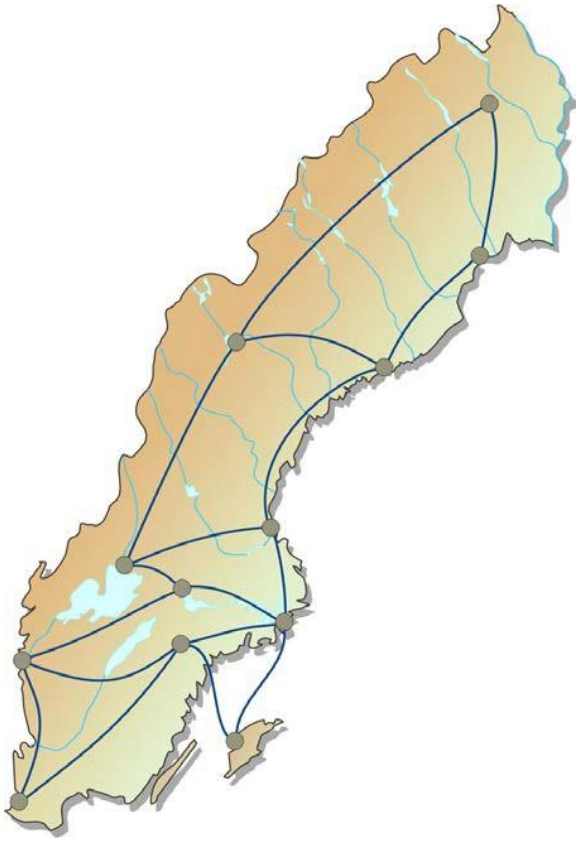
Instructions for Robust Fiber

Instructions for installation of robust fibre-optic broadband networks

Ver 1.5



CONTENTS

1

1. Introduction 4

1.1 Background 4

1.2 Purpose 4

1.3 Target group 5

1.4 About the instructions 5

1.5 Application 6

1.6 Network topologies and limits 6

1.6.1 National networks 7

1.6.2 Regional networks 7

1.6.3 Connection networks 8

1.6.4 Access networks 8

1.6.5 Limits 8

1.7 Administration and Revision 9

2. Responsibility for a fibre installation 10

a. Reliability 10

b. Environment 10

c. General information about roles and responsibilities from a work environment perspective 11

d. Work environment plan 11

e. Environmental plan 12

3. References 13

3.1 General 13

3.2 Networks 13

3.3 Sites and nodes 14

3.4 Documentation 14

3.5 Inspection 14

4. Contributory organisations 15

5. Reference dokument 16

1. INTRODUCTION

1.1 Background

The need for broadband as part of the overall infrastructure is constantly increasing throughout society. Society will be dependent for a long time on the fibre infrastructure that is being built today. As a result, broadband investment has to be robust and operationally reliable in a cost-effective manner.

Several players in the sector, with the support of the Swedish Post and Telecom Authority (PTS), have taken the initiative regarding these instructions, which describe how a robust fibre installation should be established and operated.

The instructions are a further development of previous documents produced by the Swedish Local Fibre Alliance (SSNf) as well as Swedish IT and Telecom Industries.

- 09/10/2011 Network documentation
- 09/10/2011 Robust nodes
- 09/10/2011 Robust networks
- 01/01/2015 Clarification of the Swedish Local Fibre Alliance's recommendation for Robust Networks Version 2
- Classification and documentation, fibre-based infrastructure
- Concepts and definitions, fibre-based infrastructure
- Minimum requirements, documentation for access networks

1.2 Purpose

The purpose of the instructions is:

- To increase knowledge about fibre installations and how they should be built,
- To describe and stipulate requirements for an acceptable minimum level for a robust fibre installation,
- To work to ensure that the players in the sector use the results,
- To define sector-wide terms and expressions,
- To provide supporting data for a certification process where expertise will be ensured at contracting companies and among their personnel.

The instructions will help to raise the level of robustness in fibre installations by means of the players in the sector complying with the requirements contained in the instructions. It is therefore important for network owners and clients in fibre installation projects to have these instructions as the basis for their own instructions.

1.3 Target group

The instructions are aimed at stakeholders in the sector, e.g.,, network owners, fibre alliances, equipment suppliers, contracting companies that install broadband infrastructure, manufacturers of installation machinery, players involved in the administration of training and certification for companies and individuals, as well as contractors for infrastructure projects. Officials at authorities, municipalities and county councils also constitute a target group.

1.4 About the instructions

The instructions are based on standards and regulations within the various sub-areas covered in the instructions, e.g.,, EBR, Svensk Standard, SSF, SEK and AMA.

The instructions highlight selected elements from various standards and describe requirements and recommendations for creating a robust fibre installation. The requirements regarding a fibre installation may deviate from standards and regulations for other types of cable installations.

The instructions comprise a main document along with appendices. The purpose of the main document is to provide an overview as well as references to relevant standards. The appendices include in-depth information, with minimum requirements and recommendations.

At the start of each appendix there is a list of the areas in which there are minimumrequirements. All documentation is available at www.robustfibre.eu.

The appendices cover the following:

- **Appendix 1: Terms and definitions**
  A list of the terms and definitions mentioned in the main document and the appendices.
- **Appendix 2: Robust networks**
  A review of minimum requirements regarding how ducts and fibre optic cables should be selected and routed, as well as how they should be handled, labelled and measured.
- **Sub-appendix 2.1 Robust networks, Attenuation calculation**
  A tool for calculating attenuation values in fibre optic cables.
- **Appendix 3: Robust routing methods**
  A description of various routing methods.
- **Appendix 4: Robust sites and nodes**
  A review of the minimum requirements imposed on a robust site or node
- **Appendix 5: Documentation**
  A description of the documents that should exist and the minimum requirements for these.
- **Appendix 6: Inspection**
  A review of the various steps in the inspection process and the minimum requirements that are stipulated regarding e.g., final inspection.
- **Sub-appendix, Appendix 6.1: Checklist for final inspection**
  Provides support for the inspector during the final inspection of a contract.
- **Appendix 7: Fibre installation projects**
  This appendix is a brief description of the elements included in a fibre installation project.

- **Appendix 8: Ledningskollen (Only as a Swedish version)**
  The appendix is a brief description of the elements that are part of a cable indication querie.

1.5 Application

The instructions' appendices contain minimum requirements regarding how networks and nodes should be routed and documented. Individual network owners apply the instructions according to in-house instructions, processes and building descriptions, and may have requirements that are more stringent or requirements that are not included here.

It is therefore important to note that ***the purpose of these instructions is to describe and stipulate requirements for a minimum level regarding how a robust network should be installed.***

The instructions should e.g.,, be used as:

- Supporting documentation for training.
- Technical support during procurement.
- Information material for permit issuers.
- Description of approaches for inspection.
- Description of the stages in a fibre installation project.
- Basis for specification of requirements when applying for grants.

1.6 Network topologies and limits

The country's fixed electronic communication networks are divided into four levels

- National networks (level 1)
- Regional networks (level 2)
- Connection networks (level 3)
- Access networks (level 4)

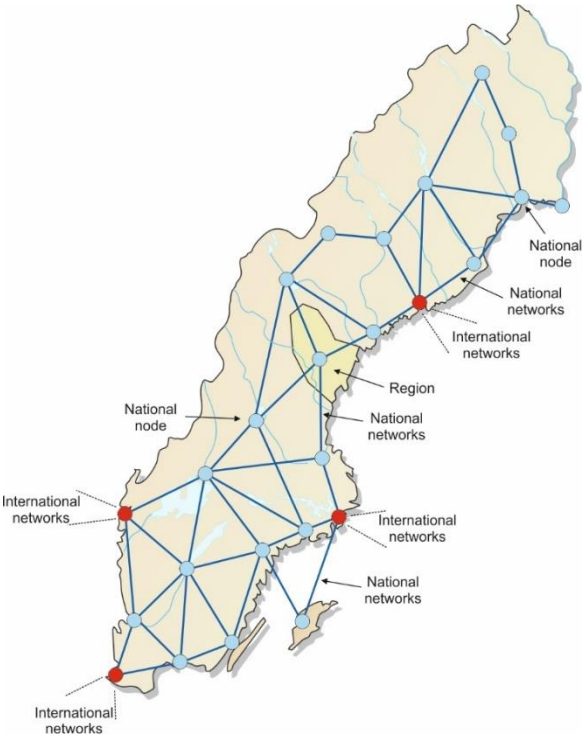
Below is an overview of the networks at the various levels.

1.6.1 National networks

The national networks:

- Link together the various regions in the country.
- Are also connected to international networks.
- Are owned by the country's major operators.
- Have very high capacity.
- Are also known as wide area networks, core networks and backbone networks.

A national node is a connection point in a national network or between regional networks. The security and functional requirements are extremely high.



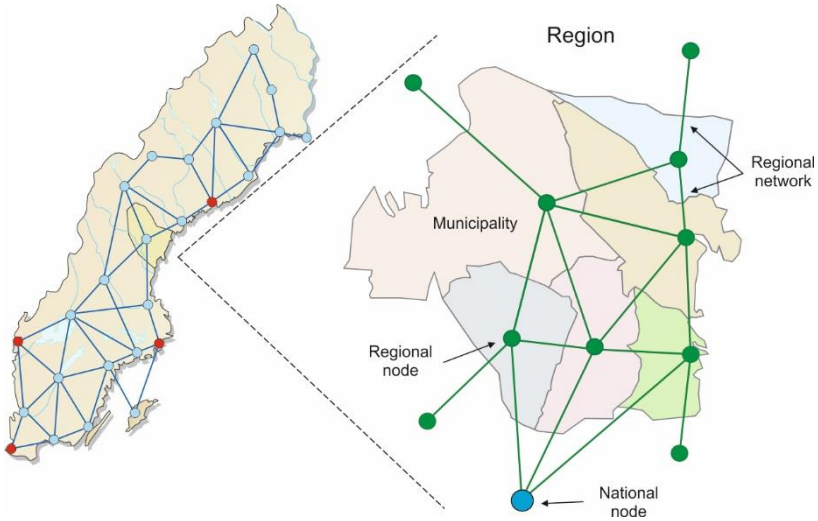
Image, National networks

1.6.2 Regional networks

The regional networks:

- Link together networks within a region.
- Owned by national or regional operators, e.g., urban network clusters and medium-sized operators.

A regional node is connected to national networks, other regional networks and connection networks in the region.



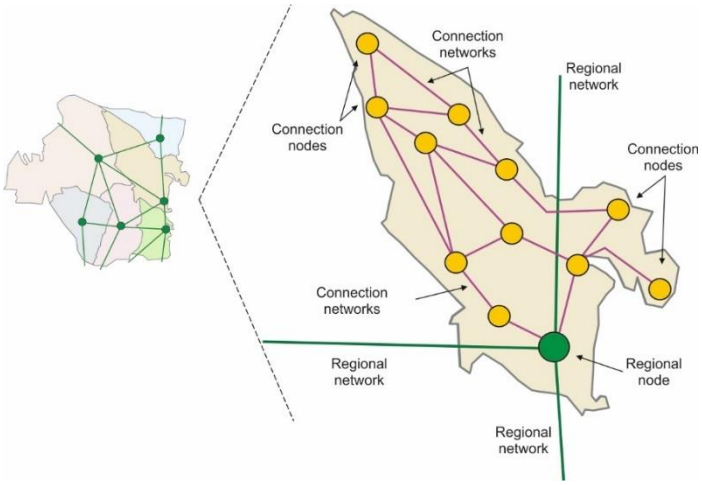
Image, Regional networks

1.6.3 Connection networks

The connection networks:

- Link together regional networks with access networks.
- Are owned e.g., by national operators and local urban networks.
- Are often a network within an urban area or municipality.

The connection node has connections to regional networks, other connection networks and access nodes.



Image, Connection network

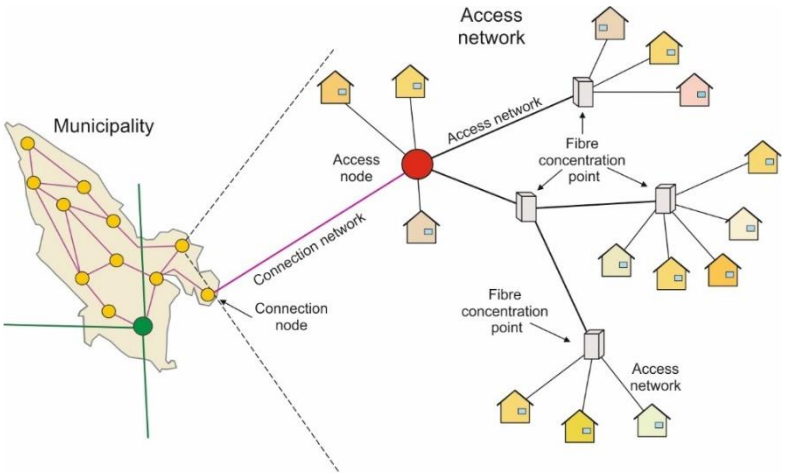
1.6.4 Access networks

Access networks:

- Are networks between access nodes and end customers.
- Are owned e.g., by national operators, urban networks and fibre alliances.

Fibre connections from end customers are terminated in access nodes. Access nodes are connected via connection networks to connection nodes or other access nodes.

MINIMUM REQUIREMENTS
In the event the access node constitutes a connection point between various network owners, the linking of the fibre connections must take place through a cross-connection.



Image, Access network

1.6.5 Limits

The instructions are limited to describing ducting for fibre-optic connection and access networks.

1.7 Administration and Revision

The document is managed by an administration council, which goes through the document at least once a year to ensure that updates with new information, changes and additions are introduced and documented in an Amendment.

