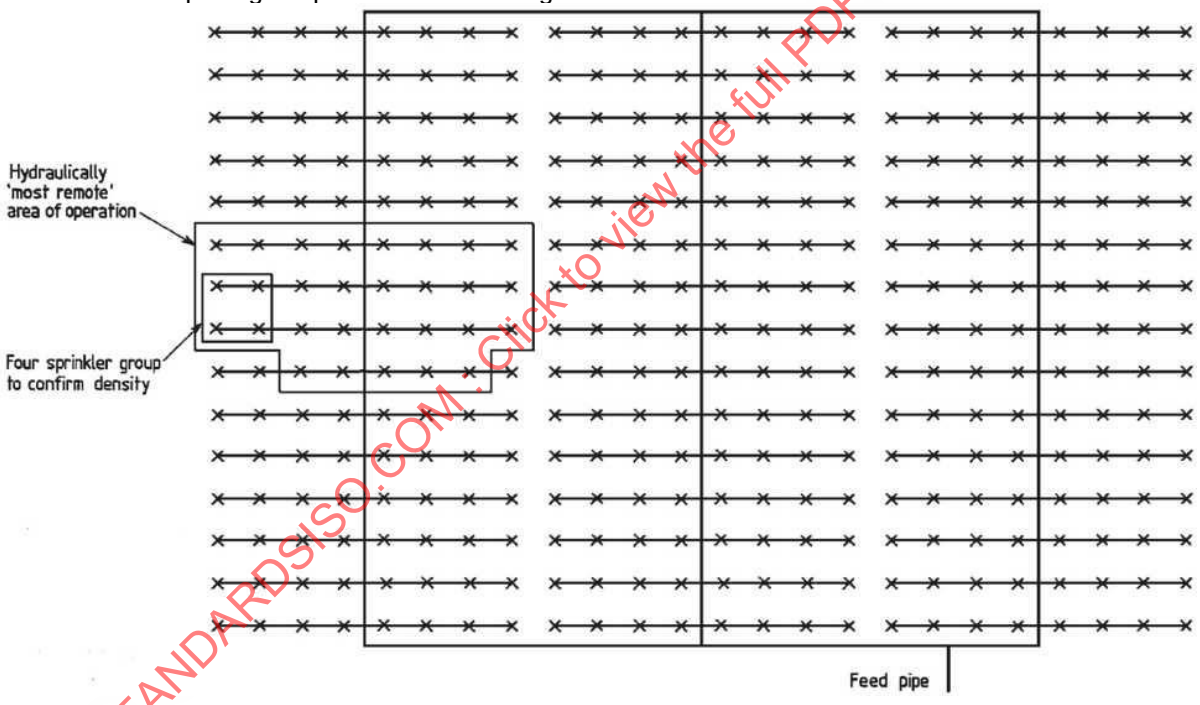


Figure 10.2 – Location and shape of hydraulically 'most remote' area of operation

For ELH occupancies using standard coverage spray type heads, the design area shall be as outlined in 7.1.1.

For ELH occupancies using residential sprinklers the area of operation shall include all sprinklers within a room to a maximum of four sprinklers. When a room contains fewer than four sprinklers, the number of design sprinklers shall include all sprinklers in that room plus sprinklers in adjoining rooms to a total of four sprinklers. In all cases the design area shall include the most hydraulically demanding group of foursprinklers.

For the purposes of determining the area of operation a 'room' shall mean a space enclosed by walls, ceiling (or roof) and floor (including a cupboard) provided that any door opening does not exceed 2 m in width and incorporates a lintel at least 300 mm deep.

For CMSA sprinklers, the shape of the assumed area of sprinklers in operation shall be as follows:

(a) 15 heads shall be 5 heads on 3 adjacent ranges;
(b) 18 heads shall be 6 heads on 3 adjacent ranges;
(c) 20 heads shall be 5 heads on 4 adjacent ranges;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(d) 25 heads shall be 5 heads on 5 adjacent ranges;
(e) 30 heads shall be 6 heads on 5 adjacent ranges; and
(f) 36 heads shall be 6 heads on 6 adjacent ranges.

For storage sprinklers, the shape of the assumed area of sprinklers in operation shall be as follows:
(g) 6 heads shall be 3 heads on 2 adjacent ranges;
(h) 8 heads shall be 4 sprinklers on 2 adjacent ranges;
(i) 10 heads shall be 4 sprinklers on 2 adjacent ranges plus 2 sprinklers on another adjacent range;
(j) 12 heads shall be 4 sprinklers on 3 adjacent ranges;
(k) 15 heads shall be 5 sprinklers on 3 adjacent ranges;
(l) 20 heads shall be 5 sprinklers on 4 adjacent ranges;
(m) 24 heads shall be 6 sprinklers on 4 adjacent ranges;
(n) 25 heads shall be 6 sprinklers on 4 adjacent ranges plus 1 sprinkler on another adjacent range;
(o) 30 heads shall be 6 sprinklers on 5 adjacent ranges; and
(p) 35 heads shall be 6 sprinklers on 5 adjacent ranges plus 5 sprinklers on another adjacent range.

NOTE – Also see 9.5.3 limitation of 71 m^2 minimum design area.

10.3.5.2

Where N_a is less than the number of sprinklers on the range under consideration, the sprinklers considered as N_a shall be those that are hydraulically most remote.

10.3.5.3

If single ranges on end-side arrangements, or pairs of opposite ranges on end-centre arrangements have fewer than N_a sprinklers, N_a shall be changed to the actual number of sprinklers on each range or range pair.

The values of N_b and r will change accordingly.

10.3.5.4

Sprinklers that constitute the remainder (r) shall be placed on the next range or, with end-centre arrangements, on the next pair of opposite ranges, in a position that is alongside the area N_a x N_b in a position that maximises the flow required.

10.3.5.5

If ranges within an area of operation are run horizontally along a sloping roof of gradient one in four or greater, N_a shall be adjusted for the two highest ranges (or three, if there is a range at the apex) to be either 15 or the actual number of sprinklers on the range under consideration – whichever is the lesser.

N_b and r will be recalculated accordingly.

10.3.6 *Confirmation of the mean area per sprinkler*

10.3.6.1

To confirm that the number of sprinklers (N) is not too few as a result of taking a statistically atypical number of sprinklers when determining the mean area per sprinkler, the actual area of the shape established shall be measured.

10.3.6.2

If that actual area is less than the assumed maximum area of operation (A), the number (N) shall be increased by one, or more, and new values shall be established for N_a, N_b, and r, and a new shape determined.

10.3.6.3

The actual area of the new shape shall be measured and again checked against the area A and, if necessary, N shall again be adjusted – the process being repeated until the actual area is equal to or greaterthan A.

10.3.7 *Water demands for supplementary sprinklers*

Where additional sprinkler heads are installed, which may operate in addition to those designed to control the fire load, then these are to be designed to operate in addition to the heads in the area of operation.

One example of such heads includes those provided to wet internal glazing, with no significant water distribution onto the floor. The design number of heads shall be those bounding the hydraulically most onerous area of operation, where such heads are installed.

A second example is where heads are installed below perforated decks and ceilings, to comply with 5.11.3.2, a SSC may require that these be included in the hydraulic calculations.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

10.3.8 *Design requiring special consideration*

10.3.8.1 *Belt conveyors*

For belt conveyors with a slope of less than 10°, allow for 10 x 15 mm sprinklers to operate at a minimum head pressure of 70 kPa. Where the slope exceeds 10°, allow for 15 x 15 mm sprinklers to operate at a minimum head pressure of 70 kPa.

NOTE – FM Global Data Sheet 7-11, provides advice on best practice for belt conveyor protection.

10.4 Determination of design flow and pressure

10.4.1 *Requirement*

10.4.1.1

The design flow and pressure at the sprinkler valves for a fully hydraulically calculated installation shall be that which is required to support the hydraulically worst-placed area of operation (including an allowance for any difference of pressure due to head).

10.4.1.2

For systems designed to protect an ordinary hazard occupancy, the assumed maximum area of operation shall be not be less than that specified in 8.1.1. However, for determining the minimum storage capacity for any storage tank (6.6.1) the design flow may be assumed to be 540 L/min for OH1 and 1000 L/min for OH2.

10.4.2 *Determination of the hydraulically worst-placed area of operation*

10.4.2.1

On each distribution pipe, and on gridded pipe configurations, between distribution pipes, an assumed maximum area of operation (determined in accordance with 10.3) shall be nominated as the hydraulically worst-placed such area.

Any such area which is similar to another under consideration may be ignored.

Conversely, any area which, due to changes in sprinkler spacing, elevation, range centres or pipe sizes, appears to impose a greater hydraulic demand, shall also be nominated.

10.4.2.2

The hydraulic demand (pressure required at the design flow) for each candidate area shall be determined by calculation in accordance with 10.5.

