

TECHNICAL REPORT

**Railway applications – Automated urban guided transport (AUGT) – Safety requirements –
Part 2: Hazard analysis at top system level**

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TECHNICAL REPORT

**Railway applications – Automated urban guided transport (AUGT) – Safety requirements –
Part 2: Hazard analysis at top system level**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
AUTOMATED URBAN GUIDED TRANSPORT (AUGT) –
SAFETY REQUIREMENTS –****Part 2: Hazard analysis at top system level**

FOREWORD

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IEC 62267-2, which is a technical report, has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
9/1390/DTR	9/1423A/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 62267 series, under the general title *Railway applications – Automated urban guided transport (AUGT) – Safety requirements*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

This Technical Report publishes the hazard analysis at top system level conducted by members of working group 45 of IEC technical committee 9 in order to allocate possible safeguards able to compensate for the absence of a driver in the front cabin of the train or attendant staff from the train as mentioned in 4.2 of IEC 62267:2009.

The hazard analysis is structured in accordance to basic functions of train operations following Table 1 of IEC 62267:2009 covering the basic hazards of train operations.

The hazard analysis tabulates the identified hazards with their associated causes and triggers as well as providing an associated list of possible safeguards able to compensate the absence of operational staff from the front cabin of a train. The results of hazard analysis do not state the choice of safeguards or the acceptable level of residual risk which may vary depending on the local safety culture. The choice of a listed safeguard or combination of safeguards, or the choice not to use any safeguard to compensate or mitigate a specific hazard in a specific application depends on the risk tolerability which is to be assessed under the responsibility of the Transport Authority and Safety Regulatory Authority by a specific risk analysis. This technical report, therefore, does not judge whether a safeguard or a combination of safeguards is necessary.

However, this technical report is intended to support Transport Authorities and Safety Regulatory Authorities in hazard identification as well as selecting and combining safeguards as a basis for a specific risk analysis required for any application with regard to their local safety culture.

IEC 62267 can be seen as a generic guideline specifying detailed safety requirements for safeguards proposed as a result of the present generic hazard analysis for the design of specific AUGT systems. The hazard analysis and the safeguards derived from it, together with their safety requirements, are based on experiences gained from design and operation of existing AUGT systems in North America, Europe and Asia.

The present generic hazard analysis and the derived safety requirements can be seen and used as part of the lifecycle of the system as defined in IEC 62278, required for any railway application including AUGT systems. The present hazard analysis covers the required hazard identification as part of risk analysis (lifecycle phase 3) and determination of safety-related system requirements (lifecycle phase 4) on a generic level, which is indispensable for design/implementation of an AUGT system. Because IEC 62267 specifies safety requirements on a generic level only, a specific risk analysis including specific hazard identification must be conducted. In order to facilitate the process of specific risk analysis and determine system requirements, the present hazard identification, the list of possible safeguards and the methodology can be used as a guide to verify the conditions of specific system environment.

The use of the present hazard analysis and derived methodology can additionally help harmonize the process of specific risk analysis in this field of application. Such a harmonized process has the intention to facilitate the necessary agreements between Transport Authorities and the resulting approval by Safety Regulatory Authorities.

RAILWAY APPLICATIONS – AUTOMATED URBAN GUIDED TRANSPORT (AUGT) – SAFETY REQUIREMENTS –

Part 2: Hazard analysis at top system level

1 Scope

This technical report provides a non normative generic hazard analysis at top system level conducted for the development of IEC 62267 for Automated Urban Guided Transport (AUGT) systems. This report is applicable to all systems covered by the scope of IEC 62267.

This generic hazard analysis cannot be used for specific applications without taking into account the specific system environment and local safety culture.

This generic hazard analysis can be used for specific AUGT systems to support the necessary activities in lifecycle process following IEC 62278 (RAMS).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62267:2009, *Railway applications – Automated urban guided transport (AUGT) – Safety requirements*

IEC 62278:2002, *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)*

3 Terms and definitions

For the purposes of this document, the terms and definitions set out in IEC 62267 apply.

4 Definition of the system and basic functions

4.1 AUGT system

The hazard analysis at top system level has been carried out based on a generic system definition which is described in Clause 5 of IEC 62267:2009. This system definition contains the system boundaries and application conditions as required by IEC 62278. Additionally, entities to be protected (persons with different purposes and behaviours present in the system as well as property) because exposed to possible hazardous situations, have been taken into account as defined in Clause 6 of IEC 62267:2009.