All documentation is available at www.robustfibre.se.

Proposed changes to these instructions are submitted by e-mail to info@robustfibre.se.

2. RESPONSIBILITY FOR A FIBRE INSTALLATION

Being responsible for a fibre installation places considerable demands on the network owner and the organization that will plan, build and manage the plant. For a network owner, the Electronic Communications Act (LEK) applies if the network owner provides:

Public electronic communications networks normally provided for remuneration or publicly available electronic communications services may be provided only upon notification to the regulatory authority.2 Kap Anmälan av verksamhet

A network owner who has reported activities in accordance with LEK also conducts a socially important activity.

By socially important activities is meant activities, services or infrastructure that maintain or ensure societal functions that are necessary for society's basic needs, values or security. In this context, activity should be understood as a broader concept. Operations, services or infrastructure also include, for example, facilities, processes, systems and nodes (MSB).

The instructions are always subordinate to applicable laws and government regulations.

2.1 Reliability

Continuous work on reliability must be carried out by the network owner. This includes performing a risk analysis of the fibre installation, e.g., sites, nodes and fibre optic cables.

The purpose of the risk analysis is to reduce the vulnerability of the fibre installation and increase awareness of the risks that exist and the consequences should an incident occur. An example of a management model for operational reliability, with templates showing how the network owner can handle the operational reliability work, can be found at the Swedish Local Fibre Alliance, www.ssnf.org.

For more information about requirements that apply to reliability for a fibre installation, please refer to the Swedish Post and Telecom Authority's regulations and general advice on security of networks and services.

2.2 Environment

This 39chapter provides a general description of environmental and work environment aspects that can occur in conjunction with a fibre installation project. All commercial operations' environmental and work environment aspects are covered to a large extent by various laws and regulations.

The legislation regarding both the environment and the work environment is continually being developed, which is why the organisation's work on these areas must be conducted on an ongoing basis in order to be successful.

Generally speaking, a specific person should be appointed within each organisation to monitor and spread information about developments within each area. With regard to the work environment, the Swedish Work Environment Authority is tasked with ensuring compliance with laws about the work environment, and the Authority supplies several different tools and checklists for the work in this area.

2.3 General information about roles and responsibilities from a work environment perspective

The Principal is the party that commissions the execution of building or installation work. In the case of a fibre installation project, the ordering network owner is the Principal. The Principal can reach agreement with a Contractor regarding taking over the role of Principal with some or all of the responsibility for the work environment that is associated with the role of Principal. In the case of a fibre installation project, the network owner may agree in writing with a contractor regarding taking over the role of Principal.

The principal is responsible for appointing a Construction work environment coordinator for planning and design (BAS-P) and a Construction work environment coordinator for execution (BAS-U). The principal is also responsible, together with the BAS-P, for drawing up a Work environment plan.

2.4 Work environment plan

During the start-up of a fibre installation project, a separate work environment plan must be drawn up for the specific project if any of the following three criteria are satisfied:

1. The work is estimated to continue for more than 30 days and where more than 20 are employed simultaneously at some point.
2. The total number of person-days is estimated to exceed 500 days.
3. If any of the 13 risks occurs (See AFS 1999:3 Section 12a C).

The work environment plan must be drawn up before the work at the location of the fibre installation project commences. BAS-U is responsible for the work environment plan being available at the workplace and for it being updated, if necessary, as the work on the fibre installation project progresses.

The work environment plan may contain the following:

- The regulations that are to be applied at the location of the installation work.
- A description of how the work environment work is to be organised.
- A description of the measures that are to be implemented to minimise the risks in the case of "work involving particular risk" and any other risks.
  Examples of work involving particular risk during a fibre installation project:
  - work with a risk of falling to a lower level where the difference in level is two metres or more,
  - work that entails a risk of being buried under soil or sinking into soft ground,
  - work in the vicinity of high voltage cables,
  - work that entails a risk of drowning,
  - work in fibre chambers and tunnels as well as installation work below ground,
  - work that is carried out under water using diving equipment,
  - work that involves the use of explosives,
  - work in a location or area where there is passing vehicular traffic.
- If the installation work is to be conducted in a location where another operation will be ongoing at the same time, this must be taken into consideration in the work environment plan by taking account of any risks to people who belong to another operation.

The ordering network owner should impose requirements on the parties that are carrying out the work in the fibre installation project, whereby the parties should document and submit such information to the client that will facilitate future work environment work and safety rounds at the installation.

The ordering network owner should, for its own part and for the same reason, ensure that parties that are carrying out work in the fibre installation project have procedures and systems in place for documenting and reporting accidents and near-accidents.

2.5 Environmental plan

In parallel with the Work environment plan's efforts to create a good work environment and prevent accidents, the preparation of an environmental plan can contribute to minimising the fibre installation project's negative environmental impact.

The environmental plan is also a way of ensuring, in a structured manner, that the fibre installation project is not taking place in contravention of applicable environmental legislation, local regulations or the individual environmental policies of the parties involved.

An environmental plan may cover the following aspects:

2.5.1 Involved vehicles and work machines and their environmental impact. Machinery must be environmentally classified, CE marked and properly maintained. Emissions levels must be within the framework of applicable regulations. Local regulations for environmental classification may occur where the areas can be classified as sensitive. Object-specific environmental requirements may occur in certain cases.

2.5.2 Analysis of the risk of leakage of oil, fuel, coolants or other environmentally hazardous chemicals into the land and watercourses or other sensitive natural environments. The risks should be associated with an action plan in the event of an accident. A decontamination company must be available in an emergency if necessary.

2.5.3 Environmental impact associated with excavation. Select a method with little environmental impact in respect of emissions from work machinery, vehicles and for the transport of backfill material.

2.5.4 Plan for handling contaminated material. Ensure that relevant contractors possess the required knowledge and have the necessary permits to handle the material.

2.5.5 Identification of risks of disruptive noise and vibrations of the environment.

2.5.6 Planning of working hours from the perspective of disruptions to the surrounding environment and the general public. Local rules and regulations govern when noisy work may be carried out.

2.5.7 Risk of large amounts of dust. Some routing methods can create a large amount of dust and require measures to reduce the spread of the dust, in the form of covering or interrupting the work in windy conditions.

2.5.8 Work in the vicinity of particular sensitive nature, trees, bushes, alleys and watercourses.

3. REFERENCES

Below is a list of standards, rules, regulations, legal requirements, etc., that may be relevant in order to find out more about a subject.

3.1 General

Laws, ordinances, statutes and regulations:

- The Alarm Systems Act.
- The Electronic Communications Act (LEK).
- The Protection of Essential Facilities Act.
- The Work Environment Act.
- The Swedish Work Environment Authority's provisions (AFS)
- The Swedish Post and Telecom Agency's regulations and general advice on security in networks and services

3.2 Networks

For nodes, property networks or fibre outlets in apartment buildings, see "Robust property networks".

An overview of cable routing according to the instructions EBR KJ 41:21, popularly known as the "Excavation bible"

AMA (General material and workmanship specifications) Site works is a reference work that is used in the preparation of descriptions and the execution of construction work.

Information about splicing units and fibre optic cables can be obtained from ITU-T and Svensk Standard.

Information about ducts:

- European Standard EN 60794–5:2007 Optical fibre cables – Part 5: Sectional specification – Microduct cabling for installation by blowing.
- SP's standard PS 144.
- EN ISO 3126:2005.

Cables:

- Product regulation for cables indoors, CPR (Construction Product Regulation) SS-EN 50 575.
- Fibre-optic cables – Type designations SS 424 18 86 developed by SEK).

Enclosure classification

The relevant standard is called SS-EN 60 529.

Impact resistance

The relevant standard is called SS-EN 50 102.

3.3 Sites and nodes

For the handling of methods and equipment for surveillance and burglar protection, please refer to the Swedish Theft Prevention Association's standards and instructions.

For rules and regulations relating to electrical safety, please refer to the National Electrical Safety Board and SEK Svensk Elstandard. Local power suppliers may have their own provisions.

Lightning protection, earthing and equipotential bonding are described in Svensk Standard.

For fire protection, regulations exist for which the Swedish Fire Protection Association is responsible.

For requirements regarding buildings, please refer to Boverket.

For physical safety in nodes, there are a number of standards that can be obtained from Svensk Standard

3.4 Documentation

The standard for the documentation of teletechnical installations can be obtained from Svensk Standard

3.5 Inspection

For more information, please refer to the Construction Contracts Committee and the General Conditions of Contract (AB and ABT).

4. CONTRIBUTORY ORGANISATIONS

The following organisations, in collaboration with PTS, have been responsible for the drawing up of the instructions.

AB Stokab
The Swedish Broadband Forum
Bynet AB
Dellcron AB
Eltel Networks Infranet AB
Empower AB
GothNet AB
ICT Consulting AB
Iftac AB
Incert AB
IP-Only AB
Swedish IT and Telecom Industries
Johan Lundberg AB
JLM Scandinavia AB
Maskinentreprenörerna AB
Netel AB
Nexans Sweden AB
Nordlund Entreprenad AB
Swedish Post and Telecom Authority
Rala Infratech AB
Relacom AB
Roland Gustavsson Grävmaskiner AB
SG Optics AB
Skanova AB
STF Ingenjörsutbildning AB
Styrud AB
Svensk Infrastruktur AB
Swedish Local Fibre Alliance
Swedish Association of Local Authorities and Regions (SALAR)
Tele2 AB
Telenor AB
Thunman Konsult
Utsikt Bredband AB
We-Consulting AB
Higher Vocational Education, Heta utbildningar Härnösand

5. REFERENCE DOKUMENT

CENELEC TS 50429 (30,31)	Opto fibre cables for installation in storm and sanitary sewers, high pressure gas pipes, drinking water pipes
CENELEC TS 50433	Guidelines for paving the way for "Broadband, 25 Mbit/s and more for all"
SS-EN 424 14 37- 6	Kabelförläggning i mark
SS-EN 424 1438	Kabelförläggning i byggnader
SS-EN 50377-xx	Anslutningsdon för fibreoptik
prEN 50377-xx	Connector sets and interconnect components
SS-EN 50411-xx	Fiberorganiserare, kapslingar, skarvboxar
SS-EN 60874-xx	Optofiberteknik – Anslutningsdon för optofibrer och optokablar, fiberoptik, art- och gruppspecifikationer
SS-EN 60875-xx	Optofiberteknik – Avgreningsdon
SS-EN 61073–1	Fiberoptik – Mekaniska skarvar och skydd för svetsskarvar
SS-EN 61274-xx	Optofibreteknik – Övergångsdon
SS-EN 61753-xx	Fiberoptik – Funktionsfordringar på anslutningsdon, Fibre interconnecting devices and passive components
SS-EN 61754-xx	Fiberoptik – Gränssnitt för kontaktdon, Fiberoptiskt kontaktdonsgränssnitt
SS-EN 61755-xx	Fiberoptik – Optiska gränssnitt för kontaktdon, Fibre optic connector optical interface
SS-EN 61756–1	Fiberoptik – Anslutningsdon och passiva komponenter- Gränssnitt för fiberhanteringssystem
SS-EN 61758–1	Fiberoptik – Anslutningsdon och passiva komponenter- Gränssnitt hos skarvboxar
SS- EN 60793-xx	Optofibrer: produktspecifikationer, mätning och provning – Bandbredd
SS-EN 60794- x	Optokablar/generella kabelnät: art- och familje-gruppspecifikationer, grundläggande provningsmetoder.
SS-EN 61280 xx	Delsystem för fiberoptisk kommunikation - Grundläggande provningsmetoder (multimodfiber/singelmodfiber)
SS-EN 61300.- xx	Fiberoptik – Anslutningsdon och passiva komponenter Provning och mätning
SS 455 12 01 (utg. 1)	Dokumentation av teleanläggningar
SEK Handbok 434	Fiberoptisk anslutning av slutanvändare – FTTX-nät
SEK Handbok 455	Dokumentation av teleanläggningar (baseras på SS 455 12 01)
EBR KJ 41:21	Kabelförläggning max 145 KV (based on SS 424 14 37- 6)
EBR B 14:00	Opto

Instructions for Robust Fiber

Appendix 1 Terms and definitions

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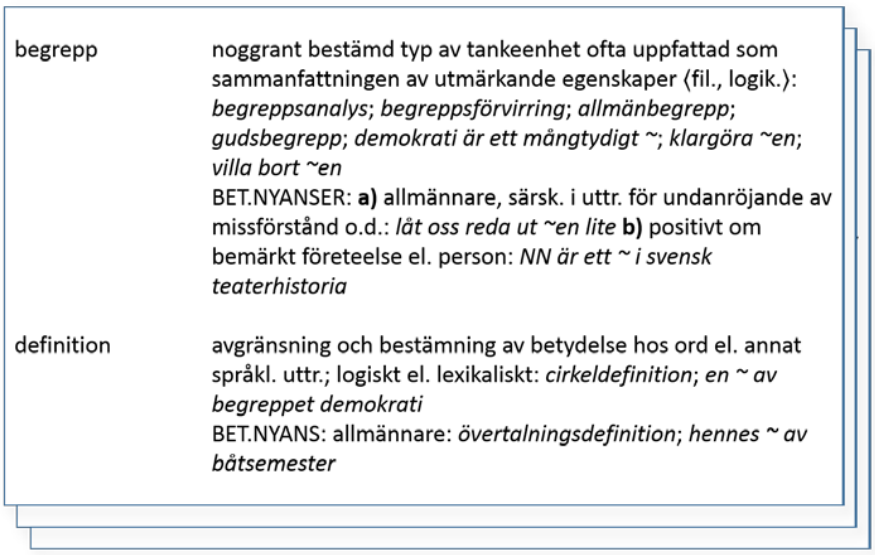

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definition	avgränsning och bestämning av betydelse hos ord el. annat språkl. uttr.; logiskt el. lexikaliskt: *cirkeldefinition*; *en ~ av begreppet demokrati* BET.NYANS: allmännare: *övertalningsdefinition*; *hennes ~ av båtsemester*

CONTENTS

1. Introduction 3

2. Terms and definitions 4

2.1 General 4
2.2 Network structure 4
2.3 Ducting 5
2.4 Fibre optic cable 7
2.5 Sites and nodes 9
2.6 Documentation 10
2.7 Inspection 11
2.8 Measurement methods 11
2.9 Underground routing methods 12

1. INTRODUCTION

The document "*Instructions for Robust Fiber*" comprises one main document and a number of appendices. This appendix, Terms and definitions, details the terms that are relevant for a fibre installation.