10.4.2.3

Proof that each candidate area is the hydraulically worst-placed in the general area chosen, shall be obtained. This may generally be done by displacing the candidate area by one sprinkler along the range and by one range in each direction, or by showing that the lowest discharging sprinkler is not on the perimeter of the cover.

10.4.2.4

The candidate area imposing the greatest hydraulic demand shall be deemed the hydraulically worst-placed area.

10.5 Method of calculation

10.5.1 *Accuracy*

10.5.1.1

The following dimensions shall be expressed in the units and to the accuracies as listed in Table 10.1:

Table 10.1 – Accuracy required for dimensions used in design requirements calculations

Dimension	Unit	Accuracy
Length and elevations	m	3 significant figures
	mm	Nearest whole unit
Flow rate	L/min	Nearest whole unit
Pressure	kPa	Nearest whole unit
Discharge density	mm/min	1 decimal place
Area	m^2	3 significant figures

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

10.5.1.2

Flows merging into a junction shall be estimated to within ±2 L/min of flows emerging from the junction.

10.5.1.3

When estimating the flows and pressure losses in each direction around a ring main or section of gridded network, the maximum acceptable difference in calculated pressure at any junction is 1.0 kPa.

10.5.1.4

The discharge from a sprinkler shall be calculated to within ±1 L/min using the formula and *K* factors set out in 10.5.5.

10.5.1.5

To check for the effect of cumulative errors the sum of the flows from the individual sprinklers shall be determined and shall be within ±1% of the calculated design flow.

10.5.2 *Calculation of static pressure head*

The static pressure equivalent of differences in height between sprinklers, junctions, datums, and so on is to be taken as:

$P = h \times 10$ ..... (Eq.7)

Where:

P = pressure gain or loss due to head (kPa)
h = difference in height between sprinklers, junctions and datums (m)

10.5.3 *Calculation of pressure loss in pipes*

10.5.3.1

Pressure losses due to water flow through pipes shall be determined using one of the following formulae in 10.5.3.2 or 10.5.3.3, as appropriate.

NOTE – It is not a requirement of this standard to limit water velocity in pipes.

10.5.3.2

Pressure losses in all types of pipe may be calculated using the Hazen-Williams formula:

$$P = \frac{\text{[illegible]}}{\text{[illegible]}}$$ ..... (Eq.8)

Where:

P = loss of pressure per metre of pipe (kPa/m)
Q = flow rate of water through pipe length (L/min)
d = mean bore diameter (mm)
C = a constant for the type of pipe, that is:

Cast iron	*C* = 100
Steel, galvanised after fabrication	*C* = 110
Steel, black or galvanised	*C* = 120
Steel, spun concrete lined	*C* = 130
Copper, PVC-M, PVC-U, and PE pipes	*C* = 140
PVC-C	*C* = 150

10.5.3.3

Pressure losses in each metre of steel or PVC-C pipe may be calculated using the simplified formula:

$P = RQ^{1.8}$ ..... (Eq.9)

Where:

P = loss of pressure per metre of pipe (kPa)
Q = flow rate of water through pipe length (L/min)
R = the appropriate value from Table 10.2.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Table 10.2 – Values of *R* for steel and chlorinated PVC pipes

Nominal bore (mm)	Steel pipe to AS 1074 or BS EN 10255						PVC-C to ASTM F442	
	Light to		Medium grade		Heavy grade			
	Mean ID (mm)	Value of *R*	Mean ID (mm)	Value of *R*	Mean ID (mm)	Value of *R*	Mean ID (mm)	Value of *R*
20	–	–	21.63	2.71×10^{-3}	20.41	3.60×10^{-3}	22.2	1.58×10^{-3}
25	29.7	5.79×10^{-4}	27.31	8.73×10^{-4}	25.68	1.18×10^{-3}	28.0	5.11×10^{-4}
32	38.2	1.7×10^{-4}	35.97	2.28×10^{-4}	34.34	2.86×10^{-4}	35.4	1.63×10^{-4}
40	43.7	8.83×10^{-5}	41.86	1.09×10^{-4}	40.23	1.32×10^{-4}	40.6	8.37×10^{-5}
50	55.7	2.71×10^{-5}	52.98	3.46×10^{-5}	51.36	4.02×10^{-5}	50.9	2.78×10^{-5}
65	71.5	8.03×10^{-6}	68.67	9.78×10^{-6}	67.04	1.10×10^{-5}	61.5	1.09×10^{-5}
80	83.7	3.73×10^{-6}	80.68	4.46×10^{-6}	79.06	4.92×10^{-6}	75.0	4.18×10^{-5}
100	108.2	1.07×10^{-6}	105.14	1.23×10^{-6}	103.31	1.34×10^{-6}	–	–
150	158.3#	1.67×10^{-7}	155.32	1.84×10^{-7}	154.30	1.90×10^{-7}	–	–
200	–	–	209.54*	4.27×10^{-8}	208.30**	4.40×10^{-8}	–	–
250	–	–	263.44*	1.40×10^{-8}	258.80**	1.53×10^{-8}	–	–

NOTE –

(1) * API 5L pipe 4.78 mm wall thickness for 200 mm and 250 mm.

(2) ** BS 3600 thickness 5.4 mm for 200 mm pipe and 7.1 mm for 250 mm pipe.

(3) # AS 4118 pipe 3.4 mm wall thickness.

10.5.4 *Pressure loss in fittings and valves*

10.5.4.1

Loss of pressure, due to water flow through pipe elbows, tees and bends where the direction of water flow is changed through an angle of 45° or more (other than the change of direction into a sprinkler or sprinkler assembly or drop from an elbow or tee into which the sprinkler or sprinkler assembly is fitted), shall be calculated by multiplying the appropriate factor from the Table 10.3 by the nominal diameter in mm of the smallest pipe in the fittings waterway. The length in metres of equivalent straight pipe thus derived shall be added to the actual lengths of pipe under consideration for use in the above pressure loss formulae.

Table 10.3 – Hazen-Williams loss of pressure factors for flow direction changes in pipes

Hazen-Williams factor (C)	100	110	120	130	140	150
Tees into branches	0.040	0.050	0.060	0.070	0.080	0.090
Elbows	0.020	0.025	0.030	0.035	0.040	0.045
Bends*	0.010	0.0125	0.015	0.0175	0.020	0.0225
* A bend is any fitting where the radius divided by nominal pipe diameter is greater than 1.5.						

Loss of pressure due to water flow through alarm valves, back pressure valves, stop valves, and so on shall be calculated using the formula:

$$P_{(0.0)} \phi \frac{\phi \pi \phi}{\square} \quad \text{(Eq.10)}$$

Where:

K = the loss factor associated with the listing for the particular size and type of valve.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

10.5.5 *Calculation of discharge from a sprinkler*

The discharge from a sprinkler shall be calculated using the following formula:

$$Q = K\sqrt{P} \quad \text{(Eq.11)}$$

Where:

Q = Discharge from sprinkler (L/min)
P = Pressure at entry to sprinkler orifice (kPa)
K = Sprinkler discharge co-efficient, using the following values:

K = 2.0 L/min (kPa)$^{-0.5}$
K = 3.0 L/min (kPa)$^{-0.5}$
K = 4.0 L/min (kPa)$^{-0.5}$
K = 5.7 L/min (kPa)$^{-0.5}$
K = 8.0 L/min (kPa)$^{-0.5}$
K = 11.5 L/min (kPa)$^{-0.5}$
K = 16.0 L/min (kPa)$^{-0.5}$
K = 20.0 L/min (kPa)$^{-0.5}$
K = 24.0 L/min (kPa)$^{-0.5}$
K = 28.0 L/min (kPa)$^{-0.5}$
K = 32.0 L/min (kPa)$^{-0.5}$
K = 36.0 L/min (kPa)$^{-0.5}$
K = 40.0 L/min (kPa)$^{-0.5}$
K = 48.0 L/min (kPa)$^{-0.5}$

Residential sprinklers ..... as per manufacturer's listing

Other types of sprinklers ..... as per manufacturer's listing.

To ensure that system performance is not compromised by substitution of differing manufacturer sprinklers, nominal *K* factors as defined above shall be used in hydraulic calculations.

10.5.6 *Calculation of flow from identical ranges*

For the purpose of calculating the design flow for terminal pipe configurations, the flow from more favourably placed identical ranges may be determined by the formula:

$$Qr = C\sqrt{Pn} \quad \text{(Eq.12)}$$

Where:

*P*n = junction pressure of the range under consideration
*Q*r = flow in the range under consideration
C = flow in the first range divided by the square root of the junction pressure at start of that range

10.5.7 *Velocity head*

The velocity head may be ignored in these hydraulic calculations. If the velocity head is used, it shall be incorporated in calculations for all distribution and range pipes.

10.6 Documentation

10.6.1 *Preliminary stage*

The contractor shall supply to an SSC the information required by 1.14.1.