4.2 AUGT basic functions

The hazard analysis at top system level has been carried out based on generic basic functions identified in Table 1 of IEC 62267:2009.

5 Methodology of the present hazard analysis

5.1 General

It is the purpose of the hazard analysis to demonstrate that the AUGT application is as safe as applications with drivers. This is the reason that it has been structured following the basic functions of AUGT systems as identified in Table 1 of IEC 62267:2009.

5.2 Hazard identification

The column “Hazard” shows the top-level hazards identified. A hazard is considered as a matter of fact present in the system as a result of train operations (e.g. closing and opening of train doors) or possible influences to these operations (e.g. obstacle in the guideway).

5.3 Cause identification

The column “Cause” contains the reason or description why the hazard may lead to an accident.

5.4 Trigger identification

The column “Trigger” contains the possible event(s) or condition(s) which leads from the identified hazard to an accident.

5.5 Hazardous situation

The combination of hazard, cause and trigger are mentioned and tabulated in Clause 7 of IEC 62267:2009 as “hazardous situation”. It shall be noted that a hazardous situation can be mitigated usually only by avoiding or mitigating causes and/or triggers. Table 1 gives a unique number for each hazardous situation.

5.6 Accident

The column “Accident (Effect)” in Table 1 contains the assumed harmful consequence for each identified hazard, cause and trigger.

5.7 Result of the hazard analysis

The column “Safeguard” in Table 1 lists possible measures (barriers) which are able to compensate the absence of

- a train driver from the front cabin of the train (Driverless Train Operation – DTO), or
- any attendant staff on board train (Unattended Train Operation – UTO),

in order to mitigate the hazardous situations to a sufficient level. The possible safeguards are gained from the experience of AUGT systems operated in the world and defined in a way that they are able to cover causes and/or triggers related to a hazard and to the assumed consequence.

During the development of the hazard analysis for each mitigation and thereby each safeguard of the identified hazards, the question of whether the safeguard compensates for the absence of driver (DTO) or staff (UTO) was addressed by the group. The resulting hazard analysis table (Table 1) shows the safeguards that were found to be able to either mitigate or compensate the identified hazards, taking into account the local safety culture. When the safeguard on its own compensates the absence of driver or staff for the identified hazard, the character “C” has been entered in the column “Remark”.

5.8 Reference to IEC 62267

The column “IEC 62267:2009” provides the references to the safety requirements described in Clause 8 of IEC 62267:2009 which might be considered for choosing safeguards or appropriate combinations of safeguards and to establish their system requirements as requested by lifecycle phase 4, described in 6.4 of IEC 62278:2002.

The entry “Out of scope” is provided if a hazardous situation and the assigned safeguard are not specific to AUGT systems because in conventional operations operational staff on board trains is not involved in hazard mitigation. Thus, “Out of scope” is entered in the column when no reference to a safeguard is provided in IEC 62267.

6 Structure of hazard analysis table

6.1 General

The present hazard analysis table (Table 1) is structured according to the basic functions of train operations for which a driver from the front cabin or attendant staff on board the train has a responsibility for ensuring safe operation depending on the grade of automation. Each basic function is intended to cover their associated top-level hazards as described below.

6.2 Hazards associated with “ensuring safe movement of trains”

Ensuring safe movement of trains and its associated basic functions “ensure safe route”, “ensure safe separation of trains” and “ensure safe speed” is intended to cover all hazards leading to derailment or collision of trains with other trains or infrastructure caused by

- unsafe routes and route elements (e.g. moving points, flank movements or oncoming train movements),
- insufficient spacing between trains and between train and infrastructure (e.g. line end),
- exceeding permitted speed (e.g. due to wrong determination, or wrong adherence).

Due to the fact that “safe movement of trains” has to be considered, at least from Semi Automated Train Operation (STO) onwards, as never being under the responsibility of operations staff on board trains and as being realised as state of the art by technical train control and protection systems, it was decided to declare these basic functions as not AUGT specific. However, safe movement of trains and coverage of associated hazards is the most important prerequisite for any AUGT system as stated by IEC 62267:2009.