The players in the sector use various expressions and terms to describe a fibre installation and its constituent components. It is necessary to gather the terms that are used in order to obtain sector-wide definitions. In the event of external contacts, it is therefore an advantage to use the common terms and definitions that are listed here.

Terms and definitions are sorted under the following areas sorted in alphabetical order within each area.

:

- General
- Network structure
- Ducting
- Fibre optic cable
- Sites and nodes
- Documentation
- Inspection
- Measurement methods
- Routing me

2. TERMS AND DEFINITIONS

2.1 General

Alliance network	Network that is established within a fibre alliance.
Fibre installation	The complete installation with all its constituent components, including e.g. sites, nodes, ducts and fibre optic cable.
Network owner	The organisation that owns and manages the fibre installation. Often the client in a fibre installation project.

2.2 Network structure

In order to describe network structure, four network levels are used. The highest level comprises national networks (level 1) and the lowest level (level 4) comprises access networks for connecting end customers. Levels 1–3 have the combined name Transport networks and are made up of networks between nodes.

National networks (level 1)	National networks link together the country's various regions and are also connected to international networks. National networks are also known as wide area networks, core networks and backbone networks.
Regional networks (level 2)	Regional networks link together networks within a region.
Connection networks (level 3)	Connection networks link together regional networks with access networks. Can include networks within an urban area, for example.
Access networks (level 4)	Networks between access nodes and end customers in order to connect individual end customers or customer groups. Connections within access networks are also known as local access. An alliance network is an example of an access network, intended to connect individual end customers outside of built-up areas. Area networks constitute a proportion of access networks. An example of an area network is a network between buildings in a shared legal property, for example within a community or in a shopping centre. Property networks are linked to access networks and are distribution networks within a building or property.

2.3 Ducting

Annular rigidity type	Ducts resistance to pressure is defined by their annular rigidity, i.e., the pressure that the product can withstand during a test before it deforms.
Backfill height	Relates to refilling from the upper part of the duct to the finished ground level(surface).
Cabinet	Distribution point located above ground, either outdoors or in a property, where ducts and fibre optic cables start or terminate or are connected to other ducts and fibre optic cables. Can also be designated a switch cabinet or an outdoor splice cabinet.
Cable indication query	Indication of the location of cables in the ground. Can be achieved by sending a detailed map of the location of cables or by using colour marking locally in the ground to indicate where cables are routed. Also known as cable staking or simply staking.
Cable fixation point	Device for connecting search string in order to facilitate cable indication/cable staking. Also known by the Swedish abbreviation KUP.
Demarcation point	The point where ducting is transferred, e.g. at a plot boundary.
Distribution point Also applies to	Point at which ducts starts, terminates or branches. Could be a Optical fibre chamber, cabinet, splicing box or node, for example. fibre optic cables. Also known as a connection point.
Ducting	Ducting is an arrangement that provides space and protection for cables. The term Ducting includes all components that jointly make up an arrangement for the protection of cables, e.g. ducts, standard ducts, microducts, cable ducts, optical fibre chambers, search wire. Ducts are also known as ducts.
Ducting section	Refers to the combined ducting between two points.
End plug	Used to seal ducts that have not yet been taken into use. Also known as end seals, sealing plugs or duct plugs.
Facade box	Box located on the facade of a building and used for splicing fibre cable for the building.
Farmland	Relates to land that is cultivated.
Frost thawing	Method for thawing ground in the event of frost. Can be performed by firing with coal or by electrically heating up the ground.

Greenfield sites	Refers to ground where there are no obstacles in the form of other cable routing, asphalted surfaces, crossings with other cables, etc.
Warning mesh	A tape in a clear colour that is placed in the refill material above buried ducts. Also known as warning net. Search wire may be incorporated directly in the marking tape.
Microducts	Is a duct with an inner diameter of approx. 3–18 mm. This type of duct is intended to be used either indoors or within other ducts (thin-walled) or directly in the ground (thick-walled).
Standard duct	Sandard duct, are ducts specially manufactured for routing fibre optic cables. Standard inside diameters range from about 12-15 mm to 50 mm.
Splice connection	Sealed connection that is used to splice ducts.
Sub-ducting	Arrangement for ducting that is surrounded by other ducting, e.g. several ducts that are surrounded by a larger duct.
Search wire	A wire made of acid-resistant, stainless steel that is routed above or below ducts. Used to facilitate the locating of ducting with the aid of a tone transmitter and cable locator. The search string may be separate or incorporated in marking tape.
TA plan	Traffic arrangement plans must include details about roadworks and how such works are to be signalled.
Wall box	Box located on a wall and used for splicing fibre cable.
Optical fibre chamber	Space level with the ground or buried (underground optical fibre chamber) from which ducts start or terminate or connect two or more sections of duct. Examples of various types of chambers: cable chamber, splicing chamber, intake chamber, pulling chamber, splicing box and loop chamber.
Wire span	Method where wire is stretched between two points. Ducts or cables are then suspended on the wire.

2.4 Fibre optic cable

Aramid thread	Durable thread made of aramid yarn that can be used for strain relief in fibre optic cables.
Broadband space	A space, normally a cabinet, in a house or apartment where fibres are terminated. A home network (connections to other rooms) can also be connected in this space, which is also known as a broadband cabinet, IT cabinet, media cabinet or media centre.
Connection	A connection connects two or more nodes via one or more fibre links/transfer units.
Connection cable	Fibre optic cable with connectors at both ends. Used to connect between outlets in ODFs or active equipment. Also known as fibre patch, patch cable or connecting cable.
Connection point	Physical point where a network is terminated at the end customer.
Connection site	Refers to a space, room or similar where cables start, branch or terminate, such as a optical fibre chamber, outdoor splice cabinet node or splicing box. See distribution point.
Cross-connection	Connection with a connection cable between two fibre outlets, e.g. in an ODF.
Fan-out	See pigtail. A fan-out is a collection of fibres, a fibre ribbon with connectors at one end that is welded to a fibre ribbon in an fibre optic cable. Also known as a ribbon tail.
Fibre	Part of a fibre optic cable. Optical fibre is a thin fibre of glass or plastic that transfers information using light instead of with electrical signals, which is the case in a copper cable. • Single fibre: A connected or non-connected fibre in a fibre optic cable. Fibre pair: Two connected or non-connected fibres in a fibre optic cable make up a fibre pair. • Black fibre: Unlit fibre connection.
Fibre blowing	Method for inserting fibre optic cable into a duct with the aid of compressed air.
Fibre connector	Optical connector that is used to terminate a fibre. Available in several different versions for different purposes.
Fibre link	Fibre that has been spliced and terminated so that communication is possible between its end points. A fibre link is also known as a transfer unit.

Floating	Method for inserting fibre optic cable into ducts with the aid of water. Suitable for long distances.
Intermediate piece	Device for connecting two fibre connectors to each other. Intermediate pieces are available in different versions for different purposes.
Loop	In distribution points, fibre optic cables can be laid in a loop (the cable is laid in a circle in several rotations). This is a way of facilitating the repair of the cable as well as the splicing in of another fibre optic cable between two distribution points.
Main cable	Fibre optic cable between distribution points or between a node and a distribution point, which then branches to smaller cables for the connection of customers.
ODF	Optical Distribution Frame, equipment for terminating, connecting and cross-connecting fibres. An ODF unit is part of an ODF (also known as an ODF module or ODF panel). An incoming fibre to a node is terminated with a connector on the inside of the ODF unit, and the fibre's capacity can be accessed on the front of the ODF unit.
ODF panel	The front of an ODF unit. Also known as an ODF module or simply a panel.
Optical cable	Individual fibre optic cable or straight-spliced fibre optic cable of the same type.
Pigtail	A single, short optical fibre that has an optical connector pre-installed at one end. Used to weld a connector to an optical fibre. Also known as a pig-tail or pig tail.
Rodent protection	Protection against vermin. Might be e.g., a sheet metal rail, reinforced duct, armoured cable or additives in the cable's/duct's sheath material.
Splice	Permanent connection of fibres (as opposed to when e.g. connectors are used). A splice is normally welded. Also known as a fibre splice or optical splice.
Splicing off	Type of splice where some of the fibre optic cable's fibres are spliced together with fibres in a second fibre optic cable, other fibres in the fibre optic cable are spliced together with the fibres in a third or more fibre optic cables. Also known as branching.
Straight splice	Type of splice where all the fibres in two cables are spliced together.
Termination	Means that a cable is terminated, and its capacity is made available for connection in a connector.
Transition joint	Also known as a station joint. Designates a joint between different cable types, e.g. an outdoor cable, indoor cable or underwater cable.
Transfer point	Physical point for fibre termination where connection takes place at fibre level between operator, network owner or customer. Transfer point is also known as entry point.

2.5 Sites and nodes

Access node	The node that is connected on one side to a connection network and on the other side to an access network. Access nodes are also known as distribution nodes or area nodes.
Auxiliary power system	A device for supplying sites and nodes with electrical power in the event of an interruption in the incoming electrical power supply. Could e.g., be a generator that is powered by a motor (permanently installed or portable), a fuel cell or a UPS with batteries.
Electrical system	System for distributing electrical connections in a site or node. TN-S entails a 5-conductor system with separate protective earth and neutral conductor. TN-C entails a 4-conductor system with a combined earth and neutral conductor.
EMC	Electromagnetic compatibility. The ability of apparatus, equipment or systems to work in their electromagnetic environment without causing unacceptable interference in this environment.
End customer	End customer refers to the party that will utilise the finished product or the service. From the network owner's perspective, this could be the customer's customer.
Meet Me Room	Separate area in a site where cross-connection between external network owners/operators can take place.
Node	A node is a distribution point where traffic flows are forwarded, concentrated and/or distributed. Can be a distribution point for fibres or distribution point where fibres are connected to other types of network. ODF and active communication equipment is placed in a node, for example.
Outdoor cabinet	Also known as an environmental cabinet. Cabinet adapted to work as a small site and node. Can contain an auxiliary power system, climate system, ODF and active equipment. SiteA physical area that contains one or more nodes. Sites have e.g., the following functions: shell protection, electrical systems, auxiliary power systems and climate systems.
UPS	Uninterruptible Power Supply. Can also even out and stabilise the voltage. Can be fitted with batteries for operating times of various lengths.
User node	The node that is found at the end user. This may be a simple fibre outlet or with active equipment. Can also be referred to as a property node.

2.6 Documentation

Accuracy class	Specifies the accuracy with which a point is measured. For example, accuracy class 2 specifies that the point must be measured with an accuracy of 25 cm or less accuracy.
Delivery measurements	Measurement of the fibre network's optical properties such as attenuation and reflection.
Duct drawing	Schematic drawing of the connection of ducts.
Easement	Concept relating to the right that a property has to utilise another property in a certain way.
GIS	Geographic Information System. A computerised system for gathering, storing, analysing and presenting geographic data on a digital base map. GIS is often used to describe a network's extent and information about the geographic location, designations, etc., of the various parts of the network.
Land agreement	Generic term for the various forms of agreement that exist to regulate rights and permits to route fibre installations.
Land lease agreement	Temporary agreement where the land owner grants e.g. the cable owner the right to use the land for laying cables.
Ledningskollen	National service for cable indication queries, design and planning queries, coordination queries and community planning queries. www.ledningskollen.se
Location map	Duct drawing where the ducting's surveyed geographic position is presented on a map with a high degree of accuracy.
Panel card	Document that shows fibre optic cable's termination points, their connectors and what they are connected to.
Placement	Placing of equipment in another party's premises. This could be e.g. in a site, a technical area or in a mast.
Prioritisation list	List of connections which clearly sets out which connections have the highest priority. Used in the event of major cable faults to prioritise the order in which connections should be restored.
Rack layout drawing	Drawing showing the units found in a rack and where in the rack they are located.
Splicing plan	The splicing plan is a detailed drawing or a connection table that shows fibre optic cables' splices and terminations, with information for identification.

Utility easements	The Utility Easements Act is a Swedish act that regulates the right for legal entities to route cables through the property of other parties. Utility easement is the strongest form of agreement for cables.
Usufruct agreement	The right to use something that is owned by another party, such as ducts.

2.7 Inspection

Construction meeting and the following-up of must	Regular meeting held during the project period for decision-making finances, timing, technology and quality. At the meeting, minutes be kept by the client and be checked by the contractor.
Contractor	Denotes a person or company that carries out work on a contract, e.g., an excavation company.
Controller	Representative appointed by the client who continually checks the installation work throughout the implementation period.
Inspector	Impartial person with experience in the area. Engaged by the client or jointly with the contractor to conduct an inspection of the fibre installation.

