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CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANTS

JOINT USE OF TUNNELS BY PIPELINES AND TELECOMMUNICATION CABLES, AND THE STANDARDIZATION OF UNDERGROUND DUCT PLANS

ITU-T Recommendation L.11

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation L.11 was published in Volume IX of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation L.11

JOINT USE OF TUNNELS BY PIPELINES AND TELECOMMUNICATION CABLES, AND THE STANDARDIZATION OF UNDERGROUND DUCT PLANS

(Melbourne, 1988)

The CCITT,

considering

(a) that many countries are interested in the joint use of tunnels and are aware of the advantages, disadvantages and specific dangers they hold;

(b) that the rules governing this type of ducting vary significantly from country to country;

(c) that the importance of the joint use of tunnels increases with increasing density of population and shrinking open spaces, i.e. in large towns;

recommends

that Administrations, who in the future will be interested in this type of installation, follow the rules described in this Recommendation.

1 General considerations

Duct tunnels and trenches are constructions containing one or generally more ducts belonging to different networks. Tunnels which can be inspected (inspectable tunnels) include one or more gangways for initial assembly work and for subsequent control, maintenance and repair operations. A tunnel without standing room, but designed for crawling should have a clear internal height of at least 0.8 m. Duct gangways may not be entered.

The above principles apply to inspectable tunnels, and apply by analogy to tunnels with crawling room only.

Tunnels may contain ducts belonging to the following types of networks:

– collective antennas;

– telecommunications;

– electricity;

– gas;

– water;

– district heating;

– ducted transport (e.g. pneumatic tubes);

– drainage water.

2 Establishment of a routing plan

2.1 *Structure*

Tunnel routing must take into account the structure of networks and their levels of priority.

The transport ducts of different networks do not generally follow the same itinerary, since neither the production units (e.g., power plants, pumping stations or telephone exchanges) nor the transit points from transport to primary distribution coincide. On the other hand, in densely populated areas, primary and secondary distribution ducts often do follow the same itineraries, so that it is advisable to run tunnels under arteries containing primary and secondary distribution ducts.

2.2 *Decision criteria*

The following factors should be taken into account when opting between trenches and tunnels:

2.2.1 *Distribution security*

A high level of distribution security will depend on the following factors:

- durability of material and joints;
- rapid location of damage when if occurs, easy access and minimum repair times;
- low exposure to outside effects (e.g. damage caused by third parties or by earthquakes).

Ducts laid in tunnels generally offer high durability and a low risk of deterioration. They may be repaired rapidly.

2.2.2 *Third party risk, disturbances due to installation and repair work*

Account should be taken of disturbances caused by installation and repair work (rerouting of traffic, noise) and of the possible consequences of damages ducts (water and fire damage).

2.2.3 *Economic considerations*

Economic considerations should include not only the cost of constructing and maintaining tunnels, but also the savings which will arise in the future from avoiding the secondary effects of buried ducts. By secondary effects are meant the effects produced on local inhabitants, local activities, vehicle traffic and the environment in general by the installation, malfunction, repair and maintenance of ducts.

2.2.4 *Technical considerations*

Before either of the laying methods is chosen, the following factors should be considered:

- ducts, network, dimension (cross-section), power (capacity), material, protection against corrosion, number, distribution priority, duct routing, compatibility with other ducts, state of ducts, repairs, overhaul, replacement, reserves, extensions, emergency ducts, provisional installations connections to buildings;
- roadway, road width, pavement width, greenery strip, traffic density, surface water drainage, superstructure;
- subsoil, type of ground, groundwater level, existing ducts, existing underground constructions;
- schedules, beginning of works, duration of works (stages), start-up.

When a tunnel is planned, special attention should be paid to branch connections with buildings, which may be derived directly from the tunnel if the necessary openings have been provided. An alternative method is to bury secondary distribution ducts alongside the tunnel.

3 Recommendations applicable to tunnels

3.1 *Phases*

The following sequence of phases should be considered:

- construction phase;
- operational phase.

3.2 *General recommendations*

In both the construction and the operational phases, the following requirements should be observed:

- *Introduction of duct components in the tunnel*

  It should be possible to introduce any components either through normal access points or through special openings.

- *Cable pulling*

  Cables in tunnels should be placed in appropriate technical containers, in order to facilitate their installation, repositioning or removal.

- *Construction aids*

  For construction work, especially in the case of heavy tubing, securing devices should be provided at appropriate locations.

- *Movement of duct components in tunnel*

  The necessary facilities should be provided for the transport of duct components inside a tunnel.

– *Reserve facility for network extension*

Since networks are likely to be extended on the future, appropriate reserve space should be set aside in the tunnel cross-section plan.

– *Clear space around ducts*

Enough clear space should be allowed between a tunnel wall and ducts, as well as between ducts in proportion to their diameter (to facilite maintenance, repair and branching).

– *Ambient temperature*

High temperatures may occur in tunnels containing heat-emitting ducts. Care should be taken to maintain physiologically acceptable environmental conditions in order to avoid any impairment to health during work or inspections. For telecommunication cables, see § 3.3.2.

