

TECHNICAL REPORT



Hydrogen effects in optical fibre cables – Guidelines

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2014 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 14 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 55 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IECNORM.COM : Click to view the full text of IEC TR 62690:2014

TECHNICAL REPORT



Hydrogen effects in optical fibre cables – Guidelines

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE

J

ICS 33.180.10

ISBN 978-2-8322-1657-6

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope	6
2 Normative references	6
3 General	6
4 Evaluation of hydrogen induced effects	6
5 Hydrogen effects in optical fibre cables	7
Bibliography.....	9
Table 1 – Evaluation criteria for single-mode (SM) optical fibre cables.....	7

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HYDROGEN EFFECTS IN OPTICAL FIBRE CABLES – GUIDELINES

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62690, which is a technical report, has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

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

Enquiry draft	Report on voting
86A/1586/DTR	86A/1605/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.

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014

INTRODUCTION

There is extensive application of optical fibre cables worldwide, both for terrestrial and submarine environments, with the provision of stable transmission characteristics over many years.

In the early 1980s, it was established that some optical fibre designs in certain cable constructions were prone to hydrogen-induced attenuation increases. The mechanism of the hydrogen induced loss was quickly established and after extensive research and development programs, fibre designs were optimized to minimize the effects. Cable designers established suitable design rules and optimized the selection of cable materials so as to also minimize the effects of hydrogen induced attenuation increases during service life.

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014

HYDROGEN EFFECTS IN OPTICAL FIBRE CABLES – GUIDELINES

1 Scope

The purpose of this technical report is to provide information concerning the behaviour of fibres and cables when exposed to hydrogen effects.

The application of multimode fibres is very rarely subject to hydrogen effects. For that reason, this technical report only highlights the effects of hydrogen to single-mode fibres.

2 Normative references

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

IEC 60794-3, *Optical fibre cables – Part 3: Sectional specification – Outdoor cables*

IEC 60794-4, *Optical fibre cables – Part 4: Sectional specification – Aerial optical cables along electrical power lines*

IEC 60794-5, *Optical fibre cables – Part 5: Sectional specification – Microduct cables for installation by blowing*

3 General

The magnitude of any hydrogen induced effect depends on the cable type (including fibre design) and its operational environment.

In the case of suitably designed, single-mode fibre cables for terrestrial applications, there is sufficient experience to not require any test in cables for significant concentrations of hydrogen which could cause an increase in optical attenuation.

The induced loss for single-mode fibre due to hydrogen at a partial pressure of up to $1,0 \times 10^4 \text{ Pa}$ ($9,9 \times 10^{-2} \text{ atm}$) is no greater than 0,03 dB/km and 0,06 dB/km, at 1 310 nm and 1 550 nm, respectively. The dynamic equilibrium pressure or balance of hydrogen within a terrestrial cable with no hermetic barrier will be significantly less than $1,0 \times 10^4 \text{ Pa}$, and therefore, optical reliability is ensured. Typical values of 40,5 Pa equivalent to $4,0 \times 10^{-4} \text{ atm}$ have been measured for duct cable several years after installation [1]¹. At these partial pressures, the attenuation increase is insignificant.

4 Evaluation of hydrogen induced effects

Depending on the cable type and its planned operational environment, an evaluation of hydrogen induced effects [2] may or may not be warranted. Table 1 offers a guide to the necessity to evaluate cables for hydrogen induced attenuation increases.

¹ Numbers in square brackets refer to the Bibliography

Table 1 – Evaluation criteria for single-mode (SM) optical fibre cables

Cable construction	Application / environment				
	Direct-buried IEC 60794-3-10	Duct IEC 60794-3-10	Aerial IEC 60794-3-20	Shallow water ^a IEC 60794-3-10	Underwater ^a IEC 60794-3-30
Metallic	1(See Note)	1	1	2	2
Non-metallic	1	1	1	1	b
Hermetic barrier (i.e. metallic tube)	2 ^c	2	2	2	2
NOTE No evaluation.					
^a Shallow water – Less than 10 m water depth, short distance. Underwater – 10 m or greater water depth, as for true submarine cable and the like. ^b Cable constructions not applicable. Other cable types of IEC 60794-3, IEC 60794-4 and IEC 60794-5 may be evaluated for testing, in accordance with this report. ^c Evaluation is recommended at the research and development phase of the cable construction involved. Use of hydrogen-absorbing materials in the cable construction may obviate the need for evaluation in cable form.					

5 Hydrogen effects in optical fibre cables

NOTE As indicated in Clause 1, the application space of multimode fibres is rarely subject to hydrogen effects. The theoretical effects of hydrogen on multimode fibres is presented in this clause for the information of users.

Both single-mode and multimode optical fibre cables can optically degrade due to the accumulation of hydrogen gas within the cable structure during its operational lifetime. The magnitude of the effect depends on the following factors:

- the fibre type, its dopant composition/concentration and its intrinsic susceptibility to hydrogen;
- the levels of hydrogen gas (i.e. partial pressure) generated in the cable during its operational lifetime;
- the design of the cable and, in particular, the choice and combination of materials used in its construction;
- the installation environment, including its operational temperature.

Hydrogen gas may build up within a cable from:

- hydrogen released from the cable components, including that associated with long-term ageing effects of the materials;
- hydrogen contained in pressurised air pumped into the cable;
- corrosion action of metallic elements in the presence of moisture;
- biological corrosion by sulphate reducing bacteria.

The optical loss mechanisms due to hydrogen can be classified as follows:

- a reversible interstitial effect associated with diffusion of the H₂ molecules into the silica glass fibre. The effect is very similar for all fibre types (both multimode and single-mode) and its magnitude is linear with the partial pressure of hydrogen;
- a permanent chemical effect due to hydroxyl formation through chemical combination of diffused hydrogen molecules and defect sites in the silica glass fibre. The magnitude of the effect is related to the square root of the partial pressure of hydrogen.

For single-mode fibres, the permanent loss will be much smaller than the interstitial loss even after 25 years in a hostile operational environment:

- a wavelength dependent loss, which is only experienced at elevated temperatures (in excess of 60 °C) in single-mode fibres, and is again much smaller than the interstitial loss observed at ambient temperature;

- monitoring the loss increases at the characteristic wavelength of 1 240 nm and 1 380 nm is a good indicator of both the interstitial and permanent chemical effects.

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014

Bibliography

- [1] HORNUNG, S., CASSIDY, S.A., REEVE, M.H. "*The distribution of H₂ gas along an inland optical fibre cable*". Symposium of Optical Fibre Measurements 1984, National Bureau of Standards, NSB-SP-683, pp. 85-88, Oct. 1984
 - [2] ITU-T Recommendation L.27(10/96), *Method for estimating the concentration of hydrogen in optical fibre cables*
-

IECNORM.COM : Click to view the full PDF of IEC TR 62690:2014