2.8 Measurement methods

Attenuation measurement	Method for measurement of output loss (attenuation) in fibre. By connecting a light source with known, stable output on one side of the fibre and a power meter on the other side, it is possible to calculate out much light is lost.
OTDR	OTDR (Optical Time Domain Reflectometer). Instrument for characterising an optical fibre.
OTDR measurement	Method for measuring attenuation and reflections in fibre, fibre joints and connectors.

2.9 Underground routing methods

Chain excavation	Also known as milling excavation. The ground is dug up with scoops (blades) that are mounted on a chain.
Directional drilling	This method can be used for various types of material, such as soft soil types, mixed material and rock. A pilot rod is drilled forwards in the ground along a predetermined line. The position of the drill head is checked with a built-in radio transmitter and guided with an angled steering head. When the pilot rod is pulled back out again, the drill hole is widened with a hole opener. At the same time, the media duct is pulled into the drilled hole.
Excavation	An excavator with a bucket that digs a trench. This can also be performed manually with a spade.
End milling	Also known as infratrenching or minitrenching. The ground is milled with a milling wheel with carbide bits. The groove is 30–150 mm wide and up to approx. 450 mm deep.
Hammer drilling	Also known as casing drilling. A compressed air-driven hammer pulls along a casing. Used primarily in rock.
Impact mole	A "rocket-shaped" rod that is driven forwards through the ground with the aid of a compressed air-driven piston. Duct can be routed directly behind the impact mole or be routed by reversing the mole. Only for short distances, approx. 10–20 metres.
Microtrenching	Also known as micro-ditching or groove cutting. The ground is cut with a saw blade, the outer edge of which includes segments containing diamonds. The groove is 15–30 mm wide and up to approx. 400 mm deep.
Ploughing	A plough with a blade that is driven down into the ground with the aid of a machine. The machine pulls the blade, either static or vibrating, through the ground. A duct runs through a laying tube behind the blade and is routed directly behind the plough.
Pressing	Pressing Can also be referred to as auger boring. A steel duct (casing duct) is pressed from one point to another. The duct remains in the ground and becomes the outermost ducting, into which ducts are then inserted. This method is only used for short distances.
Suction excavation	Powerful suction that draws material up out of the ground.

Instructions for Robust Fiber

Appendix 2 Robust networks

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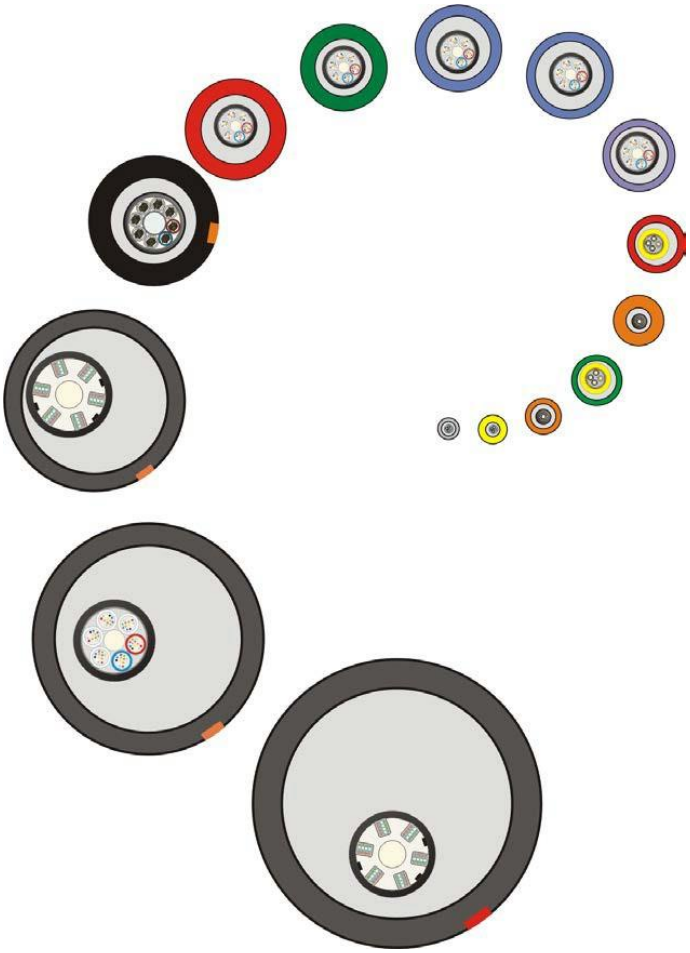


CONTENTS

1. Introduction 5

2. Networks 6

2.1 Preparations for routing of ducts and fibre optic cables 6

2.1.1 Plan network structure 6

2.1.2 Land investigation 6

2.1.3 Permits and land issues 7

2.1.4 Cable indication query 8

2.1.5 Choice of routing technique 8

2.1.6 Self-monitoring 8

2.2 Ducting 9

2.2.1 Ducts 9

2.2.2 Distribution point 11

2.2.3 Traceability 16

2.3 Routing 19

2.3.1 Sealing of ducts 19

2.3.2 Underground routing 19

2.3.3 Minimum backfil height 26

2.3.4 The location of the intake of the duct in a building 29

2.3.6 Routing on poles 34

2.3.7 Installation at bridges 36

2.3.8 Routing in tunnels and culverts 37

2.4 Fibre optic cables 38

2.4.1 Fibre optic cables, general 38

2.4.2 Fibre optic cables for underground routing 41

2.4.3 Fibre optic cables, cable gutters and cable ladders for indoor routing 41

2.4.4 Minimum requirements for pole routing 42

2.4.5 Fibre optic cables for routing in water 42

2.4.6 Fibre optic cables for routing in tunnels and culverts 42

2.5 Cable management 43

2.5.1 General requirements 43

2.5.3 Routing fibre optic cable indoors 44

2.5.4 Splicing cables 44

2.5.5 Splicing units 45

2.5.7 Optical connectors and cleaning 48

2.5.8 Termination outdoors 50

2.5.9 Termination in house 50

2.5.10 Optical radiation 51

2.5.11 Delivery measurement of fibre connections 51

2.5.12 Delivery measurement of passive fibre 52

2.5.13 Delivery measurement of active fibre 53

2.6 Labelling 54

2.6.1 Labelling and designation of ducts 54

2.6.2 Labelling cables 55

2.6.3 Numbering and labelling of racks and panels 56
2.6.4 Splicing units 56
2.6.5 Fibre outlets 56
2.7 Safety 56
2.7.1 Locks 56

1. INTRODUCTION

The document "*Instructions for Robust Fiber*" comprises one main document and a number of appendices.

This appendix, Robust networks, contains minimum requirements regarding how ducts and fibre optic cables are to be selected, routed, handled, labelled and measured. The appendix also contains recommendations and examples of what it might look like when building a robust fibre installation.

Please note that the network owner may have stricter requirements than those specified in this document.

Minimum requirements within the following areas are defined in the appendix:

- Preparations
- Ducting (ducts, optical fibre chambers and outdoor splice cabinets)
- Position measurement
- Marking
- Sealing of ducts
- Routing ducts in the ground
- Backfill height
- Connection to buildings
- Routing in lakes or watercourses
- Routing on poles
- Installation at bridges
- Routing in tunnels and culverts
- Fibre optic cables
- Cable management
- Splicing
- Splicing units
- Termination
- Delivery measurement of fibres
- Labelling
- Safety

2. NETWORKS

2.1 Preparations for routing of ducts and fibre optic cables

Prior to commencing the work of routing ducts and fibre optic cables, a number of activities have to be performed.
For further information see Appendix 7 Fiber Construction Projects.

2.1.1 Plan network structure

Network structure

Before the work of planning the design of the network, a check must be carried out regarding any need for reinforcement measures for events that may deviate from the normal and that may involve serious disturbances in important societal functions.

Based on the above control, a rough design is carried out that contains the number of possible customers. A proposal is made for a network structure to cover the area, suitable installation technology, shaft lengths and the material in which the shaft takes place.

Based on the network structure in the rough design, a detailed design is made that leads to a choice of size of optical cables and the number of splice units. Then select the type of cabinet or optical fibre chambers. Then, duct pipes must be selected to suit the optical cables selected for the system. It is recommended to plan some overcapacity for both fibre and duct work.

Network structure enhanced security

For the completion of facilities with requirements for increased safety, the document Facilities with increased safety and function, Appendix 1, is used. Robust site for essential digital infrastructure and Appendix 2. Passive secure physical connection.

Appendix 1. Robust site for socially important digital infrastructure is an instruction for how the physical protection of sites should be supplemented to be able to withstand serious disruptions. The requirements include requirements for new construction and for rebuilding existing facilities.

Appendix 2. Passive secure physical connection constitutes an instruction with requirements for how the physical protection of electronic communications should be supplemented between sites and between site and user node in order to be able to withstand serious disturbances. The requirements include requirements for new construction and for rebuilding existing facilities.

For the complete versions see: https://www.ssnf.org/nat-i-varldsklass/robust-digital-infrastruktur/

Note. An existing facility must have undergone a risk and vulnerability analysis (RSA). An existing facility that is being upgraded will undergo a renewed RSA. Threat directories and RSA for Site and Node as well as Robust secure physical connection can be found under:

https://www.ssnf.org/nat-i-varldsklass/robust-digital-infrastruktur

2.1.2 Land investigation

A decisive factor in the choice of equipment and routing technique is the implementation of a visual land investigation of the planned cable section.

Before commencing the earthworks, a visual inspection of the work area is therefore conducted. The visual inspection is conducted by appointed representatives of the client and the contractor. Representatives of affected land owners should also be present. The results of the visual inspection are documented in a report, which should be supplemented with pictures of the work area.

Consultation with the Country Administrative Board and/or the local authority regarding culture and the environment is required in certain cases.
This applies in particular in locations where there may be archaeological sites, by watercourses, in the case of unsuitable land, unique vegetation, etc.

MINIMUM REQUIREMENTS, LAND INVESTIGATION

- Visual inspection prior to implementation must be conducted and reported.
- Necessary contacts in respect of culture and the environment must be made by the network owner.

2.1.3 Permits and land issues

Depending on the cable route, it is necessary to consult with and obtain permits from affected stakeholders, such as landowners and road operators. Land agreements are entered into between the network owner and affectedland owners. The network owner is responsible for obtaining land agreements. The network owner may engage another party to carry out this work, e.g., the contractor.

Different stakeholders may administer permits differently. There may be local regulations for the relevant landowner or road operator.

Example list of the requisite permits that may be required in a project.

- General land permit from the local authority regarding the right to have cables in municipal land.
- Land agreements between the network owner and the landowners/plot owners. The agreement shall include the agreed cable position and, where applicable, where the connection of the house will take place. There are different types of land agreements, such as "markupplåtelseavtal, nyttjanderättsavtal, och ledningsrätt".
- Permits/decisions to dig from municipal and/or state road owners, ("Ledningstillstånd" Swedish Transport Administration) /track owners (railway)/ landowners, describing where to place new cables, restoration requirements and the duration of the installation work.
- In some cases, the above point may need to be supplemented with a start-up permit (opening notification) with landowners/road owners e.g. a municipality or a road association/community.
- Cable location from landowner, e.g., local authority, Swedish Transport Administration or road operator. Regulates where the cable may be located.
- Co-location Agreement - Regulates the terms and conditions of co-location.
- TA plan according to the regulations of the road manager. (For the Swedish Transport Administration see Permission for the placement of telecommunication lines).
- Permission from the Swedish Transport Administration regarding the placement of telecommunication lines. The conditions for traffic and protective devices are obtained together with the decision on Permission for the placement of telecommunication lines. For further information, see the Swedish Transport Administration's publication "Ledningsarbete inom det statliga vägområdet".
- Building consents
- Permits from pole route owners.
- Consultation with the Country Administrative Board and/or the local authority regarding culture and the environment (watercourses, archaeological sites, alleys, unsuitable land, unique vegetation, cultural monuments).
- Consultation with the County Administrative Board if, outside areas with a detailed plan, buildings are to be erected, extensions made, other facilities carried out or other such measures are taken that may adversely affect traffic safety within a distance of twelve meters from a road area (Road Act 47§).

MINIMUM REQUIREMENTS, PERMITS AND AGREEMENTS:

- Necessary permits must be obtained.
- Land agreements must be drawn up between the network owner and affected landowners/plot owners. The agreement shall include the agreed cable position and, where applicable, where the connection of houses will take place.
- Land agreements between the network owner and the road operator must be drawn up. The agreement shall include the agreed cable position.
- Local regulations must be complied with.
- Cable indication queries are created in Ledningskollen (see Appendix 8 Ledningskollen) and any local procedures.

2.1.4 Cable indication query

Before commencing the work of routing ducts and fibre optic cables, a query is created in the national service Ledningskollen (see Appendix 8 Ledningskollen) and in accordance with any other local procedures. Other cable owners in the area can thereby receive information about the planned work.

Cable indication queries from affected cable owners are ordered by the contractor where necessary. This is done to minimise the risk of damaging existing cables.

2.1.5 Choice of routing technique

Applicable routing methods are determined based on the results of the land investigation and local regulations. Agreements regarding the selected routing method per section are documented in the minutes of a Construction meeting or equivalent. Information about the relevant routing method and when the method is most suitable can be found in the appendix Routing methods.

2.1.6 Self-monitoring

Located channeling is difficult to check why the contractor should carry out self-control.

MINIMUM REQUIREMENT

The contractor's quality plan must state how the contractor intends to carry out and document his own control. The inspection shall be carried out and documented per leg. Procedures for photo and self-checks must be checked with the customer before construction starts.

2.2 Ducting

Ducting refers to the components that jointly form the transfer route and protection for one or more fibre optic cables. Ducts (standard or microducts) emerge from a node, optical fibre chamber or cabinet and constitute the transfer route to the next node, optical fibre chamber, cabinet or to the end customer.