10.6.2 *At completion*

Before final inspection, and in accordance with 1.14.2, the contractor shall supply an SSC with the following:

(a) As-built sprinkler and pipe layout plans which show the following:

(i) A node, or pipe reference system, that provides unique identification for pipes, bends, junctions, sprinkler heads, and other pipe fittings which require hydraulic consideration
(ii) Distribution pipes and diameters
(iii) Type of pipes used and C factor
(iv) Range pipes that require hydraulic consideration and diameter
(v) Sprinkler heads within each assumed maximum area of operation
(vi) The position of the hydraulically worst-placed assumed maximum area of operation
(vii) Nominated worst group of four sprinklers within the worst-placed assumed maximum area of operation to demonstrate diversity adequacy
(viii) Flow through each sprinkler and pipe between junctions
(ix) Pressures at each end of each pipe and at the entry to each sprinkler assumed to be operating
(x) Height of each such node above or below datum.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

(b) Calculation data sheets and/or computer print-outs to support the installation schematic diagrams and plans. For gridded and looped installations, these data shall be provided for each sample (candidate) area of operation considered (10.4.2); and

(c) The following details for each operating sprinkler in each candidate area:

(i) Node or reference number
(ii) Nominal orifice size
(iii) Flow from sprinkler (L/min)
(iv) Pressure at entry to sprinkler (kPa)
(v) For residential sprinklers, a copy of the manufacturer's current data sheet

(d) The following details for each hydraulically significant pipe

(i) Node or reference number
(ii) Nominal bore diameter (mm)
(iii) Formula used to determine pressure loss (10.5.3)
(iv) Flow through pipe (L/min)
(v) Length (m)
(vi) Number of tees, elbows, crosses and other hydraulically significant fittings
(vii) Total hydraulic length
(viii) Static head change in pipe
(ix) Pressure at each end of pipe
(x) Friction loss in pipe (kPa)
(xi) Direction of flow.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

11 Fire protection system shutdown precautions

11.1 General

This section provides minimum guidelines for parties involved in shutdown of fire protection systems. All work and communications must, in addition to the requirements here, meet all requirements of the Health and Safety at Work Act 2015.

Sprinkler systems may be rendered temporarily inoperative for maintenance and repairs or alterations, or they may be permanently disabled. Before isolating or disabling a sprinkler system, sprinkler contractors shall follow these procedures, taking the precautions specified in this section, as well as others required by the SSC or building owner.

11.2 Risk assessment

11.2.1 *Contributors to the risk assessment*

A full risk assessment must be undertaken. Sprinkler systems shall not be isolated or rendered inoperative overnight in buildings that contain sleeping accommodation without giving at least 24 hours' notice to the building owner, building occupier, fire brigade, and the building insurers.

This should consider the life safety implications on workers, occupants, and overall building fire and life safety provisions. Amongst others, this risk assessment may need to include input and agreement from:

(a) The fire brigade;
(b) The building owner(s) and occupier(s); and
(c) The building owner's risk consultants/insurers.

11.2.2 *Risk mitigation*

Where systems are required to be rendered inoperative and/or parts of the system isolated for extended durations or overnight in buildings that contain sleeping accommodation, treatment and care, or similar facilities, adequate mitigating measures should be implemented before the isolation and the identified risks should be reassessed.

11.2.3 *Sprinkler systems with common or shared components*

Where any sprinkler system has any component that affects more than one property, or has a common ownership arrangement, such as shared water supplies or a common sprinkler valveset, and the property is owned by separate parties, or is subject to maintenance by different contractors, the risk assessment must consider the interests of all parties, who may be affected by, and need to be notified of, the impairment.

NOTE – In instances of common ownership, a statement detailing the common ownership and the names and contact details of the relevant persons should be prominently displayed adjacent to the relevant component.

11.3 Notification and authorisation

11.3.1 *Period*

Notification shall be delivered at least 24 hours before the start of work that will isolate or render a sprinkler system inoperative. Sprinkler systems shall not be isolated or rendered inoperative overnight in buildings that contain sleeping accommodation without giving at least 24 hours' notice to the building owner, building occupier, fire brigade, and the building insurers.

Except in an emergency, the system shall not be rendered inoperative until the owner or their authorised representative has authorised the work by signing the appropriate section of the form set out in Figure 11.1. If an emergency compels immediate action to render a system inoperative, such notification shall be given as soon as possible afterwards.

Where possible, 24 hours prior notice shall be provided for system alterations, routine servicing and maintenance isolations.

11.3.2 *Shutdown notice recipients*

Notification in writing shall be delivered to the following:

(a) Building owner or his/her agent or nominated representative;
(b) Building occupiers; and
(c) The fire brigade or their authorised agent (See Appendix T).

These notifications shall also advise building owner(s) that they are to inform their insurers of any isolation that exceeds 12 hours, or any lesser period if the system is within buildings that contain sleeping accommodation, treatment and care facilities, or similar facilities, or if specified by the building owner.

If instructed by the owner, the contractor shall provide a copy of the signed authorisation to another specified party, such as the owner's insurer or risk management consultant and the fire brigade.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

11.3.3 *Shutdown notice information*

Notification to the building owner or his/her agent or representative shall include the following information:

(a) Name and address of premises;
(b) Type of occupancy, for example, day time occupancy, commercial, industrial, sleeping accommodation, treatment and care facilities, and the rest;
(c) Reason for rendering system inoperative giving details of extensions or alteration work;
(d) Date and times the system will be off;
(e) Whether blanking pieces (also known as frying pans) or sectional valves will be used to isolate a section or zone of a system; and
(f) Whether the work will involve cutting or welding and, if so, details of the precautions that will be taken;

Information may be provided in the form shown in Figure 11.1. Notification to FENZ shall include all Section A details. The building owner shall be advised to inform their insurers of Sections A and B.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

COPYRIGHT © Standards New Zealand

Fire Protection System Shutdown Form

Form from		Date / /
Building Name		
Contractor		
Contractor details	Phone number	Email address
To	Building owner	
	FENZ	Insurer/Broker

Instructions: At least 24 hours notification of all programmed isolations shall be given in writing to FENZ and the building owner prior to a sprinkler system being rendered inoperative. If an emergency compels immediate action to render a system inoperative, such notification shall be given as soon as possible thereafter.

NZ Standard 4541 and 4515 (Sprinkler Systems) requires Sections A and B to be completed prior to a fire sprinkler shutdown and sent to the following: 1) FENZ or their agents, and 2) Building owner or their agent. Section B requires 'OWNER'S APPROVAL' and for the owners to notify their insurers if the systems are isolated for more than 12 hours.

Note: **Partially isolated systems** – If a section or zone of a fire sprinkler system is isolated, blanked off, or left impaired whilst the main system is restored a tag label shall be attached to the main sprinkler stop valve indicating which sections are affected. Building owners must inform FENZ and their insurers that the system has been partially restored. They must also inform FENZ and their insurers when the isolated sections have been restored.

OWNER (or agent) Please sign your approval of this shutdown in Section B of this form and send to your Insurers/Broker/Agent

Building owner's email:	Date / /		
FENZ email:	Date / /	Insurer/broker's email:	Date / /

Section A	**Fire system/building/site details**	**PFA No**
Building name		
Building street address		
Building occupancy		
Number of occupied floors		

Type of system

Fire sprinkler system NZS 4541 ☐	Sprinkler pumps ☐	Fire sprinkler system NZS 4515 ☐	
Water supply ☐	Fire alarm ☐	Fire hydrants in buildings NZS 4510 ☐	
Fire alarm system NZS 4512 ☐	Automatic fire detection ☐	Heat detectors ☐	Smoke detectors ☐
Areas or zones affected			
Alarms monitored by			

Shutdown

Shutdown date start / /	Shutdown time	System will be reinstated daily	Continuous shutdown for /days
Reinstatement date / /	Reinstatement time		
Section of system left isolated whilst main system restored	**Area or zone to be isolated**		
	Date due for completion / /	Date completed whole system restored / /	
Work to be completed during shutdown	Alterations ☐	Repair / replace damage to system ☐	Routine maintenance work ☐
	Other:		

Please use this form to notify your "BUILDING INSURERS" of all shutdowns, reinstatements and of any sections of a system left isolated.

Note: If a section or zone of a fire sprinkler system is isolated, blanked off or left impaired whilst the main system is restored a tag label must be attached to the main sprinkler stop valve indicating which sections are affected.