6.3 Hazards associated with “driving”

“Driving” represented by the basic function “control acceleration and braking” shall be considered as not being under the responsibility of operations staff on board trains at least from Semi Automated Train Operation (STO) onwards.

Automation of acceleration and braking is realised as state of the art by technical systems. Therefore it was decided to declare these basic functions as not AUGT specific, taking into account that the associated hazards caused by insufficient acceleration and braking are covered by the basic function “ensure safe speed”.

6.4 Hazards associated with “supervising guideway”

In grades of automation DTO and UTO, the responsibility of on board staff for supervising the guideway in order to prevent as far as possible collisions with unmeant obstacles or persons in the guideway has to be mitigated sufficiently because operations staff is absent from the front cabin of the train.

Therefore the basic function “prevent collision with obstacles” is intended to cover all hazards endangering moving trains and their passengers caused by intrusive elements outside trains

(e.g. cars, parts of infrastructure, tools for maintenance left on the track) into the clearance of guideway.

Therefore the basic function “prevent collision with persons” is intended to cover all hazards for persons who are endangered by moving trains caused by intrusion into the clearance of guideway (e.g. fall into platform track) or while present beside moving trains (e.g. waiting at platform edge).

6.5 Hazards associated with “supervising passenger transfer”

In grade of automation UTO, the responsibility of on board staff for supervising the passenger transfer between platforms in stations and the train in order to prevent as far as possible injuries to persons shall be mitigated sufficiently because operations staff is absent from the train. Therefore

- the basic function “control passenger doors” is intended to cover all hazards endangering passengers caused by unintentional opening and closing of passenger doors,
- the basic function “Prevent person injuries between cars or between platform and train” is intended to cover all hazards endangering passengers while passing between platform and train caused by gaps between cars of a train and between car body and platform edge,
- the basic function “Ensure safe starting conditions” is intended to cover all hazards endangering persons caused by unexpected starting of trains (e.g. train start with open doors, train start with trapped obstacle between door leaves).

6.6 Hazards associated with “operating a train”

In grade of automation UTO, the responsibility of on board staff for operating a train in order to prevent as far as possible unsafe situations for passengers shall be mitigated sufficiently because operations staff responsible for operating a train is absent. Therefore

- the basic function “put in or take out of operation” is intended to cover all hazards endangering passengers caused by putting faulty trains in operation and endangering passengers in trains taken out of operation,
- the basic function “Supervise the status of a train” is intended to cover all hazards endangering passengers caused by train failures arising during operation.

6.7 Hazards associated with “ensuring detection and management of emergency situations”

In grade of automation UTO, the responsibility of on board staff for detecting emergency situations and to react in an appropriate way in order to minimize their consequences to passengers and property shall be mitigated sufficiently because operations staff is absent from the train.

Therefore this basic function is intended to cover all hazards endangering passengers caused by emergency situations (e.g. fire/smoke, derailment, flooded guideway). It shall be noted that emergency situations are sometimes the result of failed measures or failed safeguards intended to prevent arising of the situation.

7 Risk analysis for a specific application

A risk analysis is mandatory according to IEC 62278 and shall be carried out for each specific AUGT application. It includes risk assessment and ensures that all risks arising from the specific application have been taken into account.

The risk analysis for a specific application is also intended to identify secondary hazards related to failure analysis of the chosen safeguards and to determine their required safety targets leading to the accepted residual risk.