2.2.1 Ducts

Ducts in which fibre optic cables are to be laid can be divided into standard ducts and microducts. They are normally made of high-density polyethylene (HDPE). The inside of the ducts is made from low-friction, anti-static plastic in order to promote the maximum length of cable installation sections.

More robust ducts are also available, and these are used in the ground to surround standard ducts and microducts. Dimensions with an outer diameter ranging from 50 mm up to 160 mm are most common.

When selecting ducts for routing in the ground, consideration is given to the ground conditions where routing is to take place, the method with which the ducts are to be routed and that the ducts are appropriate for the technique that is to be used to install the fibre optic cable.

When selecting duct, it is important to ensure that the supplier has mechanical seals that fit the selected fibre optic cable, see also under Outdoor splice cabinets and sealing of ducts.

Ducts for direct installation in soil shall, as a rule of thumb, have a thickness of at least 1.8 mm. If the ducts are to be used for blowing or flushing in fibre optic cable, it is recommended that:

- The diameter of the fibre optic cable should not exceed 75% of the inner diameter of the ducts when blowing fibre optic cable. Follow the manufacturer's recommendation.
  The ducts can cope with the air pressure that is required to blow in a micro-cable or fibre optic cable. The air pressure when blowing in fibre optic cable is normally 8–10 bar. The ducts should therefore be specified as able to cope with 50% higher air pressure for a limited period. Prior to blowing, it is therefore necessary to check with the material supplier what is recommended as optical fibre chamber as the maximum air pressure for the relevant duct's dimensions.

MINIMUM REQUIREMENTS, DUCTS:

- Underground splice connections must be safeguarded in accordance with the manufacturer's instructions.
- The ducts must be designed for the routing of fibre optic cables and must have low internal friction.
- The type of duct must be selected according to the method being used for routing the ducts. The manufacturer's recommendations must always be followed.
- Annular rigidity and wall thickness must be of the correct dimensions for the conditions the ducts have to handle after routing. The manufacturer's specifications must be followed.
- The material manufacturer must be able to demonstrate that the ducts are ageing-resistant and specified for an anticipated service life of at least 30 years.
- The ducts must not contain environmentally hazardous materials, e.g., lead stabilisers.

- Where there is a risk of attack by pests, ducts with high resistance to attack must be selected. Alternatively, additional protection must be installed outside the existing ducts.
- The storage and handling of ducts must take place in accordance with the manufacturer's specifications in respect of UV light, temperature, environment, routing, winding, etc.
- Ducts must be spliced with a sealed splice connection according to the manufacturer's instructions.
- When jointing duct pipes, these should not have too much temperature difference to the joint to prevent creep.
- When cutting ducts, cut the ducts with tools for cutting ducts. This is to avoid degrees, cuts, etc. which in turn can lead to blow problems.

One problem that can arise is that moisture penetrates into the duct when blowing in (if there is no dehumidification), at splices, at ends or through the plastic material. If the moisture freezes to ice in the duct, the fibre optic cable can be damaged through tensile or crushing damage.

For this reason, the following requirements must also be satisfied:

- In order to minimise the risk of damage, the fibre optic cable must have sufficient strain relief and, with the exception of blown fibres and nanocables, be longitudinally watertight, for example with filler or a swelling material. If the fibre optic cable does not have this, the duct must be fully moisture protected with sealed splices.

Standard ducts for laying fibre optic cables Micro ducts for laying micro cable

Examples of ducts in various dimensions.

2.2.1.1 Standard ducts

Standard ducts are intended for routing directly in the ground, water or air.

Ducts designed for routing directly in the ground must have a material thickness that is dimensioned to cope with the pressure from the surrounding soil. This must be specified in the product description from the manufacturer of the standard duct. It is generally the case that, in the event of larger outer diameters, a greater material thickness is required in order to retain annular rigidity.

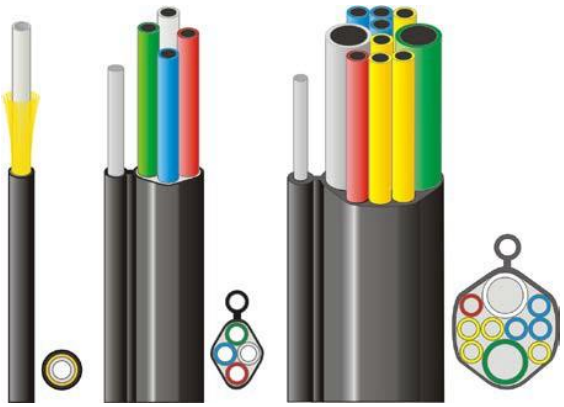
MINIMUM REQUIREMENTS

The manufacturer must state in his duct specification that the duct is dimensioned with a thickness of goods to withstand pressure from the surrounding soil.

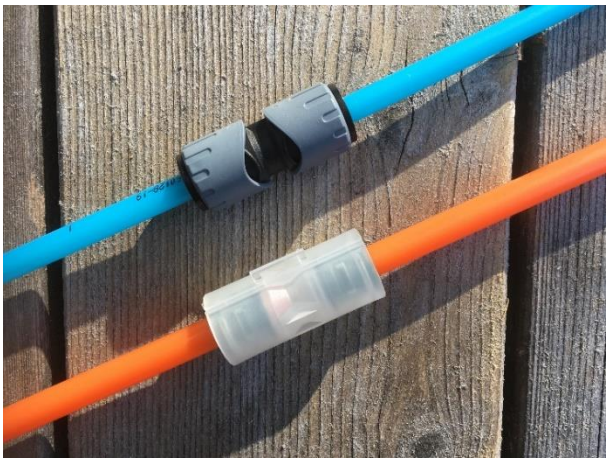
2.2.1.2 Microducts

Microducts are thin-walled ducts (sub-ducts or for indoor use) or thick-walled ducts (for direct routing in the ground, water or air). 16/12, 14/10, 12/10 (no direct routing) and 7/3.5 mm are common. Microducts are used to blow (in certain cases also to pull) micro-cables or blow fibres.

Microducts for above ground installation have in-built strain relief in the form of aramid yarn or fibreglass-reinforced plastic rods. Always use the tensioning and mounting devices recommended by the manufacturer for the microduct being installed.



Microducts for aerial installation



Examples of splicing of microducts

2.2.1.3 Labelling and identification of ducts

Labelling of ducts will aid the identification of ducts in the network. Identification is achieved through e.g., coloured, corrugated or numbered ducts in order that the ducts can be distinguished in the event they are excavated or damaged and, for example, when fibre optic cables being blown in from outdoor splice cabinets.

2.2.2 Distribution point

A distribution point is a space, a node, a manhole or a cabinet in which ducts and fibre optic cables start, branch or terminate. Examples include access nodes, cable manholes or outdoor splice cabinets.

The type of distribution point is selected on the basis of the geographic location as well

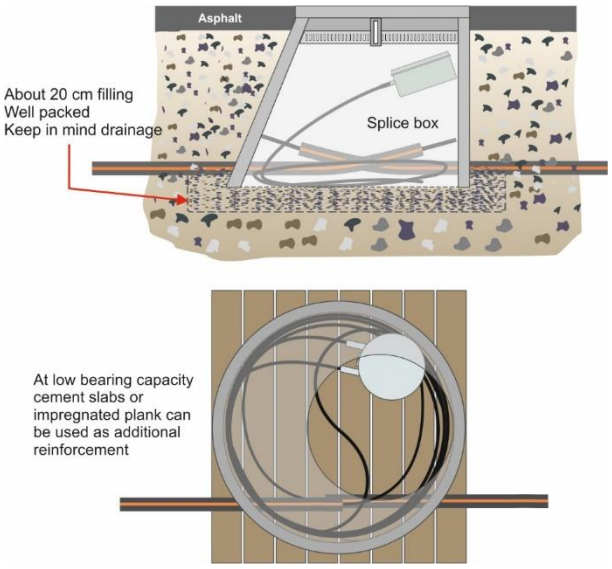
as the number of ducts, fibre optic cables and splicing units that are to be included at the distribution point.

2.2.2.1 Optical fibre chambers

An optical fibre chamber is part of the ducting.

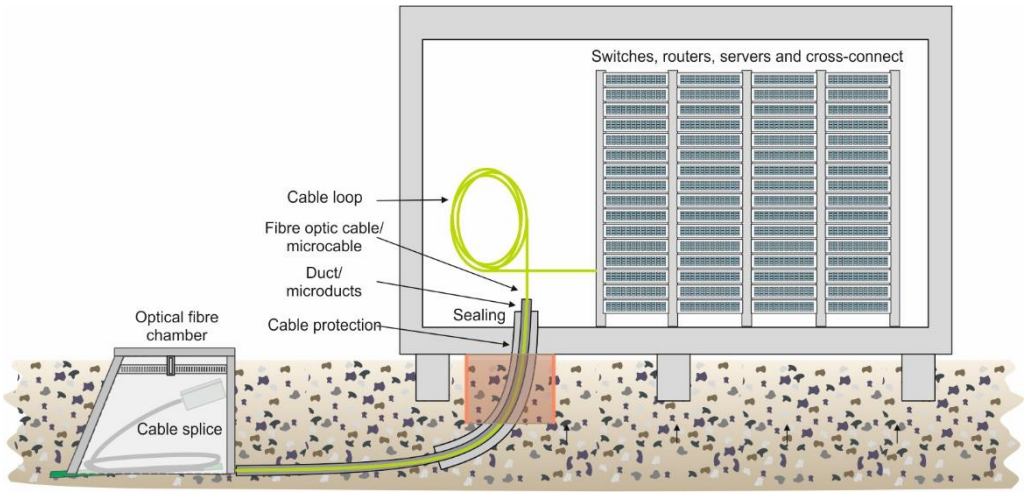
Optical fibre chambers are available in several different versions and are adapted according to where they are to be located and what they are to contain. The optical fibre chamber can be made of concrete, cast iron or plastic. Ideally select an optical fibre chamber body that is sectioned, which provides a flexible solution in terms of depth and the creation of optical fibre chambers for incoming ducts.

Optical fibre chambers are available that are intended for placing in various environments, e.g., hard surfacing (roadway, pavements) or for burying in greenfield sites. The shape of chambers can vary, e.g.,, round or square.



Examples of optical fibre chambers

Intake chambers should be located close to a node. Ducts should be interrupted there to avoid the risk of water penetrating into the node.



Example of intake fibre chamber

MINIMUM REQUIREMENTS, OPTICAL FIBRE CHAMBERS:

- The optical fibre chamber type must be designed for the environment in which it is located, e.g., roadway, pavement or buried in a greenfield site.
- Particular consideration must be given to strength. The manufacturer's regulations and recommendations must be followed.
- When choosing an optical fibre chamber, consideration must be given to the types of ducts and fibre optic cables that may be installed in the optical fibre chamber, bearing in mind minimum bend radius, type of splicing box as optical fibre chamber as the number of ducts and fibre optic cables.
- Ducts installed in the optical fibre chamber should not be bundled.
- Ducts installed in a optical fibre chamber should be pulled into the center of the optical fibre chamber to minimize the risk of the pipe creeping out. This should be done with consideration that the establishment and usability of fibre will not be impaired.
- Visible optical fibre chambers (not covered) must be locked to prevent unauthorised access.
- The contents of the optical fibre chamber must not be evident from the outside of the chamber.
- Optical fibre chambers should be positioned in such a way as to minimize the risk of water ingress and so that the required drainage can be carried out.
- Optical fibre chambers must be placed in such a way that the risk of damage during ditch cleaning is minimized.
- Optical fibre chambers placement planning should be based on site visits.
- Optical fibre chambers must be placed in agreement with the landowner. Pay special attention to the work environment regarding danger to persons during installation and service.

Recommendation

- The contractor's self-inspection should include photo documentation of the optical fibre chambers design and location.
- Placement of optical fibre chambers in trenches should be avoided.
- Placement of optical fibre chambers in trenches should be avoided.

2.2.2.2 Outdoor splice cabinet

An outdoor splice cabinet is part of the ducting.

The choice of outdoor splice cabinet is made on the basis of the number of cables and fibres as well as the number of splices that are to be handled. Then select cabinet type and the size of the outdoor splice cabinet. There must be enough space for a loop with a sufficient minimum bend radius as well as for splicing units.

Example of outdoor splice cabinet with splici

MINIMUM REQUIREMENTS, OUTDOOR SPLICE CABINET:

- The cabinet must be of class IP34 or higher.
- The cabinet be of class IK10 or equivalent.
- The cabinet must achieve corrosion class C3 for the specified service life of the ducting.
- Outdoor splice cabinets must be made of corrosion-resistant material or have a corrosion-inhibiting surface treatment.
- Outdoor splice cabinets must be locked mechanically or electromechanically.
- Outdoor splice cabinet must be adapted for simplicity of post-connection.
- Installation work in outdoor splice cabinets must be possible without affecting the function of existing installation.
- Splice unit in outdoor splice cabinets must be installed according to the manufacturer's instructions.
- Design of outdoor splice cabinets placement should be based on site visits.
- Outdoor splice cabinet must be placed in agreement with the landowner. Pay special attention to the work environment regarding danger to persons during installation and service.

Indoor cabinets do not need to be locked if the premises are locked and only authorised parties are granted access.

2.2.2.3 Moisture in outdoor splice cabinet

Moisture in outdoor splice cabinets can cause problems in terminations, splicing units, splices and cables. This can lead to operational problems and a reduced service life. Ground moisture is one of the major sources of problems.