– *Corrosion of ducts, fixtures and equipment accessories*

The working life of fixtures and equipment accessories should be as long as that of the ducts. High levels of humidity may produce condensation and cause non-rustproof metals to corrode. The appearance of corrosion should be considered in the light of Recommendation L.1. Metal components (pillars, racks or supports) should preferably be made of hot galvanized steel. In some cases, cathodic protection may be applied.

– *Vibrations*

Some ducts may be sensitive to vibrations. In some cases, vehicle traffic may produce vibrations which are propagated inside the tunnels.

3.3 *Comments on distribution networks*

3.3.1 *Collective antennas*

Extra space has to be provided in places to house amplifying equipment. Apart from that, collective antenna cables have no special requirements.

3.3.2 *Telecommunication cables*

The following requirements should be taken into account:

– *Distances from power lines*

Minimum distances from main ducts should be applied (see § 5).

– *Protection against thermal load*

Since telecommunications cables are vulnerable to thermal load, thermal conditions in tunnels must be taken into account. This applies especially for optical cables.

– *Protection against corrosion and lightning*

Telecommunication cables should generally be protected by metal sheaths or shields. This protection may be applied, but the use of joint earth electrodes is either not required or not permissible.

– *Protection against electrical interference*

Normally no special measures need be taken, although cable constructions with a high screening factor or overvoltage relays may be used in some cases.

– *Protection against mechanical forces*

Metal shields may be used to protect cables against mechanical effects such as vibrations or impacts. In the case of lead sheaths, vibration-resistent alloys should be used.

– *Protection against outside effects*

Plastic-covered cables may be protected against rodents with fibreglass or aramid-fibre shielding.

Contractable cable joints may provide protection against earthquakes.

– *Bends*

Since cable curvature is limited, layout plans must take account of permitted curvature radii.

– *Specialized work*

Since work has to be done relatively frequently on telecommunication installations, particularly on sleeves, sufficient working space should be provided (e.g. alcoves or chambers).

3.3.3 *Power cables*

The following requirements should be taken into account:

– *Bends*

  The same rules apply, by analogy, as for telecommunication cables.

– *Ambient temperature*

  The load capacity of electrical cables depends, among other parameters, on ambient temperature, which should be determined in each case to achieve the ideal balance between tunnel cooling and cable load capacity.

3.3.4 *Gas*

Tunnels containing gas ducts should be ventilated (naturally or artificially). Dilation sleeves should be leakproof and located in separate chambers.

3.3.5 *Water*

The choice of tunnel layout or cross-section should take account of the dimensions of special water duct components. Water ducts may require special precautions against climatic effects to avoid overheating or freezing. Ducts with a nominal diameter of 150 mm may give rise to special problems, in which case the following factors should be taken into account:

– *Temperature rise*

  A rise of temperature in a tunnel will have only a negligible effect on the quality of drinking water.

– *Freezing in ducts*

  The temperature in inspectable tunnels rarely falls below freezing. Should there be a risk of freezing, appropriate measures should be taken to protect the duct.

– *Bleeding and draining*

  Bleeding and draining facilities should generally be located outside tunnels.

3.3.6 *District heating*

The following requirements should be taken into account:

– *Position of ducts*

  For assembly purposes, the distance between district heating ducts (not including insulation) and the tunnel wall should not be less than 0.3 m.

– *Heatproofing*

  Continuous thermal insulation will diminish heat losses and help prevent the occurrence of thermal shock in the event of a burst water duct.

– *Junctions and intersections*

  Permitted radii of curvature for ducts should be observed at junctions and intersections.

– *Dilation devices*

  Plans should allow sufficient space for dilation devices.

3.3.7 *Water drainage*

The following aspects should be considered:

– *General*

  In most cases pipes will be naturally drained. The means that their level and slope can be adapted to tunnel layouts only within certain limits.

– *Link between drain and tunnel*

  In view of the risk of backflow, there should be no open link between the drain and the tunnel.

4 Safety plan

4.1 *Safety objectives*

Various aspects of safety should be considered:

- safety of persons working in the tunnel;
- safety of persons and property outside the tunnel;
- security of distribution.

For the first two items, safety objectives concern the risk of personal injury.

Security of distribution is independent of personal safety. The importance of distribution ducts should not be overlooked, however, not only because of the convenience they provide to the public in general, but also because they may constitute in certain circumstances a vital factor of survival.

4.2 *Safety plan*

4.2.1 *Safety during the construction and installation phase*

The safety plan should comply with existing rules governing safety at work. Special attention should be paid to rules concerning construction work in enclosed spaces. In all cases, the maximum permissible levels of harmful substances or vapours, as defined by insurance companies, should not be exceeded.

4.2.2 *Safety during the operational phase*

The company owning an installation should be responsible for issuing instructions to be observed from the start of operations.

In the event of maintenance or extension work, the safety measures laid down for the construction phase should be observed.

Fire risk and fire-fighting facilities should be established in consultation with the fire brigade.

Tables A-1/L.11 and A-2/L.11 show a model of a safety plan in the operational phase, with an indication of possible preventive measures.

The rules applicable to the construction of a tunnel, as described in § 5, should be established in the light of the safety plan.