Figure 11.1 – Typical form for notifying that an installation is to be rendered inoperative

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

Section B – Owner's approval			
Date / /	Name	Insurer(s) notified YES ☐ NO ☐	
Time	Signature	Date / /	
Note: Failure by the owner to notify insurer(s) of an impairment or partial isolation of sprinkler installation may void insurance cover.			
Owner's safety precautions to be taken during fire system shutdown			
	Forbid smoking in the area affected by the fire system shutdown.		
	No hot work during shutdown.		
	Detail Fire Wardens to patrol affected areas (one person per 1000 m²).		
	Stop hazardous processes.		
	Notify all staff and contractors working on site of the impairments.		
Service company name		Telephone number	Email address
Contact name for any queries		Telephone number	Cell phone

COPYRIGHT WAIVED

Figure 11.1 (continued) – Typical form for notifying that an installation is to be rendered inoperative

11.4 Isolation tags for sections of a sprinkler system

A tag card as shown in Figure 11.2, or similar, shall be used to identify sections of a sprinkler system left isolated. This shall be fixed by the contractor to the main sprinkler stop valve and the sectional valve controlling the area isolated. Where multiple systems or multiple buildings are affected, an isolation tag shall be placed on every system affected by the impairment.

The contractor placing isolation tags shall maintain a written record of them and these records shall be available for inspection by an SSC.

Part A shall be completed whenever a sprinkler system is isolated, and the valve house left unattended.

When a section or zone of a sprinkler system is isolated, Part B shall be completed by the contractor and the isolation card affixed to the main stop valve and the sectional valve controlling the area isolated.

Cards shall remain attached to the main stop valve and sectional valves controlling areas isolated until the whole system is restored. The party responsible for placing the tags shall also be responsible for ensuring they are removed.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

DO NOT REMOVE THIS NOTICE UNTIL THE SYSTEM HAS BEEN FULLY RESTORED

Part A

Impairment notice number:

Date:_____/_____/_____

Contractor:_____

Work permit number: _____

Sprinkler system number_____isolated

Part B

Section of sprinkler system isolated:

(Give details of location for isolated valve or blanking plate used) and area / zone of building not covered):

Date of isolation:____/_____/ _____

Proposed date of reinstatement:

____/_____/ ____

Contractor:_____

Signed: _____

Figure 11.2 – Typical form for isolation tag card

11.5 Hot work precautions

Any hot work required on sprinkler systems shall be carried out according to the provisions of the Health and Safety at Work Act 2015.

Cutting or welding involving hot work should normally not be carried out on the sprinkler system. It shall not be carried out without the contractor first obtaining specific approval from the building owner.

Such approval, if granted, may specify precautions to be taken by the contractor to minimise the risk of ignition while the installation is inoperative.

These precautions will normally include:

(a) Having charged hose reels or suitable types of extinguishers on hand;
(b) Removing or covering combustibles in the immediate vicinity of the work;
(c) Posting a watchman during the actual hot work;
(d) Re-checking the area 30 minutes after completion of the hot work; and
(e) Complying with NZS 4781 where cutting or welding is undertaken.

STANDARDSISO.COM : Click to view the full PDF of NZS 4541 :2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

11.6 Methods of temporarily isolating system sections

11.6.1 *Tagging*

Clause 11.4 provides requirements for use of isolation tags when zones or sections of a sprinkler system are isolated.

Where screwed plugs, screwed or grooved end caps, or blank flanges are used for temporary isolation, a coloured tag of sufficient length shall be attached so as to be clearly visible from the occupied area of the building. This tag shall have stencilled on it the words 'Temporary Sprinkler Isolation'.

11.6.2 *Sectional valves*

Where provided, sectional valves should be used if practicable to keep to a minimum the area in which the sprinkler installation is inoperative.

Great care shall be taken to ensure that sectional valves are reopened after completion of work.

11.6.3 *Blanking pieces or 'frying pans'*

Blanking pieces or frying pans inserted between the flanges of a pipe joint may be used to temporarily isolate sections of a sprinkler installation.

The contractor shall maintain a written record of the use of all frying pans and this record shall be available for inspection by an SSC.

Frying pans shall be cut from a single piece of sheet steel or the handle shall be welded. The handle shall:

(a) Project at least 300 mm from the edge of the pan;
(b) Be painted with fluorescent paint;
(c) Be stamped and painted with an identification number; and
(d) Be drilled and, when used in a concealed space, be connected with a coloured tag of sufficient length to be clearly visible from the occupied area of the building.

11.6.4 *Discs not permitted in union joints*

Discs inserted in union joints to effect temporary isolation are not permitted.

11.7 Interruption to water supplies

11.7.1

Where work on sprinkler systems requires a town's main supplies to be made inoperative, this work shall be planned and executed in accordance with the by-laws and guidelines of local authorities for the area. Communications, planning and execution of this work shall ensure minimum disruption to provision of services to neighbouring properties and other uses of the water supply. It must ensure the safety of property and people in the vicinity and must be executed in compliance with regulations of the Health and Safety at Work Act 2015.

11.7.2

In the event of all the water supplies to a sprinkler system becoming inoperative for a long period, where possible, a temporary supply from an alternative water source shall be made and supplied through the fire brigade inlet.

11.7.3

In the event of a town's main supplies becoming inoperative through drought or other reason, special attention should be given to keeping any other supply in efficient working condition.

Notification of an inoperative town's main water supply shall be made in writing and delivered to the building owner or their agent or representative, the owner's insurer or risk management consultant, and the fire brigade or their authorised agent 24 hours in advance of the work commencing.

If an emergency compels immediate action to render the system inoperative, such notification shall be given as soon as possible thereafter.

11.7.4

In the event a tank and pump water supply to a sprinkler system is rendered inoperative, notification in writing shall be delivered to the building owner or their agent or representative, the owner's insurer or risk management consultant, and the fire brigade or their authorised agent 24 hours before the work starts.

If an emergency compels immediate action to render the system inoperative, such notification shall be given as soon as possible afterwards.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

12 Routine testing, maintenance, and inspections

12.1 General

12.1.1

The system shall be maintained in efficient working order. Regular tests and inspections shall be made as specified in this part to ensure that the building is adequately protected and that the system is in efficient working order. There shall be a testing contract with a listed contractor to ensure that the control and alarm equipment is regularly tested. A sprinkler system shall not be deemed to comply with this standard unless, after completion of installation, it is tested, maintained, and inspected on a regular basis by a listedcontractor, in the manner set out in this part.

To allow a listed contractor to issue a certificate of compliance with inspection, maintenance, and reporting procedures (Form 12A) in order for a building warrant of fitness to be issued, the contractor shall be satisfied that the system is performing, and will continue to perform, in accordance with the design requirements of the original standard to which the system was installed. All deficiencies shall be rectified in a timely manner, taking into account the impact that the deficiency will have on the probability that the system's performance will be compromised. This shall extend to any equipment common to this, or other building(s) that may affect the performance of the system, such as common pumps and water supplies, regardless of whether the listed contractor has a maintenance arrangement for such equipment.

NOTE – A 'certificate of compliance with inspection, maintenance and reporting procedures' is commonly referred to as a 'Form 12A' as defined in the Building (Forms) Regulations. This form needs to be signed by an independent qualified person (IQP) annually. An SSC is not involved in this process. In contrast the format of a sprinkler system certificate of compliance is shown in Appendix E. This is required to be signed by an SSC, who could require sighting of a Form 12A as part of the process in gathering evidence that this certificate can be released.

12.1.2

Serious deficiencies which would lead to a significant probability of system failure shall be urgently attended to, to ensure that the system will operate reliably. Examples of such deficiencies include (but are not limited to):

(a) Any significant deficiency in the water supply (such as sudden or unexplained deterioration in excess of 10% on last result or to a point below system flow pressure demands);
(b) An increase in the fire load beyond the capability of the system;
(c) The presence of external fire loads non-compliant with 2.5 and 2.6 (NZBC Appendix B or D systems excepted);
(d) Any unprotected area within the system sprinkler protected search area (2.8 permitted exceptions excepted);
(e) Any defective or incorrectly set fire or pump start pressure switch;
(f) Over-age diesel pump set starting batteries;
(g) Defective, damaged, or painted sprinkler heads;
(h) Sprinkler system components subject to manufacturer's or other recall; or
(i) Any defective device that precludes ongoing testing and maintenance.

A Form 12A shall not be issued if:

(a) Such serious deficiencies exist; or
(b) It was not possible to gain access to an area of the protected building after two consecutive biennial surveys (see also 12.3.1).

If a process to remediate deficiencies that are not serious deficiencies has commenced, then such deficiencies shall not preclude the issue of a certificate of compliance with inspection, maintenance, and reporting procedures (Form 12A) provided that the deficiency has not continued for longer than 12 months since the time of first reporting.

12.1.3

To ensure that the testing, inspection and maintenance requirements of this standard are met, the owner of the sprinkler system shall enter into a contract with a listed contractor to conduct the routine testing, inspection, and maintenance detailed in Part 12 of this standard.

Appendix U provides guidelines for the routine inspection and maintenance of non-standard sprinkler systems.