For this reason, the following requirements must also be satisfied:

- If a cabinet has been supplied with a ground insulation plate, this must always be installed in accordance with the manufacturer's regulations. All openings between the plate and cabinet, cable and other bushings must be sealed.
- If a cabinet has been supplied without a ground insulation plate, some other ground insulation must be installed, e.g., in the form of Leca granules. For use of lecules, see section 2.3.2.2
- The sealing of ducts in outdoor splice cabinets must be performed above the ground insulation plate or other insulation and must be carried out through mechanical sealing that is appropriate for the ducts in question.
- In the event thick-walled microducts that are bundled through a plastic casing are used, the plastic casing must be cut below the ground insulation plate during installation in an outdoor splice cabinet. This is to prevent water from making its way up into the cabinet, see image below.

Example of correctly slotted casing

Example of correct sealing of duct

2.2.3 Traceability

In order to facilitate the tracing of underground ducts, position measurement must always be conducted. As a complement, a search wire should be installed together with the ducts. Warning mesh, warning net or other clear marking should be placed above the ducts to reduce the risk of damage to the cable infrastructure.

2.2.3.1 Position measurement

Position measurement means that the geographic location of the fibre installation is measured in the form of coordinates that can be displayed on a map.

MINIMUM REQUIREMENTS, POSITION MEASUREMENT:

- Measurement of the position of the fibre installation must be carried out using geodetic measurement with a DGPS (differential GPS) measuring instrument or equivalent.
- Measurement must be carried out with accuracy class 2 (≤ 0.25 metres) or even greater precision. For this reason, it may be necessary in certain cases to measure the actual position before the trench is refilled in order to ensure the quality of the measurement.
- The coordinate system that is used must be specified, e.g., WGS 84, RT 90 2.5 gon V, SWEREF 99 TM or SWEREF 99 (local zone).
- When drilling and pressing, the depth must be measured. in accordance with Annex 3.
- The fibre installation must be measured, i.e. ducts, all termination points for ducts, cabinets, optical fibre chambers and cable trays, ducts end points as well as cable fixation points.
- The position of the ends of ducts that are left in the ground for future use must be measured.
- For optical fibre chambers, cabinets and cable trays, the mid-point must be measured.
- For ducts, the start and end points, waypoints, all crossings of streets and roads as well as the location of intakes in buildings must be measured.
- Between waypoints, measurements must be performed at intervals of at least every 50 metres within built-up areas and within at least every 100 metres outside of built-up areas.
- Turns/bends/curves must be measured at intervals of 5–10 metres depending on the radius or the distance that is appropriate for the specific point.

Recommendation for position measurement:

- For standard ducts, it is recommended that all splices be measured.

2.2.3.2 Marking

Marking refers to the placing of clear marking above the ducts when routing in the ground.

MINIMUM REQUIREMENTS, CABLE MARKING IN THE GROUND

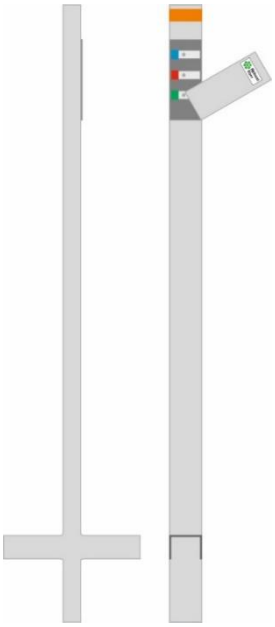
- Warning mesh or warning net with green alternatively orange colour should be placed above ducts* to reduce the risk of damage to the cable infrastructure.
- The warning must be centred, approximately 10 cm above the ducts.
- The warning must be made of a material that is ageing-resistant in the ground, and must have good handling properties, even at low temperatures.
- The colour of the warning must be clear.

* Note: Excluded for pressed or controlled drilling when laying ducts under roads, watercourses, etc.…

In order to simplify traceability search wire should be used. Alternatively, a separate search wire can be routed above or below the ducts.

MINIMUM REQUIREMENTS IF SEARCH WIRE IS USED:

- The search wire must be made of acid-resistant, stainless-steel wire.
- The search wire must be accessible (at screw or similar) in nodes, optical fibre chambers, cabinets or cable fixation points.
- The search wire must be insulated from earth in order not to short-circuit the cable locator's signal.
- Each sub-section with search wire must not exceed 1,000 metres, as cable locators can normally only manage 500–700 metres.
- The search wire's sub-section may not exceed 500 m when crossing electricity lines greater than 130 kV or in the case of extended distances parallel with and closer than 150 m to an electricity line greater than 130 kV.
- The search wire must be spliced in accordance with the supplier's regulations using tools and splicing accessories designated for this purpose.
- When crossing (drilling/pressing) roads where the fibre optic cable is routed in ducts, the search wire must be included in the duct.
- Search wire must generally not be inside a protective duct except in the case of pressing and drilling, when it is placed in the duct.



Cable fixation points for accessing search wire

Recommendation

If there is more than one KUP, or several search wires not connected to KUP at the point of spread, marking is recommended with which distance the search wire(s) follow.

Another way of marking buried ducts is to use search balls or search pegs.

These are entirely passive and require no energy, and so they have an extremely long service life. The search field around the ball or peg has a radius of approx. 1.5 m.

This means that it is extremely practical to place search balls in covered optical fibre chambers and at buried duct ends. A special search instrument is used to locate a search ball or search peg. These are available for various purposes and work at various frequencies in order to distinguish different infrastructure.

Colour	Frequency	Area of application
red	169.8 kHz	electricity
blue	145.7 kHz	water
green	121.6 kHz	drain
orange	101.4 kHz	telecommunications
yellow	83 kHz	gas
black and red	77 kHz	cable TV
lilac	66.35 kHz	often used by private users

Examples of search balls and search pegs

2.3 Routing

Ducts and fibre optic cables are normally routed in the ground, although there are several alternatives, see below.

The duct is routed such that the risk of attack by pests is minimised, for example through additional rodent protection and end sealing of ducts.

2.3.1 Sealing of ducts

MINIMUM REQUIREMENTS FOR SEALING OF DUCTS:

- Ducts must be sealed so that dirt and water cannot penetrate into the ducts. This applies to all end points where new or existing ducts are used.
- The seals must be able to cope with a water column of at least 5 m (0,5 bar).
- The duct ends in any sub-ducts (ducting arranged within an existing duct) must be properly sealed during and after installation.

2.3.2 Underground routing

The basic purpose of burying ducts is that the fibre installation is then protected in the safest way. This means that the fibre installation is as robust as possible.

For underground routing, there are a number of methods that are suitable to differing degrees depending on ground conditions, local regulations, etc. More detailed information about methods and when they are appropriate to use can be found in the appendix "Routing methods".

The planned routing method is adapted if necessary to the actual conditions in conjunction with implementation in order e.g., to achieve more efficient routing or meet the requirements regarding backfill height.

It is important to comply with local regulations regarding backfill height, methods, distance to existing ducts, etc.

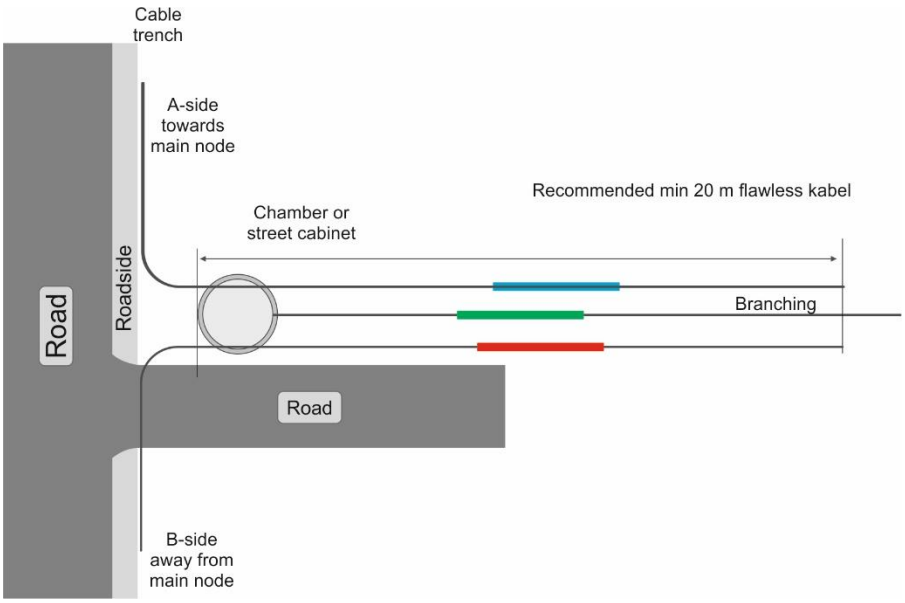
MINIMUM REQUIREMENTS FOR UNDERGROUND ROUTING:

- The projected placement method must be adapted to real conditions.
- When routing in the ground, ducts must be laid flat.
- Asphalt must not be laid on top of optical fibre chambers.
- In snowy areas or in the case of dense vegetation, outdoor splice cabinets must be supplied with a marker rod to avoid collision damage and to make the cabinets easier to find.
- Outdoor splice cabinets must be labelled in accordance with the client's instructions.
- Labelling must take place in such a way that the contents are not disclosed.
- Ducts may not be spliced in curves or bends.
- Avoid placing optical fibre chambers in dips due to the risk of water penetration.
- When pressing through a railway bank, the Swedish Transport Administration's instructions must be followed.
- Before excavation in farmland a reconciliation with the landowner regarding existing drainage must be carried out
- When laying in farmland that is used with machines that risk getting close to the depth at which the canalisation is to be laid, it is recommended that a deeper laying is considered

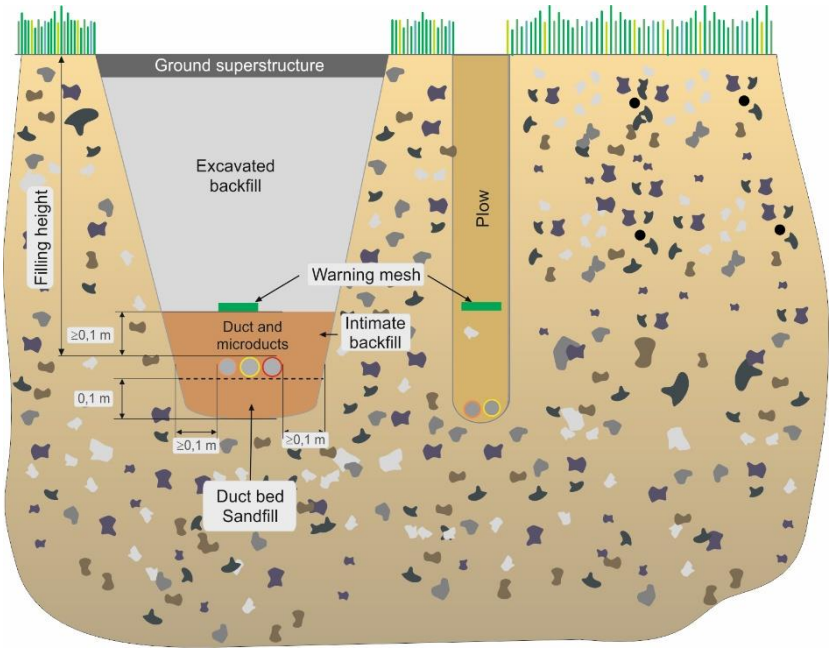
- Any excavated drainage pipes must be photo-documented before and after repair and notified to the landowner during post-inspection.
- When laying in the vicinity of free-hanging power lines and when crossing another line owner's infrastructure, check the line owner's requirements for minimum distances.

Recommendations for underground routing:

- Placing optical fibre chambers in roadways, bus stops or car parks should be avoided as far as possible, as special requirements apply regarding strength and permits are required from road operators.
  Such locations are also unsuitable from a maintenance or a working environment perspective.
- Locating outdoor splice cabinets by road intersections, by snow deposits and in positions where visibility is obscured for road users and residents should be avoided. Consideration must also be given to the work environment of those who will be working at the cabinet. Position the cabinet in a well protected location in order to minimise the risk of e.g., damage, collision damage or injuries caused by snow and brushwood clearance vehicles.
- The duct must be routed at such an incline that water cannot accumulate in the duct.
- Avoid routing ducts over tree root systems. There is a considerable risk of damage if the tree falls over.
- To avoid mistakes when splicing in optical fibre chambers and ground cabinets and to help with troubleshooting, cable from the A-side to the splice unit should be marked with blue tape, cable from the splice unit to the B-side should be marked with red tape and cable from the branch should be marked with green tape.



Examples of marking cables in optical fibre chambers and cabinets



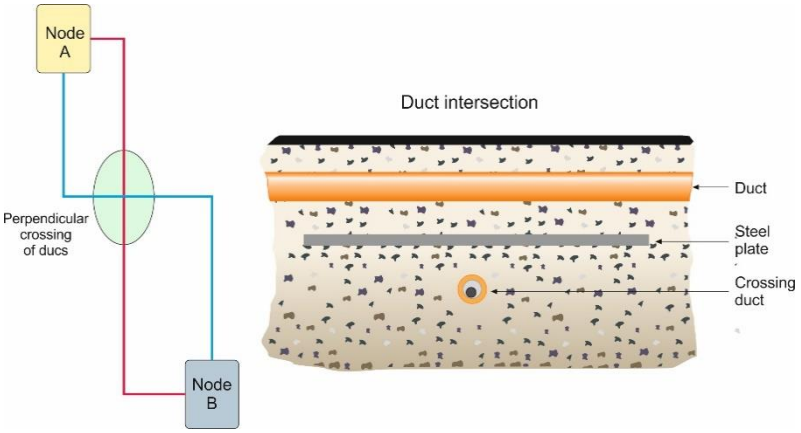
Examples of excavations

During underground routing, it is important to bear in mind that ducts are affected by changes in temperature. This is particularly important when routing over extended distances in warm weather and direct sunlight. Warm ducts can contract when they are placed in cooler ground and covered. You are recommended to leave splices and ends uncovered until the ducts have been adapted to the ambient temperature. Always comply with the manufacturer's recommendations regarding the handling of ducts.