4.3 *Special problems to be considered*

A special study of safety aspects should be made, where necessary, with regard to the following points:

- interference between telecommunication lines and high voltage or d.c. railway lines;
- tunnel design;
- ventilation;
- thermal protection;
- water drainage;
- electrical installations;
- gas or fire detection systems.

5 Construction

5.1 *Transversal cross-section*

5.1.1 *General*

The transversal cross-section of a tunnel comprises the following elements:

- ducts and related facilities, including free spaces for repairs and maintenance;
- reserve spaces;
- duct intersections and junctions;
- service gangways.

5.1.2 *Positioning of ducts*

Over and above assembly requirements, the following rules should be applied:

– *Telecommunications and antenna cables*

  The following spaces should be observed in relation to power lines:

  – low voltage, up to 1000 V: 0.3 m
  – high voltage with low induction: 0.3 m
  – high voltage with high induction: to be determined
    (rigid earthing systems)

– *Power line ducts*

  Where cables are supported by brackets or racks, thermal and electromagnetic interaction should be taken into account.

– *Natural gas ducts*

  These should be placed as high as possible in the tunnel. This will protect them against mechanical damage and in the event of a leak, gas will accumulate under the ceiling.

– *Water ducts*

  These should be placed as low as possible in the cross-section, for which facilitates installation and anchoring. A further factor is that ambient temperature tends to be lower on the tunnel floor.

5.1.3 *Service gangway*

In order to facilitate free and safe transit through the tunnel, no steps should be placed across the service gangway.

Gangway dimensions should be subject to the following rules:

– minimum width: 0.7 m
– minimum height: 1.9 m
– dimension of the largest element to be introduced in the gangway, plus at least 0.2 m.
– dimensions to be increased according to circumstances, particularly at bends, intersections and working alcoves.

5.1.4 *Transversal slope*

A transversal slope should be provided for water drainage.

5.1.5 *Examples of tunnel profiles*

Figures B-1/L.11 and B-2/L.11 represent circular and rectangular tunnel cross-sections respectively. They show how the available space can be divided among the different networks.

5.2 *Openings, access and partitions*

5.2.1 *Openings for equipment*

Openings large enough should be provided to introduce the largest pieces of equipment during assembly and maintenance work in the tunnel. The openings should be located directly above the service gangway. Further openings may be provided during construction, but these should be sealed off before operations begin. Access should be provided for delivery vehicles.

5.2.2 *Access doors for staff*

Staff access points should be located in accordance with escapeways and alarms. Generally speaking, the distance between two access points should not exceed 500 m. The possibility of introducing emergency exits between access doors should be considered.

Access doors should be arranged so that they cannot be obstructed nor allow water or fumes to enter.

Equipment openings and staff access doors should be lockable and as leakproof as possible.

5.2.3 *Partitions*

Careful consideration should be given to the arrangement of transversal partitions. These should all be compatible with escapeways and exits.

5.2.4 *Facilities for the transport of equipment and assembly accessories*

The operational layout should make provision along the service gangway for transport facilities (e.g. ceiling-mounted rails), and for construction accessories (e.g. hooks for pullies and lifting gear or anchor ties for fixtures).

5.3 *Supports and fixtures*

5.3.1 *Loads to be considered*

The following requirements should be taken into account:

– *Permanent loads*

  Permanent loads should be indicated in the operating plan.

– *Lifting*

  All ducts should, generally speaking, be secured against lifting forces.

– *Seismic effects*

  All ducts brackets, supports and cable racks should be able to resist the effects of seismic forces, in accordance with national standards.

– *Explosions*

  The ducts and other contents of a tunnel may be strongly shaken by explosions. If the safety plan shows that essential ducts may be exposed to such overloading, it should be ensured that:

  – the operation of such ducts is not affected by breakage or deformation;

  – no movement may occur which might wrench essential supply ducts off their supports or allow them to collide against tunnel walls or other part of the construction.

Such risks may be avoided with the introduction of shockproof ties and an appropriate arrangement of ducts. Expert advice should be sought in such matters.

5.3.2 *Protection against corrosion*

It is important to protect supports and ties against corrosion in view of the long life of installations (see § 3.2).

5.4 *Transit points between tunnels and open ground*

At points where ducts transit between tunnels and open ground, due account should be taken to relative movements which may occur between the two types of environment.

Tunnel exit points should be as leakproof as possible, so as to avoid the penetration of gas or water in the tunnel.

5.5 *Shut-off devices*

Suitable care should be taken to position shut-off devices of gas, water, district heating and drainage water ducts, on either side of the tunnel wall. It should be possible to operate all such devices from outside.

5.6 *Ventilation*

5.6.1 *Objectives and rules*

Ventilation should comply with the following objectives:

– *Environment*

  Power lines and district heating ducts give off heat. Insofar as such heat is not transferred to the surrounding ground through tunnel walls, cooling must be provided by ventilation.

  Controlled ventilation also provides a means of lowering air humidity and contributes to active protection against corrosion.

– *Safety*

As part of the safety plan, the aim of ventilation is to reduce the danger of explosion, to prevent the entry of vehicle exhaust gases and to maintain noxious fumes given of by welding or brazing at permitted working levels.