NOTE – The Building Act requires that a 'specified system' is inspected and maintained to ensure it performs, and continues to perform, to the original installation standard. As life cycle replacement of components occurs, or new failure modes become apparent, and so on, the testing, maintenance, and inspection requirements from later standards may need to be applied to ensure the level of performance at the time of original design and installation can continue to be met.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSNZ.COM : Click to view the full PDF of NZS 4541:2020

12.1.4

To check continued compliance with this standard, an SSC may request permission from the owner to enter the protected premises and to check any or all parts of the system and such a request shall not be unreasonably denied.

If an SSC requires any valve, pump, alarm, or other device to be manipulated as a part of the check, the owner shall arrange for the nominated contractor to attend and to carry out such operations.

The contractor shall plan the testing and inspection work to minimise the time that any water supply is to be isolated and shall record the time of such isolations.

12.1.5

A legible written copy of all routine tests and maintenance shall be made in a form acceptable to an SSC. This record shall reflect the full detail of part 12 of this standard and a copy be retained at the control valves or other agreed location on the site. If the records are not kept at the control valves, an indelible sign shall beprovided at the control valves stating where they are kept. Any significant deficiencies shall be separately notified to the owner or designate and rectified urgently.

A full report on all routine inspections shall be made in accordance with 12.3, in a form acceptable to an SSC, with a copy sent to the owner or designate.

It is required that all records will be immediately available to interested parties: including site engineering staff, building managers and other caretakers, IQPs, TA officers, sprinkler system surveyors, other listed contractors, fire insurers, and associated risk advisors.

12.1.6

Where a contractor, with the prior agreement of the owner, wishes to record test results in an electronic or digital format, the contractor shall demonstrate, to the satisfaction of the SSC, that they shall comply with each of the following:

(a) Information shall be held on a secure, reliable database with secure and effective backup;
(b) The result of each test shall be shown against relative data variables (such as pressures);
(c) A copy of this record shall be produced for the owner or designate, or produced in hard copy format and stored at the control valves, at no greater than monthly intervals; and
(d) The requirements of 12.1.5 are met without limitation.

12.1.7

To ensure that the sprinkler system can be expected to perform in accordance with its design criteria all gauge and instrument readings recorded during routine testing are to be compared to the reference information supplied as per 2.10, 6.7.4.8, and 6.7.7.1(j). Where the gauge and instrument readings are not inagreement with the reference information appropriate remedial action shall be taken to restore the performance of the sprinkler installation.

12.2 Routine tests and maintenance

12.2.1 *General*

Routine tests and maintenance shall be undertaken in accordance with the frequencies as detailed in 12.2.2 to 12.2.9.

The same tests and maintenance shall also apply to sprinkler systems in certain small community buildings that have been installed to comply with the provisions of Appendix B, but only to the extent that the items of equipment described in 12.2.2 to 12.2.9 actually form part of the system.

The tolerances that apply to the frequency of prescribed testing and maintenance routines are detailed in Table 12.1. Tolerances shall be applied to the interval from the date of the previous activity. Tolerances shall be applied in such a manner that the maintenance interval does not progressively extend beyond the required frequency specified in Table 12.1.

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

Table 12.1 – Routine tests and maintenance frequency tolerances

Frequency	Tolerance (±)
Weekly	2 working days
Monthly	5 working days
Quarterly/6-monthly	2 weeks
Yearly	1 month
Biennial and greater	4 months

12.2.2 *Weekly*

The following procedures shall be carried out at weekly intervals, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.6:

(a) Diesel engine driven pumps shall be exercised under full load for a period of at least 15 minutes if less than or equal to 125 kW, or for 30 minutes if greater than 125 kW. Diesel engine driven pumps shall be checked for:

(i) Correct start, run, and stop functions and that expected key performance indicators are being achieved, including engine speed, discharge, and suction pressures (as listed on the pressure gauge schedule); correct battery electrolyte level and charging voltage; adequate fuel (not within the fire duty sector), oil, and water levels

(ii) The diesel fuel type and grade used is strictly in accordance with the original equipment manufacturer's specifications (see also 6.7.5.10)

(iii) Starting method shall be varied weekly as follows: automatic/pressure switch; Manual A; Manual B; Emergency

(iv) Where there are multiple pressure switches, additional automatic engine starts will be required, so that no individual pressure switch is tested less than monthly;

NOTE –

(1) The power rating stated is the continuous rating at duty speed.

(2) With suitable agreement, training and supervision from the contractor, the owner's representative may test run the diesel pump set every week, except for the week in which the contractor conducts the monthly tests.

(b) Variable speed control devices on diesel engines shall be tested as follows:

(i) With the pressure control device disabled, the pump shall be exercised under full load as per 12.2.2(a)

(ii) The pressure control device shall then be exercised over its full operating range

(iii) The pump shall then be run with the pressure control device active. During this test, the pump discharge pressure shall be checked to ensure that it does not exceed the set pressure of the pressure control device. The test return isolation valve shall be modulated to ensure that the pressure control device is capable of modulating the engine speed;

(c) Electric motor-driven pumps which do not have the power supply to them continuously supervised by an approved alarm device (see 6.7.7.6) shall be:

(i) Exercised under full load for a period of at least 5 minutes and shall be checked for correct start, run, and stop functions; and delivery and suction pressures (as listed on the pressure gauge schedule)

(ii) Starting method shall be varied weekly as follows; automatic/pressure switch, manual

(iii) Where there are multiple pressure switches, additional automatic engine starts will be required, so that no individual pressure switch is tested less than monthly;

NOTE – Minimum requirements for pump speed, discharge, and suction pressures are provided in the water supply gauge schedule.

(d) An SSC may require that any additional tests and/or maintenance required by equipment manufacturers or listing agencies for the installed equipment be carried out.

12.2.3 *Monthly*

The following procedures shall be carried out at no longer than monthly intervals, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.5:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(a) The correct operation of every input into the FBA signal generator, including pressure sensors and supervisory devices (excluding floor isolate valves and zone subsidiary stop valves) and the correct operation of the FBA signal-generating unit shall be checked. Where fitted, the interconnection between the sprinkler system and the evacuation system shall be tested to ensure that the evacuation alarms will sound on operation of the sprinkler system. It is not necessary to check that all sounders operate correctly, as regular testing of the fire alarm system will ensure the adequacy of the evacuationsounders (refer to NZS 4512);

(b) All chains, locks, and straps within the sprinkler valve house and pump house shall be checked;

(c) Every hydraulic gong shall be exercised and, if necessary, oiled;

(d) Every stop valve on the water supplies, other than street valves, shall be checked to ensure that it is open, correctly marked, and secured;

(e) The control valves, and the area immediately around them in the valve house, shall be checked for free access and, if necessary, cleared. If free access cannot be achieved, the situation shall be reported to the building owner and noted in the report;

(f) All static pressure gauges listed on the pressure gauge schedule shall be checked against this schedule. If any pressures indicate a defective water supply, a flow test in accordance with 12.2.4(d) shall be undertaken;

(g) Electric motor-driven pumps which have their power supply supervised by an approved alarm device (see 6.7.7.6) shall be exercised under full load for a period of at least five minutes and shall be checked for correct start, run, and stop functions, delivery and suction pressures (as listed on the pressure gauge schedule);

NOTE – Pay attention to the interval required by the engine manufacturer between successive motor starts.

(h) Diesel engine driven pumps, in addition to the weekly test, shall be checked for:

(i) Battery installation date is current and indelibly marked on the battery
(ii) Battery electrolyte specific gravity and level are correct
(iii) Engine external cleanness
(iv) Belt tightness
(v) Clean cooling water filter;

(i) Any tank water supply shall be checked, and the level recorded. If the level is less than required, the building owner or designate shall be notified and the report annotated to that effect; and

(j) Where a fire control panel is used for monitoring subsidiary valves, pressure switches, or subsidiary systems as identified in 4.4.2.4, 4.4.2.5, or 4.7.4, the monthly testing requirements of NZS 4512 shall be completed, including battery load testing, testing through to the fire brigade. All other routine testing required by 12.2.3 shall be undertaken at the stated intervals.

(k) Where the correct operation of the system is affected by equipment common to this, or other building(s), such as common pumps and water supplies, and the listed contractor does not have a maintenance arrangement for such equipment, the listed contractor shall check that maintenance is being performed and that the equipment is in an operative state.

NOTE – It is not intended that every subsidiary stop valve be exercised monthly. Those subsidiary stop valves fulfilling the role of sectional or floor isolation valves in multiple floor buildings are addressed in 1202.4(e).

12.2.4 *Quarterly*

The following procedures shall be carried out at no longer than quarterly intervals, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.5:

(a) The installation pressure of each installation shall be dropped by means of the main drain valve, the operating pressures of the FBA, and correct hydraulic gong operation checked and all recorded;

(b) All street and site fire main valves shall be visually inspected to ensure accessibility and, where safe to do so, manually operated to ensure that they are fully open;

NOTE – Where valves are located in main traffic lanes it may not be safe to manually operate them. In such cases, the requirement to carry out a manual check to ensure that the valves are fully opened may be waived, but see 12.2.4(h).