Redundancy is used to minimise the risk of interruptions if a transfer route is damaged. Connections that are supplied with redundancy have two or more transfer routes. Particular requirements then apply in order to keep the various transfer routes separate from each other within the fibre installation.

MINIMUM REQUIREMENTS AT DUCTING INTERSECTIONS IN ORDER TO SATISFY THE DEMANDS FOR REDUNDANCY:

- Ducting intersections must be arranged at a 90° angle.
- One metre before and after the intersection, special mechanical protection must be arranged if the distance between the ducts is less than 2 metres (e.g., vertically). Special mechanical protection means some form of excavation-safe protection, e.g., a 10 mm thick steel plate or equivalent.



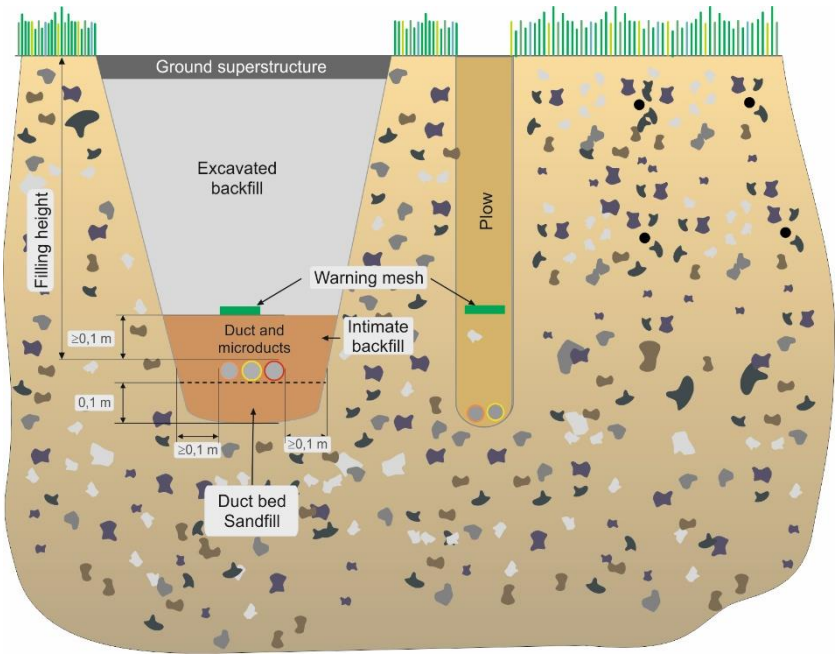
Example of intersecting ducts

2.3.2.1 Bed in ducts

Depending on the routing method, there is a requirement for backfilling and duct bedding.

MINIMUM REQUIREMENTS FOR SELECTED SANDFILL AND DUCT BEDDING:

- Duct bedding and Selected Sandfill must comprise filler material in accordance with section 2.3.2.6.
- Measures must be taken so that backfill and duct bedding remain intact.
- When routing several ducts at the same time, there must be backfill around the entire ducts, such that there are no air pockets between them.



Examples of duct bedding and backfill

Incorrectly conducted backfilling entails a risk of the ducts being pressed together when the refill material is compressed.

In order to maintain the distance between the ducts during compression, spacers are also recommended for the ducts.

Example of spacers for ducts

2.3.2.2 Positioning of optical fibre chambers and cabinets

The following applies when positioning optical fibre chambers and outdoor splice cabinets.

MINIMUM REQUIREMENTS WHEN POSITIONING OPTICAL FIBRE CHAMBERS:

- The bottom section must be positioned on a bed with well-functioning drainage capacity. The grain size of the material must be adapted to the current soil condition. The bed must be well compacted and levelled off and must be at least 200 mm thick. Consideration must be given to any differences in level at the surface when creating the bed. Any need for a ground cloth should be considered.
- Instructions from the supplier must be complied with when positioning optical fibre chamber.

Recommendations when positioning optical fibre chambers:

- If the ground/surface has a low bearing capacity, impregnated planks or cement slabs should be placed below the chamber body in order to reduce ground pressure.
- In order to keep the inside of the chamber cleaner and to increase the bearing capacity, non-woven fabric can also be placed beneath the bed.

MINIMUM REQUIREMENTS WHEN POSITIONING OUTDOOR GROUND CABINETS:

- Outdoor ground cabinets must be positioned on a bed similar to that used for optical fibre chambers.
- Instructions from the supplier must be followed when installing ground cabinets.
- Outdoor ground cabinets should be positioned so that the marking on the outside of the cabinet is at ground level.
- Cabinets must be ground-sealed with ground insulation board and approved sealant or alternatively leca balls.
- If the outdoor ground cabinet is to have ground insulation board, you must fill up with lots up to ground level marking on the inside.
- Outdoor ground cabinets must, considering any risk of danger to persons during installation and servicing, be installed with the cabinet opening facing the street/road.
- The top layer of the ground around the cabinet must be the same as the existing ground surface so that it blends into the environment.
- Backfilling must be performed using "Selected Sandfill", medium gravel.
- Backfilling around the cable cabinet must not contain sharp stones or stones larger than 50mm.

- If the ground conditions are such that there is a risk of the foundations/cabinet becoming unstable, the installation must be reinforced with concrete slabs or impregnated planks.

Recommendation

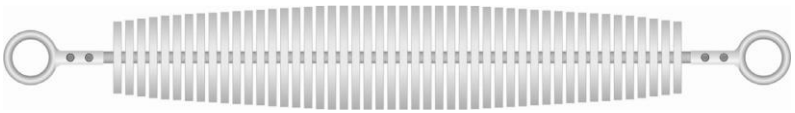
If the cabinet is to be filled with leca balls, it should, if possible, be at least 35 cm leca balls and the filling should be finished above ground level.

2.3.2.3 Gauging

One way of checking that the ducts has not been damaged in conjunction with routing is to conduct gauging. An item (a gauge) with a diameter that is slightly smaller than the inner diameter of the duct is pulled or blown through. Gauging should be performed using a gauge of a certain length, not with a gauge in the form of a ball. A ball can easily pass through sections in the ducts that are subsequently impossible for a cable to get through.

Recommendations when performing gauging:

- The diameter of the gauge should be approx. 20% less than the inner diameter of the duct.
- The gauge should be in the shape of a duct with cones at either end. Each end should comprise an eyelet for attaching a line.



Example of gauge

2.3.2.4 Frost thawing

Before conducting frost thawing, it is important to check what local regulations exist regarding methods for thawing frost.

Ducts and fibre optic cables are sensitive to high heat. It is therefore necessary to always check with the relevant manufacturer before performing frost thawing.

If another cable owner is to perform frost thawing for a cable located deeper than the fibre installation, it is important to point out that ducts and fibre optic cables are sensitive to high temperatures. This is particularly important where the fibre optic cable is routed with little backfill height, e.g., in the case of microtrenching.

2.3.2.5 Collocation

Collocation means that ducts and cables that are owned by several network owners are routed in the same trench. Agreement regarding terms and conditions for collocation is reached between the parties on a case-by-case basis.

The requirements regarding collocation must be at least in accordance with "*Instructions for Robust Fiber*". It is important to consider different colour marking in the event of collocation.

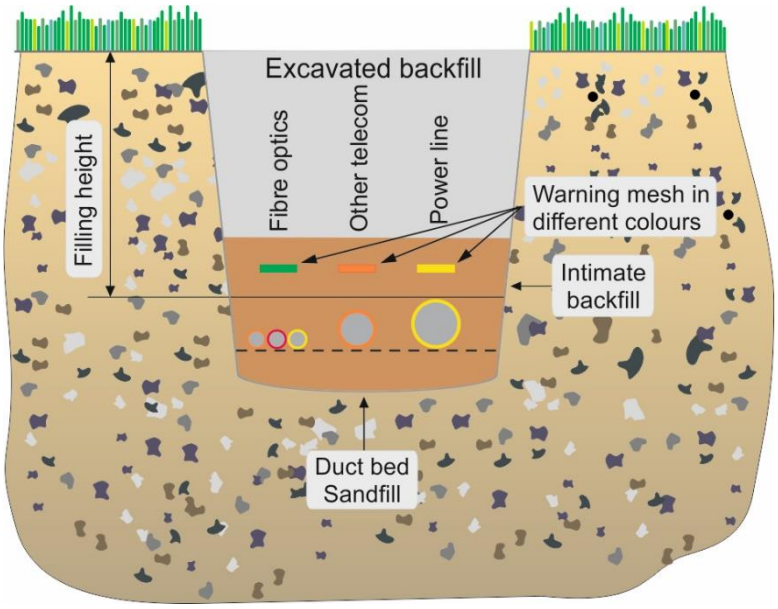
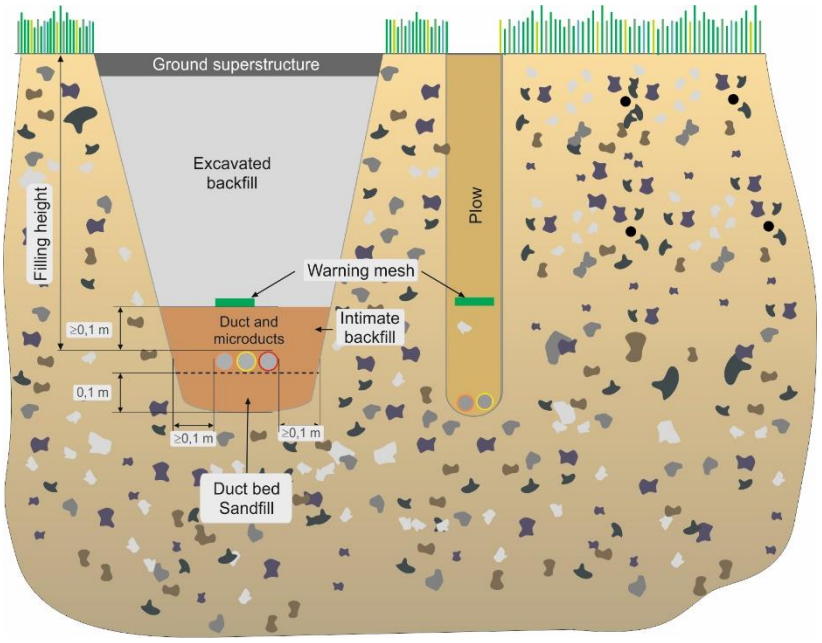


Image of Collocation

2.3.2.6 Backfill masses

Backfill masses for shafts when laying ducts include backfill masses for pipe beds, backfill, remaining backfill and ground superstructure as shown below.



Sandfill

MINIMUM REQUIREMENTS FOR FILLING MASSES

- **Backfill surrounding**
  Backfill surrounding shall be at least 0.1 m thick at the side, and over ducts calculated from the top edge of the coarsest pipe.
  Backfill surranding shall consist of unbroken or crushed material with 0–8 mm grain size.

- **Existing masses at the bottom of the shaft**
  Existing masses in the trench bottom must correspond to the requirement for backfill surranding.

- **Backfilling when existing masses at the bottom of the shaft do not meet the requirement for backfilling.**
  A duct bed with backfilling material, and with a thickness of 0.1 m, calculated from the base of the shaft to the bottom of the lowest ducting pipe, shall be laid under the ducting pipe.

- **Ground superstructure**
  A fill 0.15–0.2 m is laid at the top of the shaft (0.15–0.2 m) to correspond to existing masses in the rest of the ground.

- **Remaining filling**
  For the remaining filling of the shaft, filling mass is used which closest to the duct / cable protection does not contain stones with sharp edges and where a maximum of 10 % consists of the grain size of 100–150 mm.

- **When normal filling height cannot be achieved due to obstacles, such as rock, stone or the like, the following measures must be taken.**
  - Filling material closest to the protective duct may have a maximum grain size of 20 mm.
  - Type, lowest class SRS * if the filling height> 0.25 m.
  - Type, minimum class SRE * if the filling height <0.25 m. In the case of open installation, the manufacturer's instructions must be followed.

  * Duct /pipe class EBR: SRS / Protection / Pipes / Difficult conditions)
  * Duct / pipe class EBR: SRE (Protection / Pipe / Extra strong)

Note. For in-depth information on fillers, see AMA facility.

2.3.3 Minimum backfil height

Backfill height is the distance between the upper edge of the buried duct and the finished ground level. General requirements regarding minimum backfill height can be seen from the table below.

Other requirements and regulations may be determined by road operators and landowners regarding routing and the placement of cables in e.g., urban areas, by major roads and in farmland.

Local rules and regulations must always be followed.