8 AUGT hazard analysis table

Table 1 – Hazard analysis table

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
0.1	Ensuring safe movement of trains / Ensure safe route							
	Hazardous situations resulting from unsafe routes and route elements (e.g. moving points, flank movements or oncoming train movements)			Derailment of trains or collision with other trains	1	Train control and protection system		Out of scope
0.2	Ensuring safe movement of trains / Ensure safe separation of trains							
	Hazardous situations resulting from insufficient spacing between trains and between train and infrastructure (e.g. line end)			Collision with other train or infrastructure	1	Train control and protection system		Out of scope
0.3	Ensuring safe movement of trains / Ensure safe speed							
	Hazardous situations resulting from exceeding permitted speed (e.g. to wrong determination or wrong adherence)			Derailment or collision with other train or infrastructure	1	Train control and protection system		Out of scope
0.4	Driving							
	Hazardous situations resulting from insufficient acceleration and braking are considered as covered by the basic function ensure safe speed following state of the art			–	1	Train control and protection system Automated acceleration and braking	Non-safety related function because covered by ensure safe speed	Out of scope
1	Supervising guideway / Prevent collision with obstacles							
1.1	Obstacle in guideway clearance	Element from outside protrudes into the guideway clearance inside tunnel e.g. drill	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, destroying of the car body	1	External rules	Procedures if work is in progress near the tunnel	Out of scope
1.2	Obstacle in guideway clearance	Element from outside the system has fallen into the guideway clearance e.g. tree, crane, car (vandalism included)	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, destroying of the car body	1	Rules for checking guideway clearance		8.3.4
					2	Physical barriers on bridges		8.7.4
					3	Physical barriers along the track		8.7.3
					4	Wayside obstacle detection device	C	8.7.7
					5	On board obstacle detection device	C	8.5.5
1.3	Obstacle in guideway clearance	Element from inside the system left after maintenance in the guideway clearance e.g. tools or materials	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, damage to the car body	1	Rules for checking guideway clearance	C	8.3.4
					2	On board obstacle detection device	C	8.5.5
					3	Rules for hand-over of the guideway following maintenance		8.1.3.6

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
1.4	Obstacle in guideway clearance	Element from inside the system falling in the guideway clearance during operations (e.g. parts of a train, or the structure or wayside equipment)	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, destroying of the car body	1	Rules for checking guideway clearance		8.3.4
					2	On board obstacle detection device	C	8.5.5
					3	Design rules for trains		Out of scope
					4	Design rules for structures		Out of scope
					5	Design rules for wayside equipment		Out of scope
1.5	Obstacle in guideway clearance	Obstacle intrudes the guideway clearance at closed level crossing	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, damage to the car body	1	Level crossing supervision		8.7.12.2
					2	Level crossing barrier		8.7.12.1
1.6	Obstacle in guideway clearance	Obstacle present on level crossing when closing is requested	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, damage to the car body	1	Level crossing supervision	C	8.7.12.2
1.7	Obstacle in guideway clearance	Obstacle (e.g. car) coming from level crossing intrudes into the guideway clearance between stations	Train is approaching	Collision with obstacle, person might be injured e.g. derailment, collision, damage to the car body	1	Prevention and detection of intrusion into the guideway from the level crossing	C	8.7.12.3
2 Supervising guideway / Prevent collision with persons								
2.1	Person in station at platform edge	Part of train protrudes into platform area	Train is approaching	Person is hit by the train (death or injury)	1	Train complies with guideway clearance		Out of scope
2.2	Person in station at platform edge	Person protruding into the guideway clearance	Train is approaching	Person is hit by the train (death or injury)	1	Warning means related to platform edge		8.4.1.2
					2	Action of operational staff	C	8.2.2
					3	Emergency stop switch on platform		8.4.1.5
					4	Platform fences		8.4.1.3
					5	Partial-height platform screen	C (depending on height and distance to platform edge)	8.4.2.2
					6	Full-height platform screen	C	8.4.2.1

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
2.3	Person in station at platform edge	Approaching or passing train causes pressure pulse	Train is approaching	Person falling down (death or injury)	1	Warning means related to platform edge		8.4.1.2
					2	Reduced speed in stations		Out of scope
					3	Full-height platform screen	C	8.4.2.1
					4	Partial-height platform screen	C	8.4.2.2
2.4	Person on platform-track in station	Person falls accidentally from platform edge or steps down on purpose from platform (trespassing)	Train is approaching	Train collides with person (death or injury)	1	Emergency stop switch on platform		8.4.1.5
					2	Action of operational staff		8.2.2
					3	Traction power cut-off for platform track		8.4.1.6
					4	Partial-height platform screen	C (for accidental falls only)	8.4.2.2
					5	Full-height platform screen	C	8.4.2.1
					6	Refuge between rails or under the platform		8.4.1.4
					7	Open platforms with detection systems	C	8.4.3
2.5	Person on platform-track in station	Person entering platform track from outside – trespassing	Train is approaching	Train collides with person (death or injury)	1	Guideway segregated by legal statute		8.7.1.2
					2	Warning means along the guideway		8.7.2
					3	Open platforms with detection systems	C	8.4.3
					4	Physical barriers along the track	C	8.7.3
					5	Traction power cut-off for platform track		8.4.1.6
					6	Emergency stop switch on platform		8.4.1.5
					7	Action of operational staff		8.2.2
2.6	Person in guideway clearance between stations	Person entering guideway clearance between stations from platform track	Train is approaching	Train collides with person (death or injury)	1	Intrusion detection device between platform track and guideway between stations	C	8.7.5
2.7	Person in guideway clearance between stations	Public, staff or rescued passengers entering guideway clearance between stations from outside	Train is approaching	Train collides with person (death or injury)	1	Physical barriers along the track	C	8.7.3
					2	Guideway intrusion detection device	C	8.7.6
					3	Guideway physically segregated	C	8.7.1.1
					4	Guideway segregated by legal statute		8.7.1.2