5.6.2 *Ventilation systems*

The systems of ventilation are:

– *Natural ventilation*

Natural ventilation causes a draft which arises as a result of differences of temperature and pressure. In many cases natural ventilation will produce sufficient movement of air.

– *Mechanical ventilation*

With pressured mechanical ventilation, air from the outside is blown down the tunnel with a fan. Apart from the movement of air, this leads to an increase in pressure, which prevents dangerous gases from entering the tunnel.

5.6.3 *Choice between natural and mechanical ventilation*

The criteria for the choice between ventilation systems are:

– *Technical and safety criteria*

Mechanical ventilation is generally needed in the following cases:

– when old gas ducts, which may not be leakproof, run alongside the tunnel;

– if there is risk that toxic or inflammable materials may enter the tunnel.

As far as operating safety is concerned, one advantage of natural ventilation is that since it relies on no mechanical or electrical component there is not risk of air circulation being stopped as a result of a breakdown.

– *Technical environmental criteria*

In shallow underground constructions, where the walls are in contact with the surrounding ground, internal temperature changes in the tunnel are offset by the thermal inertia of its surroundings. This is why natural ventilation is generally sufficient to provide the required environmental conditions.

– *Protection against corrosion*

A high level of humidity and especially condensation will speed up the corrosion of ducts and fixtures. A high level of humidity in a tunnel may be caused by:

– the infiltration of water through the tunnel walls;

– bleeding or cleaning water;

– the cooling of warm humid air introduced from outside by ventilation.

High relative humidity should be avoided by the evacuation of any outside water by the shortest route. Mechanical ventilation should be switched off if the starts introducing warm humid outside air into a cool tunnel, as long as this does not lead to any undue increase in other risks.

5.6.4 *Dimensioning of mechanical ventilation*

The distribution of internal partitions should take account of ventilation sectors.

– *Dimensions according to temperature limits*

Temperature limits are generally determined according to physiological acceptable working conditions or according to the capacity of electricity ducts. Owing to the considerable effect of the surrounding terrain on heat transfer as well as thermal effects caused by the construction, relatively little cooling effect is produced by ventilation. Also, little effect is derived from the above-ground outside temperature.

– *Dimensioning allowing for the possibility of gas leaks*

The dimensioning of mechanical ventilation should allow in normal service for the possibility of slight leaks from the gas duct, provided that the concentration of gas is always maintained below the minimum explosive limit, with a sufficient margin of safety.

5.6.5 *Indications concerning the installation of a ventilation system*

In the case of natural ventilation, the cross-section of air inlets will be determined mainly by the quantity of air required.

Consideration should be given to providing suitable outlets on which mobile air extractors (such as those used by the fire brigade) may be attached to the event of a fault or special work.

5.7 *Water drainage*

5.7.1 *Objective and rules*

The objectives is to extract the following types of water:

– groundwater and seepage water entering the tunnel owing to the permeability of the tunnel walls;
– tunnel cleaning water;
– water from the bleeding of water pipes;
– water from district heating ducts;
– water leaking from water pipes;
– condensation water.

The drainage of water from a burst duct should be provided under the safety plan.

The water drainage system should meet the following requirements:

– there should be no passage of gas from the tunnel to the drainage pipe;
– no odours should pass from the ducts to the tunnel (traps should be provided).

5.7.2 *Internal network in the case of small quantities of excess water*

The water drainage system will be similar to that of a building. If only small quantities of water are involved, a drainage channel may be provided if a tunnel is suitable inclined.

5.7.3 *Water drainage in the event of a burst duct*

In the case of a burst duct, the normal drainage channel will usually be insufficient to drain off excess water, possibly on account of insufficient capacity in the drainage pipe to which the tunnel is connected. The safety plan should determine what sort of quantity of escaping water needs to be taken into consideration for removal by the tunnel drainage system, in conjunction with appropriate damming and diversion facilities.

5.7.4 *Water drainage through piping situated below the tunnel*

This system allows water to be drained by the effect of gravity. Special care should be taken to prevent any backflow.

5.7.5 *Water drainage into piping situated above the invert level*

In this case, water has to be pumped from a drainage well. The safety plan should indicate whether one or more pumps are needed. The same considerations apply to the provision of separate emergency drainage. An electric pump should be supplemented with a second pump, driven by a different power source. Some sort of signalling system should generally be provided.

5.8 *Signalling systems*

5.8.1 *General*

Signalling and alarm systems should be installed only if all active safety measures have been considered and are deemed to be inadequate. Signalling and alarm systems should be covered by the special safety plan, but it should be borne in mind that the effectiveness of such equipment is only limited and that it is costly to maintain.

5.8.2 *Gas alarm systems*

These systems activate an alarm (signalled at access points) as soon as they detect a dangerous mixture of gas and air. In tunnels equipped with a ventilation system, the latter may be activated to dilute the mixture. Signalling systems, should be set so that the alarm is given at the latest when the gas concentration reaches 50 percent of the minimum detonation threshold. A system should be provided to ensure continuity of operation in the event of a power cut. All leaks should be detected. Detectors should be placed at regular intervals and if necessary above joints, valves, etc.

