cuits are usually symmetrical pairs, the test levels for the associated power-feeding-equipment are approximately the same as those for coaxial systems. (See Recommendation K.17)

5. Future work

This Recommendation describes the protective measures and calculation methods able to be confirmed at the present time.

Further studies of the problems of protecting optical fibre cables will be made and work in the following areas, typically, are involved:

- coordinating the protection of cables and working staff against overvoltages due to induction from faults in nearby power lines with that for lightning protection. Limits and precautions for staff and cable protection as given in the Directives are applicable also for optical fibre cables with metal parts as far as power induction is concerned. See also Question 6/V in 1988-92;

- the prediction of trouble rates expected on optical fibre cables, see also Question 22/V in 1988-92 and COM V-58, 1987 which will be considered.

Cables of this type may carry lightning currents during storms but the passage of these currents is not expected to cause dielectric breakdown or transmission impairment. Two tests have been devised for these cables, one to establish that adequate dielectric strength exists for general cases and one to determine threshold values of surge current resistivity for cable selection. The two tests are:

- For dielectric strength

  The metallic components electrically insulated from each other should be considered in pairs. Any pair should be tested where a discharge across the pair might intercept either an optical fibre or a non-metallic moisture barrier. If a cable has a metallic moisture barrier, tests should be made additionally between this barrier and each metallic component insulated from it. Either a.c. or d.c. may be used to carry out these dielectric strength tests. For a.c. tests 10 kV r.m.s. at a frequencyof 50 or 60 Hz shall be applied to the pair of metallic components for five seconds. For d.c. tests, 20 kV shall be applied to the pair of metallic components for five seconds. At the end of these tests, no evidence of dielectric breakdown or transmission impairment should be evident.

- For surge current resistibility

  A cable sample 1 metre in length shall be immersed in wet sand contained in a non-conducting rigid box having a length of approximately 0.75 metres. The sand shall be 20 - 40 mesh silica sand, and shall be fully saturated and drained. The cable sample shall be placed in the test box and the wet sand tamped around it. A discharge electrode shall be located near the centre of the test box, betwen 2.5 and 5.0 cm from the sample. All conducting components in the cable shall be electrically connected together to form one terminal and a test current shall be placed between this terminal and the discharge electrode. It is important for the test current to flow through the sample and to encourage this to occur any insulating covering over an outer metallic shield or moisture barrier shall be opened with a small slit or hole facing the discharge electrode. The test current waveform may be either unidirectional or damped oscillatory. The time-to-peak value shall be 15 µs. The frequency of the damped oscillatory current waveform shall be between 16 and 30 kHz, and the time to half-value shall be between 50 and 80 µs. A unidirectional current waveform shall have a time to half-value between 40 and 60 µs. Following the applications of dishcharge currents in ascending amplitudes the sample is tested for loss of its transmission or lowered resistance to moisture penetration. The test identifies a threshold value of surge current which causes cable or transmission deterioration, and assists administrations to select cables which will be adequately reliable in the light of their experience of damage due to lightning.

4. Protection of remote-power-feeding circuits in optical fibre equipment

It is advisable to protect remote-power-feeding circuits, e.g., supplied over cables, against overvoltages if disturbance from power lines or lightning is possible. Although the power-feeding cir-

The admissible current related to the primary damage, i.e. loss of transmission or lowered resistance to moisture penetration of the cable, can be evaluated by means of the test methods described in § 3(d) of this Recommendation.

If the annual damage rate N_d is higher than the tolerable number of faults N_t, protection measures are necessary to reduce N_d and to minimize the risk of such damage.

Each Administration can define its tolerable number of faults.

3. Protective measures

Protective devices and practices for telecommunications networks are indicated in Chapters 5 and 6 of the CCITT Handbook.

For optical fibre cables, the following protective measures are usually considered:

a) Correct connection of metallic moisture barriers

The moisture barrier of an optical fibre cable should be continuous, i.e. it should be connected across all splices, regenerators etc. along the length of the cable. The moisture barrier should be connected to earth, either directly or through lightning arrestors, at the termination at each end of the cable length.

b) The use of shield wires above the cable

It may be important to protect the plastic sheath of the moisture barrier against perforation due to lightning discharges. Such a perforation may occur if the potential of the soil relative to remote earth as a result of a lightning strike exceeds the breakdown voltage of the polyethylene sheath of the moisture barrier.

The installation of a shield wire above the optical fibre cable will reduce the likelihood of the polyethylene sheath of the moisture barrier being perforated.

The efficiency of shield wires can be very considerable and can be derived from Chapter 7 of the CCITT Handbook.

c) The use of metal-free cables

This type of cable may be suitable for use in areas exposed to lightning or where severe power induction is experienced. While damage due to these causes may be minimized or prevented, for buried cables, the lowered resistance of the cables to moisture penetration and the difficulty of locating them during subsequent maintenance activities should be considered.

d) The use of cables which have metal components but have adequate resistibility to a level of lightning surge currents

Recommendation K.25

LIGHTNING PROTECTION OF OPTICAL FIBRE CABLES

1. Introduction

Communications using optical fibres are commonly considered to be immune from damage through surge currents, e.g., lightning. Not all optical fibre cables are, however, completely non-metallic. Components which provide tensile strength during installation, a moisture barrier, rodent protection or communication facilities during repairs may have metal parts. Lightning may strike these components and damage may be caused to the cable.

This damage may be minimized if adequate insulation exists to separate metallic components and if the cable is designed to withstand thermal and mechanical effects at the location of the strike. Adequate dielectric strength between metallic components may prevent repeated arcing taking place between components.

General information regarding the protection of telecommunication lines against lightning given in CCITT Handbook "The protection of telecommunication lines and equipment against lightning discharges" (Edition 1974 and 1978) can be used for both aerial and buried plants with optical fibre cables containing metallic components.

This Recommendation gives interim advice as follows:

- to give guidance in the use of the CCITT Handbook to evaluate the need to protect optical fibre cables (§ 2) and in selecting the protective measures to minimize damage due to lightning (§ 3);

- to give test methods to evaluate the resistibility of optical fibre cables (§ 3(d)).

Future work on this Recommendation is described in paragraph 5 (Future work)

2. Need for protection

The need for lightning protection of an optical fibre cable depends on the annual frequency of fibre damage N_d and on its tolerable number N_t.

The annual damage rate can be estimated by using CCITT Handbook Chapter 7 "Frequency of breakdowns in telecommunication system as a result of lightning discharges". See also § 5 (Future work).
The maximum lightning current which does not cause faults in the cable is the admissible current indicated in the formulae of this chapter and it refers to secondary damage, i.e. dielectric breakdown in the cable.