INTERNATIONAL TELECOMMUNICATION UNION

CCITT

L.14

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

**CONSTRUCTION, INSTALLATION
AND PROTECTION OF CABLE AND OTHER
ELEMENTS OF OUTSIDE PLANT**

MEASUREMENT METHOD TO DETERMINE THE TENSILE PERFORMANCE OF OPTICAL FIBRE CABLES UNDER LOAD

Recommendation L.14

Geneva, 1992

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation L.14 was prepared by Study Group VI and was approved under the Resolution No. 2 procedure on the 31st of July 1992.

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CCITT NOTE

In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication Administration and a recognized private operating agency.

Recommendation L.14

MEASUREMENT METHOD TO DETERMINE THE TENSILE PERFORMANCE OF OPTICAL FIBRE CABLES UNDER LOAD

The CCITT,

considering

(a) that optical fibres are susceptible to strain;

(b) that the service lifetime of cabled fibres depends on the environmental conditions under which the fibres are used; important herein is the strain of the fibre after installation of the cable;

(c) that in cables with loosely packaged constructions, an elongation of the fibre, invoked by an elongation of the cable, may lead to an increase in attenuation as soon as the fibre touches the inner wall of the secondary protection; there is, however, no simple relation between the applied elongation and the increase in attenuation, the latter also being dependent on the material characteristics of both primary and secondary coating;

(d) that in cables with a central tube construction (as well with a single fibre as with a fibre bundle or ribbon package), a considerable elongation of the cable and the fibres can be reached without any increase in attenuation;

(e) that in cables with tightly assembled constructions, the elongation of the fibres is directly following the elongation of the cables without any increase in attenuation below the specified allowable elongation which can be easily detected;

(f) that it is necessary to evaluate the tensile performance of optical fibre cables;

(g) that guidelines for testing need to be formulated,

recommends

(1) that in order to gain insight in the mechanical behaviour of an optical fibre cable under tensile load, fibre elongation and/or optical attenuation shall be measured as a function of cable elongation;

(2) that for measurement of the behaviour of the attenuation of an optical fibre as a function of the tensile load on a cable, IEC 794-1 method E1 “Tensile performance” shall be followed;

(3) that for measurement of the fibre elongation as a function of cable tensile load, the following measuring method shall be applied.

1 Introduction

Various cable constructions are based on a concept in which the cable will have a certain strain margin.

The cable structure shall be such as to protect the optical fibre against the strain induced during the installation and the operational cable lifetime. It shall ensure that during pulling operations under restricted pulling forces, a minimum of elongation is applied on the fibres to prevent significant fibre crack growth and attenuation increase.

A method is given for the direct measurement of the tensile performance of optical fibres. This method can provide information on both the maximum allowable pulling force for field installation, as well as information about the strain margin of the cable. The method is based on the phase shift of a modulated signal launched into the fibre.

2 Measuring principle

For evaluating the fibre elongation strain in the range of loads specified for the optical fibre cable under test, a phase shift method is used.

The elongation of optical fibres in a cable that is loaded with a tensile force, is measured by use of a modulating light source. In the frequency domain the change in phase of the modulating signal is a function of the change in length of the fibre. Depending on modulation frequency, the fibre elongation can be measured with high accuracy, even with short cable test lengths. Depending on the cable structure and the desired information (maximum pulling force and/or cable strain margin), the way of clamping the cable may require a different setup.

An optical fibre cable of a suitable length is mechanically loaded with a tensile force. The pulling force on the cable is measured with a loadcell. The cable elongation caused by this force is measured. The elongation of the fibres is measured by using a light source of suitable wavelength, modulated with a stable frequency; the measurement accuracy depends on the frequency of the modulating signal. At the receiving end of the fibre the signal passes a detector with sufficient high frequency response. The phase of the electrical signal from the detector is compared with the phase of the signal from the frequency generator. The change in the phase difference is proportional to the elongation of the optical fibre. This phase/length dependency has to be settled once for every fibre type in a calibration measurement setup.

When an optical signal is sinusoidally modulated, the phase of the modulation signal propagates with the group velocity along the fibre, so that after a length L of the fibre the phase will be:

$$\phi = (2\pi f/c)\ NL$$

where:

f is the modulation frequency;

c is the free space velocity of light;

N is the effective group index of the fibre including dispersion effects.