Gas detectors are indispensable in the case of tunnels connected directly to buildings. Service entrances in buildings should be leakproof. If fixed gas detection systems are not provided or should fail to operate, the absence of explosive or toxic gases should be checked with portable instruments before entry to a tunnel.

5.8.3 *Flood alarm systems*

Flood alarm systems should include floater switches placed at low points and in drainage wells, with additional floaters on different levels, thus setting off successive alarms.

5.8.4 *Fire alarm systems*

The need for a fire alarm system should be considered on a case-by-case basis.

5.9 *Other service installations*

5.9.1 *Telecommunication systems*

Internal service communications should be provided for inspections and repairs. The choice will depend on the length of the tunnel, the frequency of inspections and the maintenance plans of different users.

5.9.2 *Electrical power supply*

It may be necessary to use flameproof service equipment in the tunnel.

5.9.3 *Lighting*

Tunnels should generally be equipped with a permanent electrical lighting system. An independent emergency lighting system should also be provided.

5.9.4 *Tunnel cleaning*

The possibility of using clearing machinery should be considered at the outset (passage width, water taps).

5.9.5 *Marking and signalling*

All obstacles and safety devices should be clearly marked (steps, emergency exists, direction of exit). Ducts should be identified with specific, clearly visible and durable marking. In complex tunnel systems, route markings should be provided to help persons unfamiliar with the layout to find their way.

5.9.6 *Rules of usage*

Safety rules should be laid down for visits to the tunnel, drawing attention to communication, safety and evacuation facilities.

6 Standardization of plans for underground ducts in tunnels used jointly for pipelines and telecommunication cables

6.1 *Introduction*

This section describes the graphic representation of underground ducts in joint trenches or tunnels.

The graphic representation of underground ducts in joint tunnels is standardized in several countries, and this document therefore confines itself to a general presentation. The management of the network concerned is responsible for updating plans and documents.

Plans must contain all particulars required for the operation, maintenance and extension of underground ducts, as well as for their protection and continual operation during repairs.

6.2 *Terminology*

The term **underground duct** is defined in this Recommendation to mean a vector for the distribution of a fluid, connecting the place of production with the place of consumption or drainage. It covers pipelines for electricity as well as telecommunication cables.

6.3 *Field of application*

Underground duct plans form part of a general information system. These ducts, whether situated in public or in private areas, constitute public networks for distribution and drainage and for the protection of the environment.

6.4 *Rules applicable to underground duct plans*

6.4.1 *Scope of information*

Underground duct plans must contain, for the benefit of their users, complete and up-to-date information on:

- the characteristics of the various ducts;
- their location and level;
- their network connections.

6.4.2 *Characteristics*

Plans must contain all the particulars required for the operation, maintenance and extension of underground ducts, as well as for their protection and continual operation during repairs; they must correspond to the particular features of each network.

6.4.3 *Location and level*

It should be possible from the plans to determine the position of ducts and duct components accurately, to transpose it to other documents and to relate it unequivocally to official survey points. Measurements must be taken in conformity with current surveying rules.

6.4.4 *Network connections*

It should be possible to determine from the plans how ducts are connected to the network to which they belong. Overall plans or diagrams will often be required.

6.5 *Basic plan*

6.5.1 *Special rules*

The basic plan provides the basic reference for underground duct plans. Its purpose is to map the layout of areas where ducts are situated.

6.5.2 *Contents*

The basic plan essentially contains information on:

- fixed points (triangulation points, base points, levelling points);
- property limits, frontiers;
- buildings;
- types and boundaries of crops.

6.6 *Duct or network plans*

6.6.1 *Types of plan*

The network plan contains references to all the equipment and telecommand devices of a distribution or drainage network. Network plans are of the following types:

- drainage water;
- electricity;
- telecommunication installations;
- district heating;
- gas;
- collective antenna installations;
- water.

6.6.2 *Special rules*

Every duct or network plan must meet the operational requirements of the network concerned. The following rules shall apply:

- it must contain all legally required information;
- for ducts, it must give information on their development, construction, operation and maintenance;
- it must contain instructions for use in the event of breakdown or malfunction;
- it must supply operators and third parties with information on the location and level of ducts.

6.6.3 *Contents*

A duct plan generally comprises the following data:

Geometric data

– duct location;

– duct level.

Duct data

– fluid transported;

– managing enterprise;

– function;

– type and content;

– profile;

– dimensions;

– material;

– operational condition;

– construction or duct components;

– identification.

Auxiliary installation data

– Protective devices.

6.6.4 *Scale of plan*

The choice of scale depends on the density of ducts. The scale of the duct plan should correspond, if possible, to that of the basic plan drawn up in accordance with the survey.

The following scales are recommended: 1:100, 1:200, 1:250 or 1:500, according to the concentration of buildings in the area.

6.7 *Preparation of plans*

6.7.1 *Definition*

By **preparation of plans and data management** the capture, updating, processing and representation of all data relating to underground ducts is understood. Any information system for underground ducts can thus be run either manually or by computer.

6.7.2 *Surveys*

The principles of surveys are as follows:

Whenever ducts are laid or altered, their location and, if necessary, their level should be surveyed.