(c) The hose reel water supply shall be checked (if applicable);

NOTE – It is recommended that water supplies to all supplementary fire protection systems are inspected during this quarterly inspection. This includes any riser, hydrant, deluge, and other fire protection systems installed in conjunction with the sprinkler system.

(d) Each water supply shall be individually tested through the main drain valve, with the valve fully lifted off its seating and the results recorded and then compared with the tabulated reference pressure(s). If the water supply is a boosted town main, the pump(s) shall be isolated for this test. If there are multiple control valve sets in the same enclosure (for example, fed from the same manifold), then this test can berecorded once (then progressively rotated through each of the other valve sets at subsequent 3-monthly

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

intervals). However, each alarm valve shall be lifted from its seating and then resultant operation of the associated alarm gong also confirmed every 3 months;

NOTE –

(1) Where the drain valve is used for this test, because of the comparatively low flow from a 50 mm orifice, a significant deterioration in the water supply may produce only a minor reduction in residual pressure. It is, therefore, essential to use accurate gauges and to read and record the gauges with great care.

(2) This test should be regarded as indicative. In the event of a reduction in pressure below the reference pressure:

(a) The water supply should be regarded as being defective and the fact reported IMMEDIATELY to the owner or designate unless the defect can be remedied forthwith, and

(b) A full water supply test is to be carried out using the fire sprinkler inlet (or substitute device).

(e) Where reasonably accessible, each subsidiary stop valve and its supervisory system shall be physically checked to ensure the valve is fully open, operates correctly, and is correctly marked and secured. Where not easily accessible, each subsidiary stop valve indicator shall be visually checked to ensure thevalve is fully open, correctly marked, and secured. If not checked quarterly they shall be fully exercised annually;

(f) Flow switches and their associated panel indicators installed in buildings of more than six storeys or where flow switches are used for critical functions, shall be tested using the test facility described in 4.7.4;

NOTE – The use of flow switches to control an evacuation system, such as an EWIS system would be regarded as a critical function.

(g) A check shall be carried out of all subsidiary systems, including pre-action systems, deluge systems, and water mist systems. See Appendix U for guidance. The pressure of the antifreeze solution in tail- end antifreeze systems shall also be checked to ensure it remains at least 150 kPa above the standing pressure of the sprinkler system;

(h) A visual inspection shall be undertaken to ensure that Toby boxes covering street isolation valves are clearly marked and accessible;

(i) Where sprinkler heads are in dirty atmospheres and are protected by covering with lightweight paper bags, the bags shall be checked and replaced quarterly if heavily contaminated. This inspection may be carried out by the building owner or designate;

(j) Sprinkler heads below the filters in commercial cooking fume extraction equipment shall be checked and replaced if heavily contaminated;

(k) Where break or infill tanks comprise part of a water supply, correct actuation and shut off of the automatic infill valve shall be determined (see also 6.4.3.2(c));

NOTE – Use of the main drain valve (see 12.2.4(d)) will normally prove sufficient to actuate the automatic infill valve for this purpose.

(l) In dry systems covering refrigerated areas, check the number of compressor cycles (by reference to the cycle counters) or run time (from the hour meter) over four, 3-month periods, corresponding to the peaks of summer, autumn, winter, and spring, respectively. Thereafter, note and record the number of cycles every 3 months, then compare with the trend data for the respective seasons. If this comparison shows the number of cycles has increased more than 10 per cent, establish the cause for the increase and also inspect sprinkler pipework for ice plugs (see 12.2.5(k)) and take remedial action as necessary. Both trend and ongoing compressor cycle numbers shall be individually recorded in accordance with the provisions of 12.1.5;

(m) Where a fire control panel is used for monitoring subsidiary valves, pressure switches, or subsidiary valves as identified in 4.4.2.4, 4.4.2.5, or 4.7.4, all inputs to the control panel shall be tested for correct indication and operation; and

(n) Any other feature interfaced with the sprinkler system, and required to be tested quarterly by the building's compliance schedule.

12.2.5 *Yearly checks*

The following procedures shall be carried out at the frequency specified, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.5:

(a) Every diesel engine forming part of a diesel engine driven pump unit shall be serviced by a competent diesel mechanic every year, the oil brought to normal operating temperature then changed, and a check made of the air filter, the primary cooling circuit coolant corrosion inhibitor for correct specific gravity together with any obvious signs of corrosion, and the fuel for bacterial sludging. The accuracy of the level gauge of every diesel engine fuel tank shall be checked and confirmed to be accurate to within 10%. This may be achieved using a dip stick or other suitable method of verifying the contents of the

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

tank for comparison with the installed gauge. Where cooling systems are fitted with sacrificial anode(s), the anode(s) shall be examined for obvious signs of corrosion and replaced as necessary at intervals not exceeding that specified by the original equipment manufacturer. This service shall be followed by a full load run of the pump unit for at least 1 hour, with any pump enclosure doors closed. Additionally, every second year, the service shall include changing the oil filters, fuel filters, belts, and thermostats. This service shall be followed by a full load run of the pump unit for at least 2 hours;

(b) The function of check valves forming part of all antifreeze installations shall be checked annually;

NOTE – Functional testing of the check valve should indicate that the valve both seals and opens.

(c) All antifreeze solutions shall be tested annually in accordance with the provisions of 12.7;

(d) Flow switches, unless required to be tested quarterly in 12.2.4(f), shall be tested annually;

(e) Backflow prevention devices forming part of the water supply system being supplied with potable water shall be tested annually according to the procedure specified in the NZBC Clause G12;

NOTE – Automatic backflow preventers, and fire sprinkler systems are required to be tested in accordance with the procedures on the compliance schedule issued by the TA. The compliance schedule for automatic backflow prevention references the United States Environment Protection Agency *Cross-Connection Control Manual* and AS 2845.3.

(f) Any pump set flexible couplings that rely on elastomeric elements for transmission of drive shall be inspected for obvious wear and deterioration annually. If any evidence of wear or deterioration is obvious, the coupling's elastomeric element shall be replaced;

(g) Where multiple installations are served through a single fire sprinkler inlet (see Figure 6.17), the check valves shall be exercised annually, to ensure that they are free and not seized shut;

(h) Antifreeze drops shall be drained and refilled with fresh antifreeze agent annually, or alternatively, replaced with dry barrel sprinklers;

(i) Where sprinklers are located to protect commercial cooking extraction equipment, sprinklers above filters shall be checked annually, and replaced if heavily contaminated;

(j) Water storage tanks are to be inspected and maintained in accordance with the recommendations of the suppliers of the tank;

NOTE – The tank manufacturer may recommend annual checks. See also 12.2.7(b) and 12.4.

(k) Automatic sprinkler piping installed in freezers or cold stores shall be initially inspected internally for ice plugs 6 months after commissioning a new installation. If found clear, internal inspections shall be carried out annually;

If ice plugs are found:

(i) An investigation shall be carried out to ascertain the cause, and to prevent further recurrence of ice plugs

(ii) The frequency of ice-plug investigations shall be reduced to 6-monthly, until two subsequent investigations with no ice-build-up are found.

NOTE –

(1) Ice plugs are most prevalent within 3.0 m to 5.0 m of the point where the sprinkler piping enters the freezer environment, as well as at the first elbow or tee fitting in the freezer.

(2) An ice plug is forming, requires removal and more frequent re-inspection when there is more than 10 mm ice or frost build-up on the inside of the pipe, over any length.

(l) Annual checks and maintenance of hand-operated fire equipment in accordance with the provisions of NZS 4503; and

(m) An SSC may require that any additional tests and/or maintenance required by equipment manufacturers or listing agencies for the installed equipment be carried out.

12.2.6 *Biennial checks*

The following procedures shall be carried out at the frequency specified, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.5:

(a) Each battery of every diesel engine driven pump set shall be routinely replaced every 4 years except that one of the batteries shall be initially replaced after 2 years so that, thereafter, one battery is replaced every 2 years. Replacement batteries shall be marked in accordance with the requirements of 6.7.3.9 when installed. The rating of any replacement battery shall comply strictly with the controller load and engine cranking requirements of 6.7.3.9.

NOTE – It is strongly recommended the battery warning label shown in 6.7.3.9 should be retrospectively displayed for diesel pump sets of all vintages.

In this context, 'battery' means a set of cells connected to a single charger;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(b) All surfaces of fire walls which provide separation between sprinklered and unsprinklered firecells or between sprinklered and unsprinklered buildings shall be inspected to confirm that the wall has not been perforated or its integrity impaired. Such inspections shall be made annually for non-masonry fire walls and at intervals not exceeding 2 years for masonry firewalls; and

(c) Any other feature interfaced with the sprinkler system, and required to be tested by the building's compliance schedule.