However, a phase change is not only induced by a fibre length change, but also by a change in the group index N, due to the elasto-optic effect. A calibration measurement for every fibre type is necessary to give the precise relation between the phase change and fibre elongation. It is important that no differential movement is allowed between the cable elements at each end of the length of cable under test.

3 Procedure

3.1 *Calibration fibre*

A reference fibre of known length and of the same type as the test fibre, shall be used to determine the relation between the change in phase shift and the fibre elongation.

3.2 *Bench calibration*

Install the reference fibre on the elongation bench and connect it to the optical measurement apparatus.

Increase progressively the fibre elongation strain within the range of elongations which are expected to occur during the tensile test of the cable.

Measure and record, preferably continuously, the change in phase shift as a function of the reference fibre elongation.

The relation thus determined takes into account the strain induced changes of the group index.

Note 1 – It is recommended to carry out the calibration with several reference fibre samples of the same type, preferably taken from different fibre drums, in order to avoid the effects of local irregularities in the fibre.

Note 2 – It is not necessary to repeat this calibration before each cable tensile test as long as the same type of fibre is used in the cables to be tested.

3.3 *Test sample measurement*

Put the ends of the cable test length in the clamping devices.

Connect the test fibre of the cable under tensile test to the measurement apparatus.

Carry out the cable tensile test as described in the IEC 794-1-E1.

For most cable constructions (e.g. stranded type cables), clamping on cable elements except the fibres, is practical and sufficient to get both the maximum allowable pulling load and the strain margin of the cable.

However, for certain cable constructions (e.g. single loosetube), it may be necessary to prevent the fibres from slipping, in order to obtain the correct excess length.

Both the force applied on the cable and the fibre elongation have to be recorded as a function of the elongation.

Care shall be taken that during the pulling of the sample the reference length do not change.

During this test, measure and record, preferably continuously, the changes in phase shift as a function of cable load and/or elongation.

Calculate the corresponding fibre elongation strain, using the factor deducted from the calibration described in § 3.2.

If required, the load value where the beginning of fibre strain occurs is defined, on the plot of fibre strain versus load, as the intersection of the linear portion of the curve with the load axis.

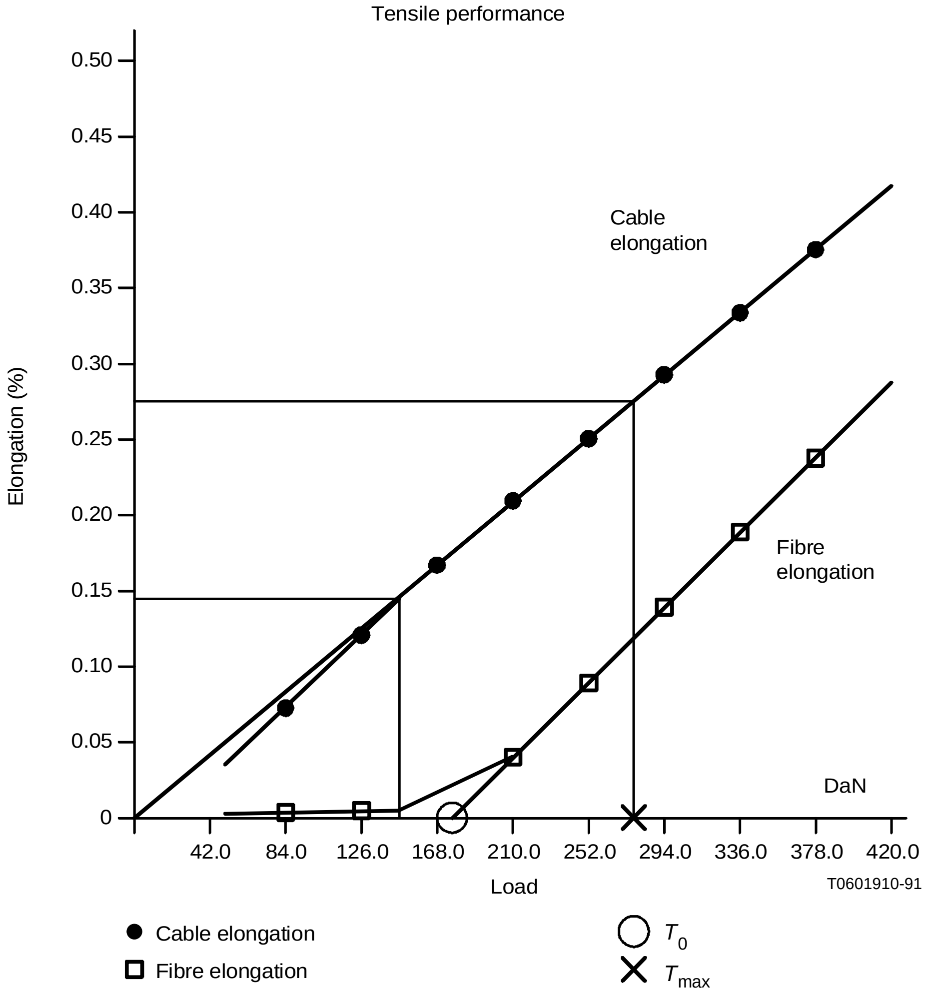
Note – As a first approximation, the length of fibre under elongation strain is taken equal to the length of cable under tensile load, except the cables with tightly assembled constructions. It shall be noted however, that the calculated value of fibre elongation strain is affected by the accuracy on the value of this cable length, and also by the excess length of fibre in the cable which depends on the cable design (loose structures).