If excavations reveal ducts which were hitherto unknown or the location of which had been uncertain, these ducts must be surveyed. This rule also applies to ducts located by detection.

6.7.3 *Accuracy of location*

The accuracy of the points used to locate ducts must comply with land survey rules.

6.7.4 *Survey methods*

One of the following survey methods must be used:

– polar coordinates;

– orthogonal coordinates;

– distance resection;

– prolongations.

6.7.5 *Procedure for preparing plans*

- single-plan system. The basic plan and duct data should appear on the same medium. Ducts have to be copied onto the basic plan.
- system of separate superimposable plans. With this system, each level of data appears on a separate sheet. The basic plan, duct data and network data can appear as different data levels.

6.7.6 *Representation*

Ducts are represented graphically by means of conventional signs described in special standards.

6.7.7 *Writing*

Writing must be clearly legible and uniform and must be suitable for reduction and reproduction.

6.8 *Use of data processing systems – General analysis*

A very large volume of data on underground ducts needs to be captured, stored, updated, processed and reproduced, and they have to be extractable in different combinations. It is therefore advisable to use computer techniques, since this is the only way of establishing an integrated system of information on underground ducts. Such a system can meet various requirements, such as combining different data levels by the automatic process of separate superimposable plans; it can also produce extracts (plans, lists, etc.) with a diversified content.

An underground duct information system has to be designed as a continuous sequence of operations, including data capture in the field or in the office, storing and processing, and printing out of plans and lists.

6.9 *Maintaining plans up to date*

6.9.1 *Updating*

Duct plans cannot fulfil their purpose unless they are constantly updated. The following principles should be observed:

- data on new or modified ducts must be collected and processed as soon as work is completed;
- basic plans must be kept up to date.

6.9.2 *Access to localization data*

Localization documents should be available for consultation at any time between the completion of duct laying and the entry of data in the plan.

6.10 *Model plan*

6.10.1 *Content*

The model plan in Annex C shows distribution duct pipelines in addition to transport duct tunnels.

6.10.2 *Graphic representation*

The tunnels and pipelines should be drawn to scale, corresponding in width to the internal diameter of the tubes.

6.10.3 *Representation of ducts*

Since so many ducts and cables are either hung, laid or fixed inside tunnels, it is not possible to represent each duct individually. They are therefore represented in cross-sections of the tunnel, which are placed next to the pipeline or on separate sheets with an indication of their location.

Branches, splices, spurs and other details are entered either on the plans or in special files. The distribution ducts for the different fluids should be indicated by conventional signs.

ANNEX A

(to Recommendation L.11)

TABLE A-1/L.11

Safety plan against outside risks

Risk	Consequences	Level of risk	Security requirements	Possible preventive measures [a]		
				At source	During construction	In service
Incoming gas from parallel ducts or intersections	Explosion, fire, asphyxia or poisoning	Rare Caused only by a burst duct Damage will be extensive (to persons, ducts and tunnel)	Same as for load-bearing structure	Sealing or replacing gas ducts	Sealing duct exit between tunnel and ground Natural ventilation Forced ventilation (tunnel under pressure) Tunnel to be divided into segments, with fireproof partitions	Measure gas concentration before entering tunnel Check gas concentration regularly
Incoming water from outside	Possibility of drowning Damage to duct	Rare	Distribution security	Protection against flood water	Well-placed openings Leakproof doors, trap-doors and covers All pipes to be secured against upward thrust Efficient water drainage system	Monitoring system
Unstable ground foundation	Duct bursts, particularly at transit point from tunnel to ground	Foreseeable effects	Same as for load-bearing structure	Consolidation of foundation ground	Flexible fixtures Appropriate designs of duct transit points	Monitoring by measurement

a) The above list of preventive measures is not exhaustive.

TABLE A-1/L.11 *(continued)*

Risk	Consequences	Level of risk	Security requirement	Possible preventive measures [a]		
				At source	During construction	In service
Seismic tremors	Duct bursts, particularly at transit point from tunnel to ground	Variable possibility according to regions Substantial effects	Continued operation of all ducts		Tremor-resistant fixtures Special design of duct exit points	
Effect of weapons, explosion impact	Duct bursts	In time of war, effects are likely to lead to serious damage	Continued operation of all ducts		Shock-resistant fixtures Appropriate design of duct exits	
Sabotage	Duct bursts Explosion Fire	Rare	Continued operation of all ducts		Lockable entry points	Entry control

a) The above list of preventive measures is not exhaustive.