12.2.7 *Quadrennial checks*

The following procedures shall be carried out at no longer than quadrennial intervals, and the results of the procedures shall be recorded in accordance with the provisions of 12.1.5:

(a) Inspect and overhaul all of the following types of valves in a sprinkler system (including, therefore, those forming any part of the water supplies):

(i) Alarm valves

(ii) Stop valves (see Note 1)

(iii) Check valves (see Note 2);

(b) Soft seated water supply check valves shall have their elastomeric components replaced. Metal-seated check valves shall be physically inspected or tested, and necessary remedial action shall be undertaken to ensure that they are in a serviceable condition;

NOTE –

(1) Stop valves that are of the type that are not serviceable need only be visually inspected.

(2) On a town's main supplies, only those check valves on the incoming main that are within the boundary of the premises on which the protected building is located are subject to inspection and overhaul.

(c) Every water supply tank shall be visually checked for cleanness and, if necessary, emptied and cleaned out;

NOTE – Suitable underwater cleaning regimes may preclude the need to drain the tank for this purpose. See also 12.2.5(j) and 12.4.

(d) All pilot-operated control valves (including pressure reducing valves, pressure relief valves, pressure sustaining valves, tank level control valves, and the like), shall be disassembled, have elastomeric components replaced, cleaned, reassembled and be recommissioned;

(e) Diaphragm style valves used on fire sprinkler inlets and as part of pump or diesel engine cooling circuits shall have their elastomeric components replaced;

(f) Pump set flexible drive couplings, which rely on the integrity of the elastomeric element shall have the element replaced; and

NOTE – If physically possible, it would be preferable to replace the pump coupling with a coupling complying with 6.7.1.5(e). This approach would be expected to reduce the longer-term maintenance costs for the sprinkler system.

(g) All small bore strainers, including those on Type Y alarm bypass trims shall be inspected and cleaned as necessary.

12.2.8 *Non-standard sprinkler systems*

In addition to the tests already specified in the preceding clauses, an SSC may specify such other tests as may be necessary for non-standard types of systems. See Appendix V for further information. The results of the procedures shall be recorded in accordance with the provisions of 12.1.5.

12.2.9 *Listed kitchen fire suppression systems*

Listed systems installed for the protection of commercial cooking extraction systems in accordance with 5.10.12.1 shall be routinely tested and maintained in accordance with their manufacturer's instructions, and any special instructions included with their listing criteria. These shall be inspected every 6 months.

12.3 Routine inspections

12.3.1

To operate effectively, sprinkler systems shall comply with this standard in all respects at all times. To ensure that building alterations; changes in occupancy, processes, or storage; or progressive deterioration of sprinkler system components do not prejudice the system, a comprehensive inspection shall be carried out biennially.

Such inspections shall be carried out by a listed contractor who has been independently accredited by an internationally recognised accreditation body to AS/NZS ISO/IEC 17020 as a Type A inspection body to

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

inspect fire sprinkler systems for compliance with NZS 4541. See Appendix E, Figure E2 for a compliance flow chart.

To facilitate access to all areas of the building, and to establish whether changes have occurred since the prior inspection, such inspections should be prearranged and planned with the building owner. Also see 12.3.2(i).

Any area of the building not reasonably able to be accessed during inspection shall be listed in the inspection report. If the area of the building unable to be inspected exceeds any of the following tolerances, then the area concerned shall be inspected before the report being issued:

(a) 10% of individual rooms or suites in buildings such as hotels and apartments;
(b) A nominal 5% of floor area in buildings such as offices and retail occupancies; or
(c) A nominal 5% of floor area in occupancies such as manufacturing or warehouses.

If such areas cannot be accessed at the next biennial inspection, the contractor shall not issue a Form 12A until such time that access is provided.

12.3.2

The routine inspection shall include checks on the following:

(a) The operation, flow, and pressure characteristics of the performance of each water supply and the design flow and pressure at the time of inspection. Where a water supply comprises a pump-boosted main, both the unboosted and pump-boosted characteristics shall be tested and recorded. A drain test of the unboosted water supply shall also be completed and recorded;

NOTE –

(1) See 6.6.4.1 on the need to coincide the flow testing of artesian bores with the time of lowest bore head pressure.

(2) Installations installed to the 2003 or earlier editions of the standard may have a Class A or B1 water supply with up to two supplies dependant on a town's main. In such cases, it may be necessary to have a traffic management plan to allow each supply to be individually tested on a safe manner. Consideration can be given to retrofitting a supervised isolation valve upstream of each town's main water supply check valve to remove the need to implement a traffic management plan, should the requirement to close any intermediate valves on the water supply reticulation not also be required for a compliant Class B1 water supply test.

(3) Appendix R provides two methods of assessing the capacity of a territorial authority's water supply. The fire protection industry has traditionally accepted that when using 80% of the water supply pressure, that 10% of the margin is for long-term deterioration in the public water supply and that 10% of the margin is for daily or seasonal fluctuations. NZS 4541 is silent on this matter, and on retesting a water supply, requires no margin between supply and demand. If the margin between supply and demand is less than 10%, unless the listed contractor responsible for the inspection, testing and maintenance requirements is confident that the water supply is adequate at all times, it is recommended that a 7-day pressure recording is carried out to verify the adequacy of the water supply, before a system is issued with a Form 12A.

(4) Permanently installed in-line flow meters will require a current calibration certificate at the time of flow testing.

(b) The continuing adequacy of the water supplies to infill or break tanks shall be tested. An acceptable method of doing so is by refilling a measured volume over time, while also noting the running pressure over this refill period does not fall below 100 kPa at the inlet to the automatic flow control valve;

(c) The operation of all pumps, tanks and tank filling, and any equipment associated with the water supplies;

NOTE – This includes verification of the correct setting of any pressure sustaining valves installed as required by 4.4.6.3.

(d) The operation, labelling, and securing of all valves and controls and any other equipment that forms part of the sprinkler system, including all supervisory signalling and indicating devices;

NOTE – This includes verification of the correct operation of any flow control valves for hazardous areas as required by 4.4.12.

(e) The accuracy within ± 4% of all pressure gauges at normal supply pressure when checked against a test gauge certified to Part 2 of BS 1780;

(f) The currency of the block plan, water supply reference information and gauge schedule, the adequacy of signage, and any required operating and maintenance instructions;

NOTE – A survey site plan is not an acceptable alternative to either the block plan or water supply information required by 2.9 and 2.10.

(g) Confirmation that all the routine tests and maintenance items due, as identified in Part 12 of this standard, have been completed and adequately recorded in accordance with the provisions of 12.1.5;

(h) The accessibility, functionality, and labelling of the fire sprinkler inlet;

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(i) The adequacy of sprinkler spacing and location. The survey contractor shall also ascertain from the building owner or designate whether there have been changes to the building or alterations to the sprinkler system. If the nature of alterations to the sprinkler system could affect adequacy of the system and adequate documentation including confirmation of a site inspection by an accredited inspection body cannot be provided to validate the compliance of these alterations, this shall be stated in the survey as a significant deficiency requiring rectification accordingly;
(j) The adequacy of the design density for the storage heights, configurations, and categories, and process risks present at the time of inspection;
(k) The adequacy of in-rack protection, in-rack barriers, and aerosol cages for racking layouts present at the time of inspection. Care shall be taken to correctly establish material categories, rack widths, and any related barrier provisions;
(l) The adequacy of clear space below sprinkler heads;
(m) The adequacy of all storage height signs;
(n) The suitability and condition of installed sprinkler heads, and adequacy of visible pipework and its support structure;
(o) Protection (including sprinklers, pipework, and any required separations) within ceiling and other concealed spaces with permanent access and any other such spaces in which there have been alterations to either the building or the sprinkler system that have not previously been inspected;

NOTE – A routine inspection is normally expected to be carried out from trafficable areas to identify changes to the sprinkler system or the building and its environment which could impair the performance of the sprinkler system.

(p) The separation between protected and unprotected areas including the presence of any external fire loads (including adjacent or neighbouring buildings) and the adequacy of associated fire separation provisions;
(q) The concentration of antifreeze installations;
(r) The coverage and maintenance of hand-operated firefighting equipment in accordance with NZS 4503; and
(s) An SSC may require that any additional tests and/or maintenance required by equipment manufacturers or listing agencies for the installed equipment be carried out.

12.3.3

The report on the survey shall cover the items inspected and the results of all tests and additionally shall specifically provide the following information:
(a) The method of separation between protected and unprotected areas;
(b) The required design density and area of operation for each area of the building and the height of the highest sprinkler in each area;
(c) The required design flows and design pressures at the time of the inspection;
(d) A graph showing the water supply (or supplies) as tested, with the design flows and pressures marked in relation to the flows and pressures obtained;
(e) A list of all matters that require remedy to maintain compliance with this standard.

Once the SSC has received evidence the deficiencies identified in the list described in 12.3.3(e) are remedied, or if no deficiencies are noted, an SSC may at the request of the building owner issue a certificate of compliance as prescribed in Appendix E.