APPENDIX I

(to Recommendation L.14)

Presentation of the results

An example of a presentation of the cable and fibre elongation is given in the case of loosely packaged construction by Figure I-1/L.14.



Note – T_0 corresponds to the load at which the fibre becomes under strain.
T_{max} corresponds to the maximum specified pulling load.

FIGURE I-1 / L.14

Fibre and cable elongation as a function of load

An example of one measurement setup is shown on Figure I-2/L.14.

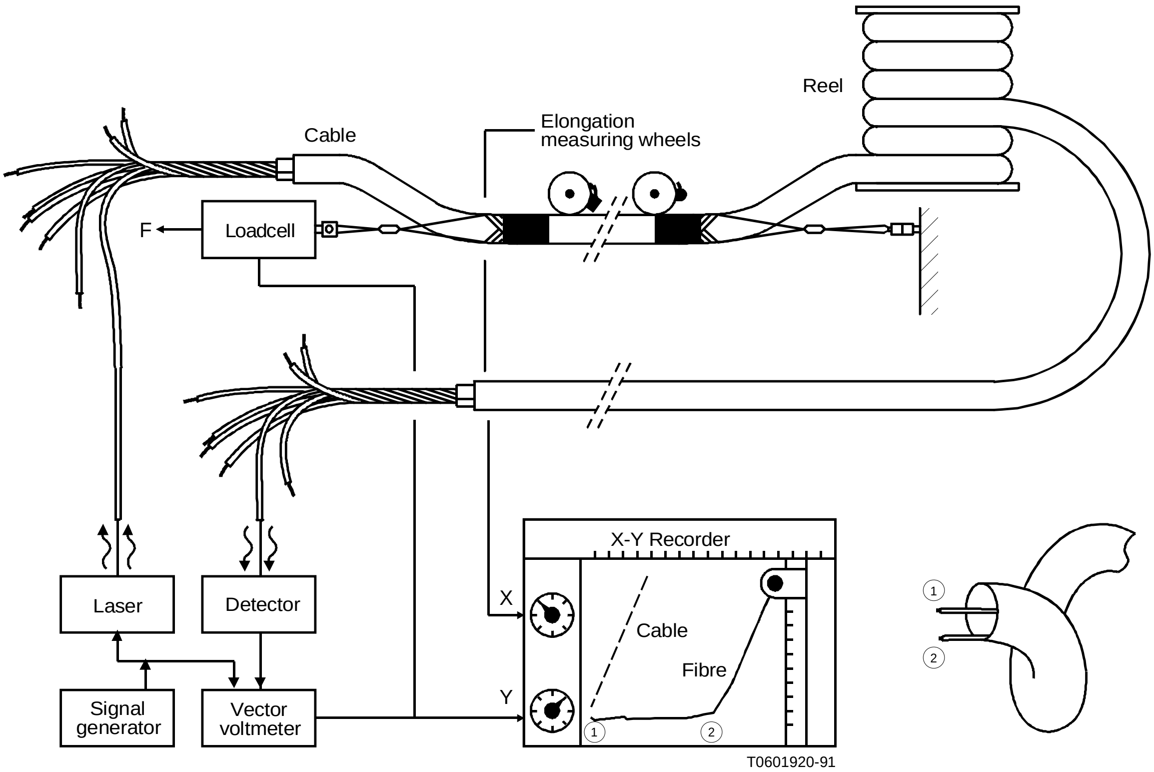


FIGURE I-2 / L.14

Set up for optical fibre strain measurements