TABLE A-2/L.11

Safety plan for risks inherent in tunnel ducts

Description of risks		Consequence	Level of risk	Security required	Possible preventive measures [a)]		
Network	Risk				At source	During Construction	In service
Electricity	Fire, smoke	Physical injury Duct bursts Cables on fire Destruction of anticorrosion protective coatings and insulation	Rare Gives rise to personal risk and extensive material damage	For persons, same for load-bearing structures	Careful laying of ducts	Segments to be separated with fire-resistant partitions	Fire alarm system
	Toxic and corrosive fumes	Intoxication of persons Damages to ducts and metal elements			Restricted use of PVC-coated ducts Exclusion of PVC cable fixtures		
	Oil leakage from oil-filled cables	Pollution of groundwater and spring water	Rare, gives rise to indirect personal risk	For persons, same as for load-bearing structures	Oil-filled cables to be placed as high as possible in tunnel	Oil drainage device	Monitoring of oil pressure
Gas	Explosion and fire due to leak	Physical injury Duct bursts Tunnel damage	Rare Personal risk and extensive material damage	For persons, same as for load-bearing structures	Steel pipes to be used for ducts and welded joints to be checked	Natural ventilation Mechanical ventilation Gasproof and fireproof partitions	Regular checks for possible leak Duct corrosion checks Regular gas concentration measurement Gas concentration to be measured at each inspection
	Presence of gas without explosion	Asphyxia and intoxication	Rare Physical injury				

a) The above list of preventive measures is not exhaustive.

TABLE A-2/L.11 (*continued)*

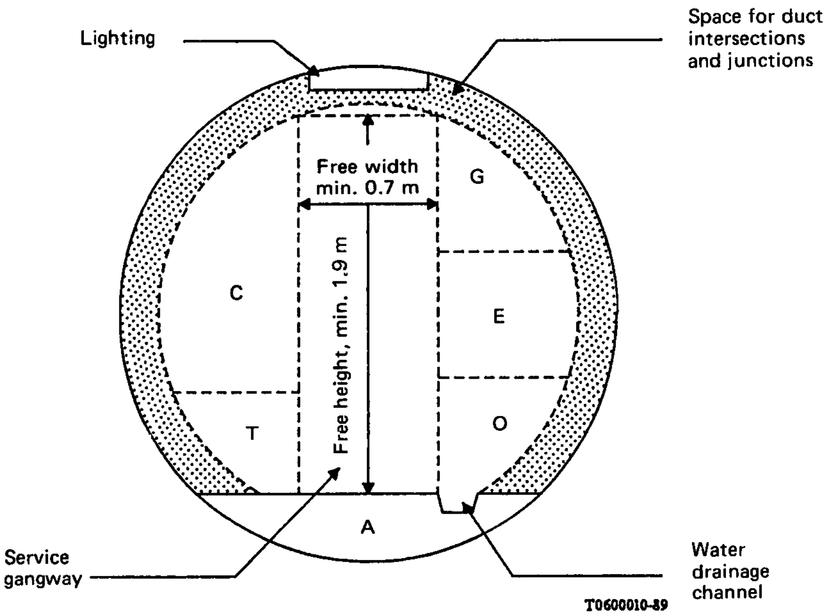
Description of risks		Consequence	Level of risk	Security required	Possible preventive measures [a)]		
Network	Risk				At source	During Construction	In service
Water	Tunnel flooding due to duct burst	Possibility of drowing Damaged ducts	Rare Personal risk and little material damage	For persons, same as for load-bearing structures	Careful design and construction of installation	Strong fixtures Automatic valves Effective water drainage system All pipes to be secured against upward pressure	Regular checks for possible leaks Corrosion checks Alarm system (with floater switch)
District heating	Escaping steam or hot water due to duct burst or leak	Physical injury Duct bursts and other damage to ducts due to rapid rise of temperature	Rare Extensive damage	For persons, same as for load-bearing structures	Careful installation of ducts	Shut-off valves at tunnel ends controlled from outside Remotely controlled shut-off valves Partitions	Alarm system
Drainage water	Partial flooding	Damage to ducts	Rare, Little material damage	Limitation of material damage	Ducts to placed above the highest water level		
	Complete flooding of tunnel	Physical injury and material damage	Rare	For persons, same as for load-bearing structures	Leakproof and lockable access points and inspection holes	Ducts to be secured against upward pressure	

a) The above list of preventive measures is not exhaustive

ANNEX B

(to Recommendation L.11)

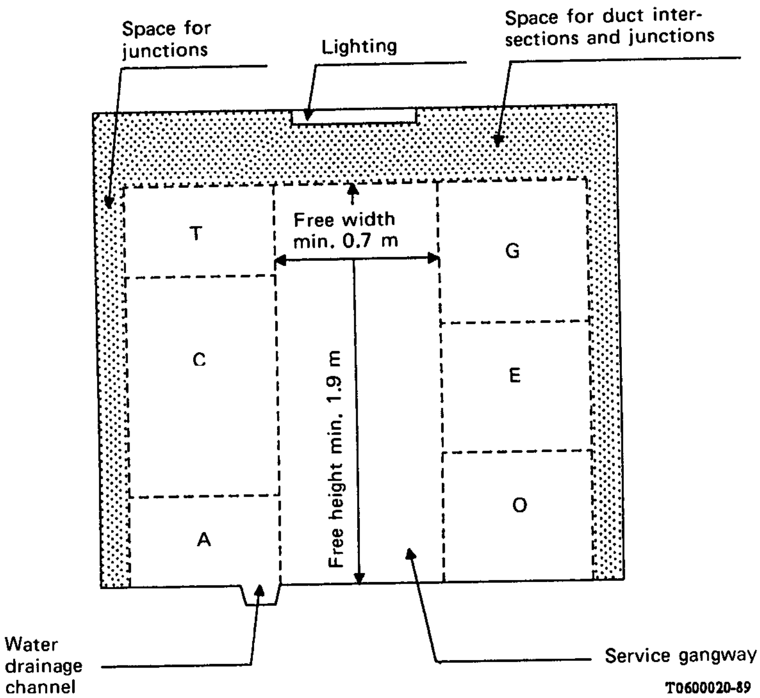
Examples of tunnel profiles



T Telecommunication duct area (in tubes)
E Power duct area
G Gas duct area
O Water duct area
C District heating duct area
A Waste water duct area