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
2.8	Person in guideway clearance between stations	Passenger or staff entering guideway clearance between stations from train	Train is approaching	Train collides with person (death or injury)	1	Rules for rescue of passengers		8.3.1
					2	Keep doors closed between two stations		Out of scope
					3	Door closed supervision	C	8.5.1
2.9	Person in guideway clearance between stations	Person enters guideway clearance from level crossing	Train is approaching	Train collides with person (death or injury)	1	Prevention and detection of intrusion into the guideway from the level crossing	C	8.7.12.3
2.10	Person in guideway clearance between stations	Staff in guideway for maintenance purposes	Train is approaching	Train collides with staff (death or injury)	1	Work zones	C	8.7.13
2.11	Person in safety space between stations	Staff (coming from platform end, from outside the system or from a train – organised evacuation) and part of a train protrude into safety space	Train is approaching	Train collides with staff (death or injury)	1	Train complies with guideway clearance		Out of scope
2.12	Person in safety space between stations	Staff (coming from platform end, from outside the system or from a train – organised evacuation) protrudes in the guideway clearance	Train is approaching	Train collides with staff (death or injury)	1	Training and education for staff		Out of scope
2.13	Person in safety space between stations	Staff (coming from platform end, from outside the system or from a train – organised evacuation) and passing train causes pressure pulse	Train is approaching	Train collides with staff (death or injury)	1	Training and education for staff		Out of scope
2.14	Person in safety space between stations	Unauthorised person (passenger, public coming from platform end) in safety space of guideway between stations	Train is approaching	Train collides with staff (death or injury)	1	Rules forbid entry the safety space, when there is no emergency		Out of scope
					2	Platform end door with controlled access	C	8.7.8
					3	Intrusion detection device between platform track and guideway between stations	C	8.7.5
					4	Warning means along the guideway		8.7.2

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
2.15	Person in safety space between stations	Person enters safety space of the segregated guideway from outside the system	Train is approaching	Train collides with person (death or injury)	1	Guideway intrusion detection device	C	8.7.6
					2	Physical barriers along the track	C	8.7.3
					3	Guideway physically segregated	C	8.7.1.1
					4	Guideway segregated by legal statute		8.7.1.2
2.16	Person in safety space between stations	Unauthorized person enters safety space of segregated guideway from a train (self-evacuation)	Train is approaching	Train collides with person (death or injury)	1	Warning means in the train for evacuation		8.5.17
					2	Traction power cut-off		8.1.3.5
					3	Keep doors closed between two stations		Out of scope
					4	Door closed supervision	C	8.5.1
2.17	Person on level crossing	Person enters level crossing reserved for train movement	Train is approaching	Train collides with person (death or injury)	1	Level crossing supervision		8.7.12.2
					2	Level crossing barrier		8.7.12.1
2.18	Person on level crossing	Person is still present on level crossing when closing is requested	Train is approaching	Train collides with person (death or injury)	1	Level crossing supervision	C	8.7.12.2
2.19	Staff in transfer area between automated and non-automated sections of the guideway	Staff protrudes into the guideway clearance	unexpected automatic movement of train	Train collides with staff (death or injury)	1	Rules for train operation in depot	C	8.3.6
					2	Safeguards for transfer areas and depots	C	8.8
3 Supervising passenger transfer / control passengers doors								
3.1	Passenger beside train doors during movement	Doors open or are released for opening between stations	"-" "-" indicates intentional blank	Injury or death of person after falling from the train	1	Keep doors closed between two stations		Out of scope
3.2	Passenger beside train doors while stationary	Door opposite the platform or outside the platform area opens or is released for opening	Passenger wants to leave the train	Injury or death of person after falling from the train	1	Door release for passenger transfer	C	8.5.2