12.4 Twelve-yearly inspections

The following applies in the absence of more stringent requirements from the manufacturer of any tank. Water supply tanks shall be drained at 12-yearly intervals, and then inspected internally and externally for absence of corrosion and ongoing serviceability. Particular attention shall be paid to the following components: suction inlets (including strainer and vortex plates), level indicators, tie rods, roof supports, external banding, fittings including access ladders and hatches, supply pipework and level control devices, tank walls, liners and base fittings.

NOTE – Suitable diver inspection and underwater cleaning regimes may preclude the need to drain the tank for this purpose. See also 12.2.5(j) and 12.2.7(b).

12.5 Testing of sprinklers

12.5.1

See Appendix V for guidance on the requirements for testing sprinklers.

12.5.2

Where sprinklers have been in service for 50 years, or 10 years for dry barrel sprinklers and multiple jet controls (MJC), they shall be either:

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

(a) Replaced; or
(b) Representative samples from one or more sample areas shall be submitted to a recognised testing laboratory acceptable to an SSC for field service testing. Testing shall be repeated at 10-yearly intervals.

When dry barrel sprinklers have been tested the sprinklers in the subject area shall have a maintenance tag attached with the date that testing was conducted.

NOTE – Dry barrel sprinklers are often called dry drops in New Zealand. The term dry barrel sprinkler includes dry sprinklers designed for all orientations, including pendent, upright, and sidewall orientations.

12.5.3

Representative samples of solder-type sprinklers with a temperature classification of 163°C or greater that are exposed to semi-continuous to continuous maximum allowable ambient temperature conditions shall be tested at 5-yearly intervals.

12.5.4

Sprinklers manufactured before 1920 shall be replaced.

12.5.5

A representative sample of sprinklers shall consist of a minimum of no fewer than 10 sprinklers or 1% of the number of sprinklers in an individual sample area, whichever is greater.

12.5.6

Where one sprinkler within a representative sample fails to meet the test requirement, all sprinklers represented by that sample shall be replaced.

12.5.7

Sprinklers that have been the subject of a replacement or recall program as advised by the SSC shall be replaced.

12.6 Water supply strainers

Following any significant flow through a water supply strainer, the strainer shall be internally inspected and cleaned. Significant flows are those that have a potential to block a strainer. This would include a full flow test, any sprinkler operation where a significant number of sprinklers operate, or a flow where experience on the site, or in the general area, indicates that the strainer may be partially blocked.

12.7 Testing of antifreeze solutions

Antifreeze solutions shall be tested annually using the following procedure:

(a) Using installation records, maintenance records, and information from the owner, chemical tests, or other reliable sources of information, the type of antifreeze in the system shall be determined:
    (i) If the type of antifreeze is found to be a type that is no longer permitted, the system shall be drained completely and replaced with an acceptable antifreeze solution
    (ii) If the type of antifreeze cannot be reliably determined, then the system shall be drained completely and replaced with an acceptable antifreeze solution;

(b) If the antifreeze is not replaced in accordance with 12.7(a), test samples shall be taken at the top of each system and at the bottom of each system:
    (i) If the most remote portion of the system is not near the top or the bottom of the system, an additional sample shall be taken at the most remote portion
    (ii) If the connection to the water supply piping is not near the top or the bottom of the system, an additional sample shall be taken at the connection to the water supply;

(c) The specific gravity of each solution shall be checked using a hydrometer with a suitable scale and shall take into account the temperature of the fluid to allow for variations in specific gravity. The results shall be compared against the manufacturer's published data, or where this is unavailable, against Figures 12.1 and 12.2 as appropriate;
(d) If any of the samples exhibits a concentration in excess of what is permitted by 3.2.5.2 and 3.2.5.3, the system shall be emptied and refilled with a new acceptable antifreeze solution. If a concentration greater than what is currently permitted by 3.2.5.2 was necessary to keep the fluid from freezing, alternate methods of preventing the pipe from freezing shall be employed; and
(e) If any of the samples exhibits a concentration lower than what is permitted by 3.2.5.3, the system shall be emptied and refilled with a new acceptable antifreeze solution.

NOTE –

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

COPYRIGHT © Standards New Zealand

(1) For the purposes of this clause, an acceptable antifreeze solution is one that complies with 3.2.5. This limits the maximum concentration of antifreeze solutions and requires that they be premixed and listed for the purposes of being used in a sprinkler installation.

(2) It is recognised that the provisions of 12.7(d) may be onerous. If the owner of an existing sprinkler system does not comply with these provisions, compliance with this standard cannot be claimed.

(3) As the specific gravity of antifreeze solutions varies with temperature, relying on specific gravity alone is not a reliable method of testing for solutions concentration. It is imperative that the specific gravity is measured while allowing for the temperature of the solution.

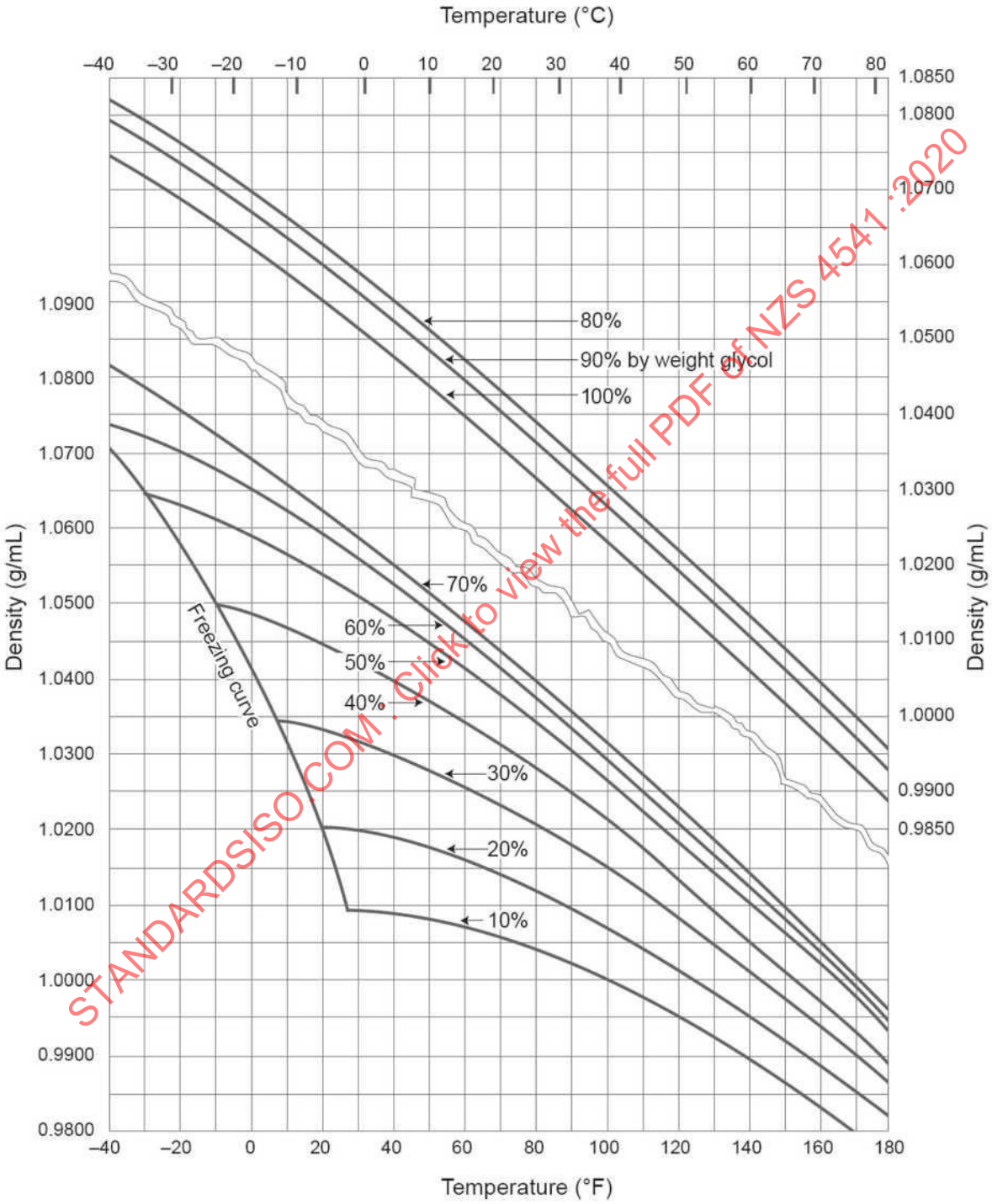


Figure 12.1 – Density of propylene glycol in solution

STANDARDSISO.COM : Click to view the full PDF of NZS 4541:2020

This publication is for exclusive use of Enterprise Singapore and is not for third-party distribution