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**SERIES L: CONSTRUCTION, INSTALLATION AND
PROTECTION OF CABLES AND OTHER ELEMENTS OF
OUTSIDE PLANT**

Method for estimating the concentration of hydrogen in optical fibre cables

ITU-T Recommendation L.27

(Previously CCITT Recommendation)

ITU-T L-SERIES RECOMMENDATIONS
CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE
PLANT

For further details, please refer to ITU-T List of Recommendations.

FOREWORD

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

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NOTES

1. In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.
2. The status of annexes and appendices attached to the Series L Recommendations should be interpreted as follows:
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Recommendation L.27**METHOD FOR ESTIMATING THE CONCENTRATION
OF HYDROGEN IN OPTICAL FIBRE CABLES***(Geneva, 1996)***Introduction**

Considerable experience has been gained using optical fibre cables in terrestrial and subsea applications showing that optical fibres provide a stable transmission medium.

There are some situations where the concentration of hydrogen within a cable can rise to a sufficiently large value to cause the optical loss of the fibre to increase (see Appendix III). Therefore, there is a need to determine the build-up of hydrogen in a cable by considering the ways that hydrogen can be generated within it.

If the escape of hydrogen through the polyolefin sheath or the overlap of a moisture barrier balances the hydrogen generated in the cable, the resulting concentrations within the cable do not cause a noticeable change in optical loss (see Appendices I and II).

Considering

- a) that hydrogen within a cable can result from:
 - the hydrogen released from the cable components;
 - the electrolytic action between components of different metal in the presence of moisture;
 - the corrosive reaction of metallic components in the presence of moisture;
 - the hydrogen within the air pumped into pressurised cable networks;
- b) that hydrogen can escape by permeation through the cable sheath except for hermetically sealed sheaths of where the external concentration of hydrogen is greater than that within the cable core;
- c) that the optical loss change, which is most noticeable at the wavelength of 1.24 μm and/or 1.38 μm , arises from:
 - a temporary change due to molecular hydrogen within the fibre core which is proportional to the concentration (partial pressure) of hydrogen;
 - a permanent chemical change which depends on the dopant and its concentration, due to hydroxyl formed by the chemical combination of diffused hydrogen molecules and structural defects in the silica glass of the fibre,

it is recommended

- 1) that for cable types which may allow the concentration of hydrogen within the cable core to build up to a value which could cause a noticeable increase in optical loss:
 - i) the concentration of hydrogen anticipated within the cable core should be estimated from a knowledge of the hydrogen released from the components of the cable. If desired, the measurement method of gas chromatography described in Annex A can be used to determine the amount of hydrogen released from the cable components;
 - ii) the concentration of hydrogen in filled cables should be managed by one or more of the following:
 - minimized by careful selection of the components of the cable;
 - reduced to zero by the use, within the cable, of a hydrogen-absorbing material which should have an active life comparable to the life of the cable;
 - have reduced influence on optical performance by the use of hermetically coated fibres or by the use of a hermetic sheath around the cable core in the event of the external concentration of hydrogen being greater than that within the cable core;

- iii) the concentration of hydrogen in unfilled cables should be purged from the cable at regular intervals;
 - iv) lengths of unfilled prototype cable or specially prepared short samples (up to 10 m) of filled prototype cable may be tested to confirm the estimated concentrations of hydrogen by the measurement method described in Annex B;
- 2) that the long-term effectiveness of hydrogen-absorbing material, when used, should be confirmed by the measurement method described in Annex C.

For cables of all dielectric construction, there is sufficient experience of stable transmission properties to make unnecessary the testing for significant concentrations of hydrogen which could cause an increase in optical loss.

Annex A

Measurement of hydrogen released by each cable component by gas chromatography

A.1 Principle

Gas chromatography may be used to estimate the hydrogen concentration. The concentration of hydrogen in a vessel is estimated by comparing the N_2 , O_2 and H_2 peaks, measured by gas chromatography, with that of a known hydrogen concentration. Hydrogen release can usually be accelerated by raising the ambient temperature. Such acceleration conditions as temperature and time depend on the volume of the sample. The temperature is usually from 50 °C to 160 °C and the time within 48 h. The elevated temperature should be selected to be below the level which would melt or deform the cable materials. The time should be long enough for the thermal activity to saturate. After thermal activation, the temperature is reduced to its initial level and the hydrogen concentration is measured by gas chromatography. A flow chart, for estimating the amount of hydrogen released in the cable material sample, is shown in Figure A.1.

A.2 Equipment

The basic equipment is shown in Figure A.2. A gas chromatograph is used for the quantitative analysis of hydrogen. It usually measures the hydrogen content by separating hydrogen from the other gasses by virtue of this element's unique retention time in the column and then determining its concentration with a thermal conductivity detector. The usual conditions of such a gas chromatograph are as follows:

- 1) *Column*
 - Length: 1 to 4 metres
 - Filter: Molecular sieve 5A
 - Temperature: 40 °C to 50 °C
- 2) *Carrier gas (Argon gas)*
 - Flow rate: 30 to 40 ml/min
- 3) *Detector (Thermal conductive detector)*
 - Temperature range for detection: 25 °C to 50 °C

A.3 Measurement procedures

A.3.1 Sample preparation

Optical fibre cables usually contain components as follows:

- coated silica fibres;
- polymerised materials, such as:
 - tubes or slotted rods in which the coated silica glass fibres may be inserted;
 - wrapping tapes including water-blocking tapes;