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
3.3	Passenger enters space between train and platform screen while train is stationary in station	Train doors are released for opening or are open but the platform screen doors are not, or vice versa	Passenger makes a false step into space between platform screen and train	Injury or death of person	1	Door release for passenger transfer		8.5.2
					2	Alignment of train doors with full height platform doors		8.4.2.1 a)
					3	Alignment of train doors with partial height platform doors		8.4.2.2
					4	Design measures to minimise the distance between train and platform screen	C	8.6.8.1
3.4	Hand of passenger (or other part of body) on the door leaf	Space between sliding door leaf and car body large enough for trapping hands	Opening of doors	Injury of person because of entrapment	1	Design to minimise the possibility of trapping by an opening door (may include stickers or optical and/or acoustic warning measures)		Out of scope
3.5	Passenger during passenger transfer	Part of a passenger between door leaves with high closing force	Closing of doors	Force of door leaves injures passenger	1	Design to limit closing pressure (force) of door leaves	C	
					2	Optical and acoustic door signals prior to closing		
4	Supervising passenger transfer / Prevent injuries to person between cars or between platform and train							
4.1	Passenger during passenger transfer	Gap between train and platform edge large enough for somebody to fall through or get trapped	Passenger falls into gap (disregardful or pushed by other passenger)	After falling, injury or death due to passenger contact with exposed live conductor (e.g. rail) or to the train moving	1	Marking of train door areas on the platform		
					2	Public address system (platform) (e.g. announcement "mind the gap")		
					3	Public address system (train)		
					4	Emergency stop switch on platform		
					5	Emergency stop demand on board		
					6	Emergency call device on platform		
					7	Emergency call device on board		
					8	Warning means on platform related to gap		
					9	Surveillance by operational staff		
					10	Gap-filling device on board or on platform	C	
					11	Gap supervision device on board or on platform	C	
					12	Minimise gap between platform edge and car body	C	
					13	Warning means in the train related to gap		
					14	Safeguards to protect passengers from electrocution after falling into the gap		

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
4.2	Passenger during passenger transfer	Coupling area large enough for a person to fall into it	Passenger falls into coupling area (disregardful or pushed by other passenger)	Injury or death due to passenger contact with exposed live conductor (e.g. rail) or to the train moving	1	Emergency stop switch on platform		
					2	Emergency stop demand on board		
					3	Emergency call device on platform		
					4	Emergency call device on board		
					5	Warning means on platform related to gap		
					6	Surveillance by operational staff		
					7	On board closing of coupling area of train	C	
					8	Partial barriers on the platform at the stopping position of the coupling area of train cars	C (assumed that the coupling areas align with the barriers)	
					9	Monitoring device for coupling area	C	
					10	Safeguards to protect passengers from electrocution after falling into the gap		
5	Supervising passenger transfer / Ensure safe starting conditions							
5.1	Passenger during passenger transfer in the vicinity of open train doors	Passenger transfer	Train unexpectedly starts moving	Injury or death of person after being hurt by car body or falling from the train	1	Train immobilisation during passenger transfer	C	
					2	Door closed supervision		
					3	Reaction to unexpected train movement		
5.2	Passenger during passenger transfer in the vicinity of open train doors	Passenger transfer	Train unexpectedly starts moving and continues to move with doors open	Injury or death of person after being dragged by moving train or falling from the train	1	Emergency stop switch on platform		
					2	Emergency stop demand on board		
5.3	Passenger on platform while passenger or his belongings (belt, dog leash, etc.) remaining between door leaves while doors are closing after passenger transfer	Passenger on platform close enough to train door	Train starts moving	Injury or death of person because of entrapment	1	Door closed supervision		
					2	Detection of obstacles during the closing of the doors	C	
					3	Emergency stop switch on platform		
					4	Emergency stop demand on board		
					5	Detection of trapped objects after the doors have been closed	C	
					6	Full-height platform screen		
					7	Partial-height platform screen		
					8	Manual release of trapped objects		