FIGURE B-1/L.11

Example of circular cross-section



T	Telecommunication duct area (exposed cables)
E	Power duct area
G	Gas duct area
O	Water duct area
C	District heating duct area
A	Waste water duct area

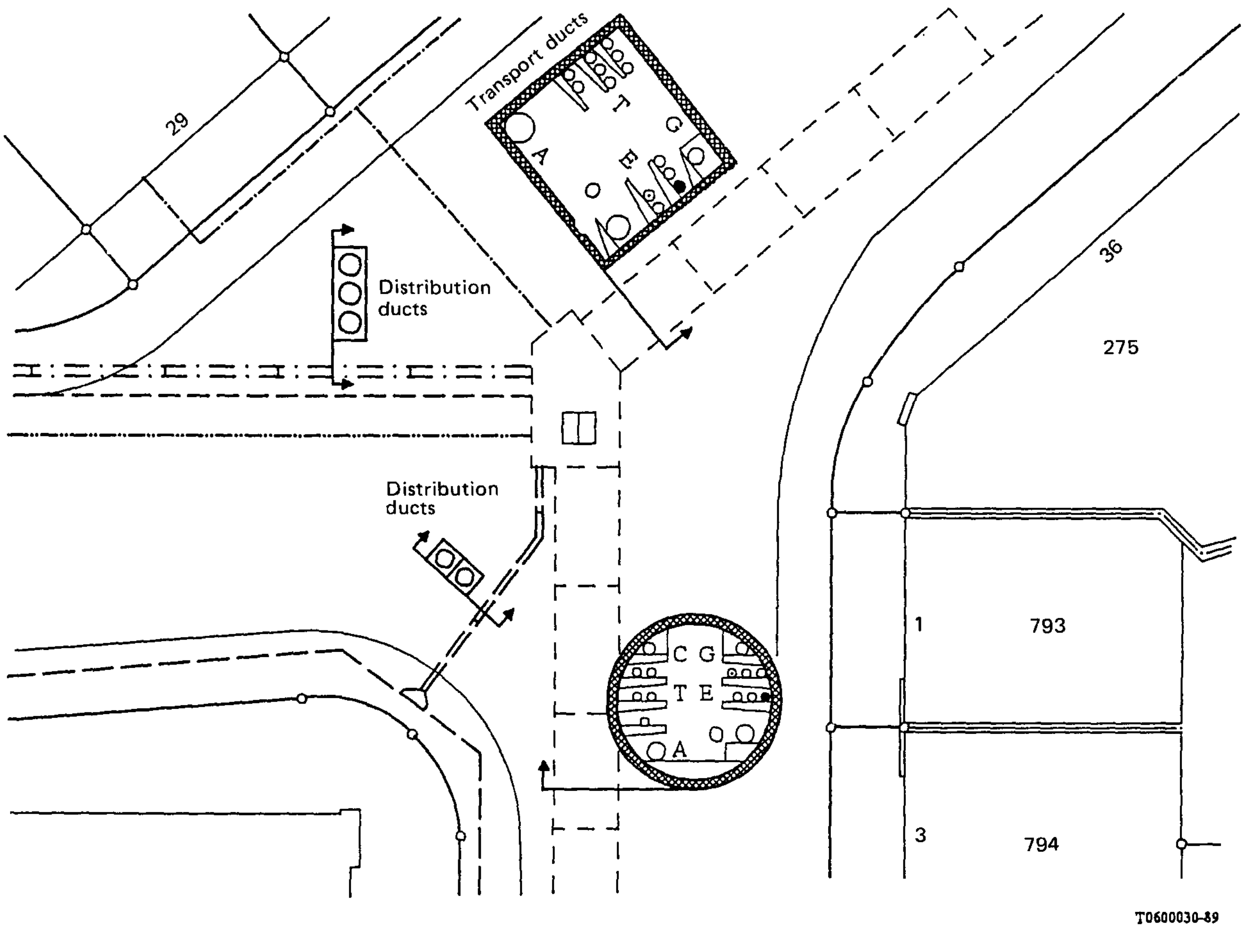
FIGURE B-2/L.11

Example of rectangular cross-section

ANNEX C

(to Recommendation L.11)

Model plan



Convential signs

Construction components or invisible installations

Visible duct components

Information taken from the land register (streets, plots, buildings, etc.)

Water to be drained, A

Electricity, E

Telecommunications installations, T

Gas, G

District heating, C

Collective antenna installations, V

Water, O

FIGURE C-1/L.11

Model plan