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
5.4	Passenger in space between train and platform screen	Space between train and platform screen large enough for a person to get into it	Train starts moving	Injury or death of person because of entrapment	1	Emergency stop demand on board		
					2	Emergency stop switch on platform		
					3	Ensure that platform screen doors cannot be closed when a passenger is between train and platform screen	C	
					4	Detection of obstacles during the closing of the doors		
					5	Design measures to minimise the distance between train and platform screen	C	
					6	Device on board or on platform to supervise the lateral space between train and platform screen doors	C	
6 Operating a train / put in or take out of operation								
6.1	Passenger on board a train taken out of operation (scheduled or unscheduled)	Train unsupervised	Passenger trapped in train or leaves the train under unsafe conditions	After passenger leaves the train, injury or death caused by falling on the track, being hit by another train, or receiving an electric shock	1	Action of operational staff (visual check by staff)	C	
					2	Rules for taking a train out of operation	C	
					3	On board video surveillance		
					4	On board announcement for taking a train out of operation		
					5	Emergency call device on board		
6.2	Passenger on board a train taken out of operation (scheduled or unscheduled)	Train unsupervised	Passenger asleep or unwell, and unaware of safeguards on board the train and has no possibility for emergency calls	Passenger injury or death due to undetected emergency situations	1	Rules for taking a train out of operation	C	
					2	Action of operational staff (visual check by staff)	C	
6.3	Passenger on board a train with a failure affecting safety	Failure not detected	Train is put in operation	Passenger injury or death following for example opening of a door during train movement	1	Train status supervision and testing	C	
7 Operating a train / supervise the status of the train (safeguards relevant to UTO only)								
7.1	Passenger in a stranded train between stations	Train cannot move in automatic mode	Passenger leaving train	Passenger injury or death following for example self-evacuation	1	Manual operation	C (safeguard may be insufficient on its own where the distance between stations is important)	

Case	Hazard	Cause	Trigger	Accident (effect)	No.	Safeguard	Remark	IEC 62267: 2009
7.2	Passenger on board a moving train decoupled without authorisation	Person remains in uncontrolled part of the train	"-" indicates intentional blank	Passenger injury or death following for example derailment or collision with other train	1	Supervise train unit integrity	Hazard is covered by the control system	Out of scope
7.3	Passenger on board moving train while loss of train consist	Person exposed to open car end or is in uncontrolled car	"-" indicates intentional blank	Passenger injury or death following for example a fall from the car	1	Ensure train composition integrity	In NTO & STO, the same concept of design is generally used	Out of scope
					2	Supervise train integrity	In NTO & STO, the same concept of design is generally used	Out of scope
7.4	Passenger in train with failure	Inadequate or incorrect reaction of the train which may affect safe operation	Undetected technical failure during operation	"-" indicates intentional blank	1	Train status supervision and testing	C	
					2	Train design leading to a safe state	In NTO & STO, the same concept of design is generally used	Out of scope
7.5	Passenger on board train with wrong driving mode	Possibility of unauthorised access and unauthorised driving mode selection	Train starts in wrong driving mode	Passenger injury or death following for example derailment or collision with other train	1	Locking of driving mode switch	C	
					2	Interlocking between automatic and manual modes of operation		
					3	Ensure safe driving modes	Hazard to be covered by "ensure safe movement of train"	Out of scope
7.6	Person or obstacle in front of the train	Train movement in wrong direction	Train starts	Person injury or death	1	Ensure safe driving direction	Hazard to be covered by "ensure safe movement of train"	Out of scope
7.7	Person on board train during coupling	Overspeed during coupling movement	Coupling jerk with overspeed	Person injury or death due to collision	1	Safe speed during automatic coupling	C	
8	Ensuring detection and management of emergency situations							
8.1	Person on board train exposed to fire/smoke	Fire starts inside train due to non-prevention of ignition	Failure of component, imprudence or vandalism	Person injury or death caused by fire or smoke	1	Fire protection (measures to mitigate ignition)		
					2	Fire extinguishers		
					3	Rules for passenger behaviour		
					4	Monitoring by the OCC staff		8.2.1
					5	Rules for fire emergency		