2.3.3.1 General requirements regarding minimum backfill height:

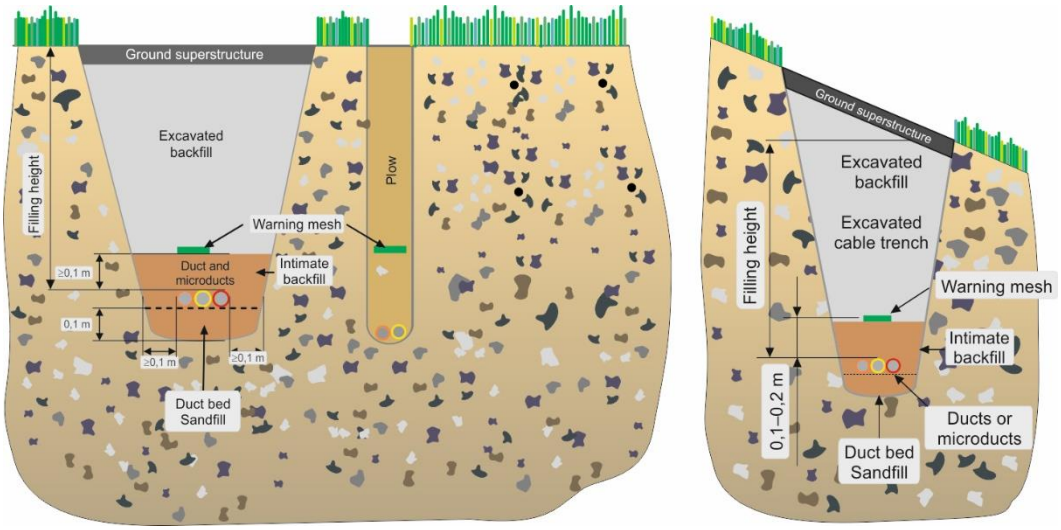
Minimums backfill height requirements

- When pressing through a road or railway embankment, the road operator's and the Swedish Transport Administration's regulations must be followed.
- For minimum backfill height requirements, see Table Backfill Height below.

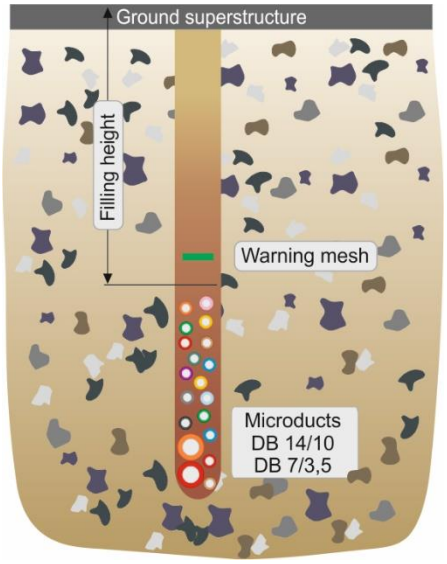
At intersections with other lines, fibre optic cables are normally routed above power cables, water and sewage ducts as well as district heating. Additional protection around the ducts may be required. A risk analysis is recommended to ensure that the correct measures are implemented.

Surface	Backfill height	Method	Information
Building land adjacent to residential buildings	30 cm	All	
Roadway and pedestrian/cycle path	25 cm	Microtrenching End milling	An additional 10 cm in the case of non-paved surface (gravel road).
Pedestrian/cycle path	30 cm	All	
Crossing of minor road	70 cm	All	Smaller roads such as farm, field or forest road.
Roadway	45 cm	All	
Crossing of ditch	55 cm	All	Calculated from a properly cleared ditch bottom.
Greenfield sites (not farmland)	45 cm	All	
Green spaces outside of building land	45 cm	All	
Farmland	75 cm	All	Consideration must be given to any drainage

Table, Backfill height



Examples of backfill heights



Shows backfill height during microtrenching

2.3.4 The location of the intake of the duct in a building

A house refers to a villa or terraced house as an individual dwelling. For the connection of apartment buildings, residential, commercial premises, office premises see recommendation "Robusta fastighetsnät".

The position of the intake of the duct in a house is determined by the network owner in consultation with the house owner.

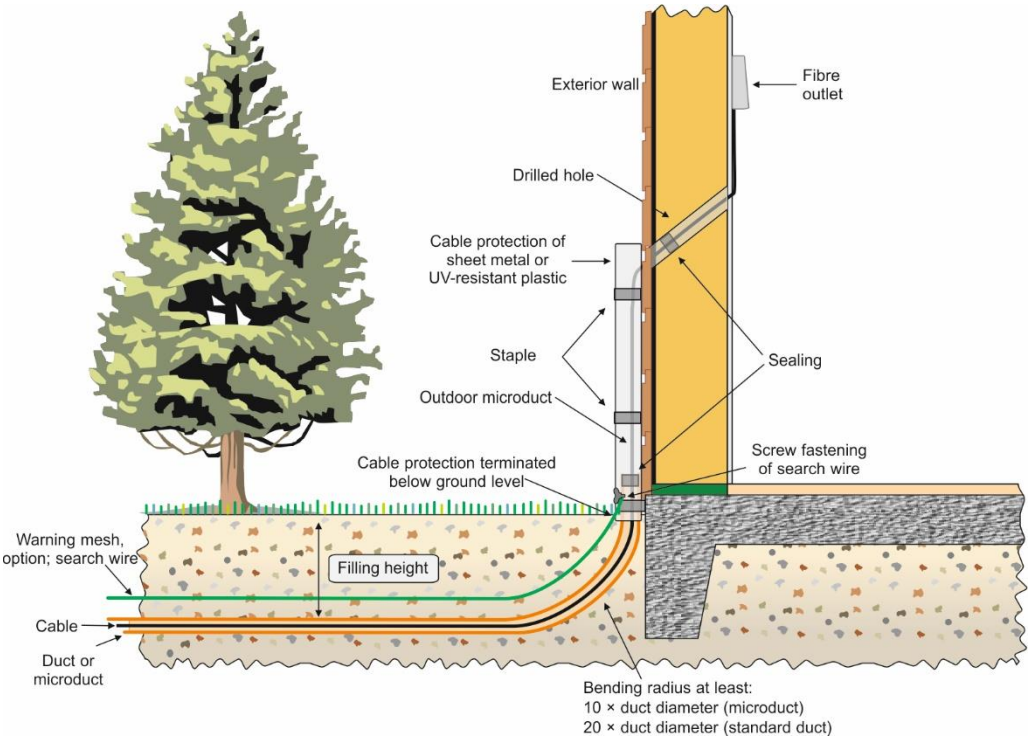
The minimum requirements for connecting a house are presented in the following points.

2.3.4.1 Intake of duct above ground level in property

Intake of ducts above ground level shall be determined by the network owner in consultation with the house owner.
The basis for decisions is the network owners risk assessment and local regulations.

MINIMUM REQUIREMENTS REGARDING INTAKE OF DUCTS ABOVE GROUND LEVEL:

- The bend radius of standard ducts must be at least 20 times the duct's outer diameter, while the bend radius of microducts must be at least 10 times the duct's outer diameter. If not, drawing the fibre optic cable through the duct is rendered more difficult or, in the worst-case scenario, impossible.
- At building foundations, the duct must terminate at least 10 cm above ground level.
- For the cable insertion into the house, a hole must be drilled at an incline of at least 30°, with the highest point inside the house.
- Ducts must be sealed against the hole through the housewall. The space around the duct must therefore be sufficiently large to provide space for a sufficient amount of sealing compound or a mechanical seal.
- Sealing must be performed as close to the inner wall and outer wall as possible.
- The ends of ducts must be sealed until the fibre optic cable is routed to prevent dirt or similar penetrating. Ducts must also be sealed after fibre installation.
- Ducts must be sealed against the fibre optic cable in the fibre outlet to prevent water leaking in from the duct.
- Cable protection that can cope with an outdoor environment must be used to cover visible duct on house walls.
- Marking tapes should be put forward to house life.
- If search wire is used, it must be professionally attached and accessible according to the requirements of the network owner with maintaining insulation.
- Any search wire must be terminated at a screw or cable protection at the house shell.
- UV-sensetiv duct pipes must have mechanical protection (e.g., sheet metal chute) that cover the duct pipe so that the pipe is protected against both mechanical damage and UV light along its entire lenght.
- In the case of overhead cables, connections must be made in accordance with the manufacturer's instructions.



Example of intake into building

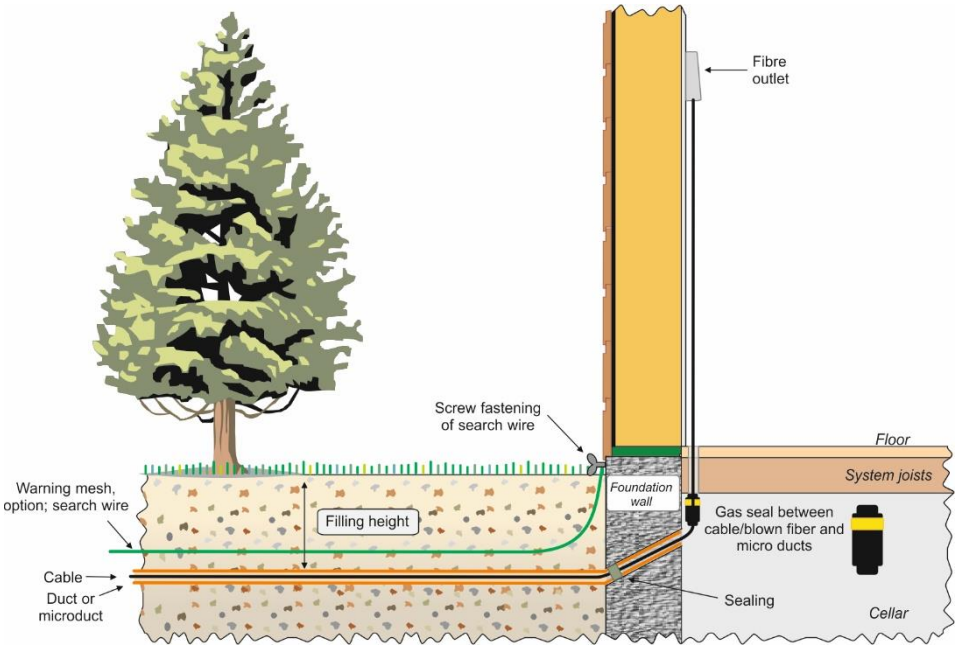
2.3.4.2 Intake of duct below ground level

Intake of ducts below ground level shall be determined by the network owner in consultation with the house owner.

The basis for decisions is the network owners risk assessment and local regulations.

MINIMUM REQUIREMENTS REGARDING INTAKE OF DUCT BELOW GROUND LEVEL:

- The cable trench must be dug up to the building shell with a backfill height of at least 30 cm above the duct.
- A hole must be drilled into the house at an incline of at least 30°, with the highest point inside the property. If the hole is drilled through the foundation's existing drainage protection, the protection must not be impaired, rather it must be reinstated.
- The duct must be sealed against the hole through the building foundations. The space around the duct must therefore be sufficiently large to provide space for a sufficient amount of sealing compound or a mechanical seal.
- The ends of ducts must be sealed until the fibre optic cable is routed to prevent dirt or similar penetrating. Ducts must also be sealed after fibre installation.
- If search wire is used, it must be professionally attached and accessible according to the requirements of the network owner with maintaining insulation.
- Warning mesh must be placed up to the building shell.
- Any search wire must be terminated at a screw at the building shell.
- If the property has ground cover such as Isodrän or Platon membrane, the manufacturer's recommendations regarding sealing must be followed.



Example of intake into building

2.3.5 Routing in lakes and watercourses

Before starting routing in lakes or watercourses, it is important to conduct a thorough check of the section in question in order to ensure that the section is suitable with regard to bottom conditions, maritime traffic, etc. It is also common to employ pressing or directional drilling when routing below watercourses. Below is a description of minimum requirements when routing along the bottom.

MINIMUM REQUIREMENTS WHEN ROUTING IN LAKES AND WATERCOURSES:

- When routing fibre optic cable in lakes or large watercourses, it is necessary to obtain the consent of the County Administrative Board. In certain cases, an environmental impact plan must also be drawn up.
- Contact must be made with the responsible authorities for the pilotage traffic area to discuss the need for cable marking and signs. The network owner is the sign manager and is responsible for erecting and maintaining the signs.
- Contact must also be made with the responsible authorities for the maritime traffic area in order to discuss the need for landmarking and information for the updating of nautical charts, both after laying and after removal/decommissioning. Requirements for position indication and delivery of digital data must also be established.
- When routing fibre optic cable (underwater cable) or ducts in water, it is necessary to use a design approved for the purpose for placing in water in respect of water depth, the nature of the bottom, future dredging, etc. You must therefore always consult with the cable manufacturer.
- If ducts are intended for water in watercourses, fibre optic cables need not be adapted to water more than the requirements for long-waterproof optocables for ground.
- On lake bottoms where there may be wrecks, rocks or similar, a bottom survey must be conducted to ensure that the cable/duct is routed outside of the risk area.
- When routing underwater cables, the cable must be secured from any tensile forces e.g. by making several turns/loops around a concrete filled drum/ring or similar at both landing points
- When routing underwater cables, a loop must be located at both land attachments, ideally around the outside of a cement ring or equivalent, which then also has an anchoring function.
- After routing, the duct/underwater cable must follow the bottom contours and be securely anchored.
- Duct/underwater cables must be routed at the authorised distance from all types of buoys and beacons.
- When crossing other ducts, such as water and sewage ducts, the duct/underwater cable must be routed under these.
  If this is to difficult to implement, an alternative solution crossing agreement shall be drawn up with the relevant cable owner(s).

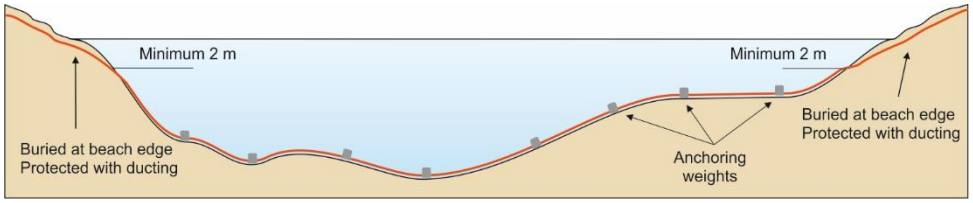
Recommendations when routing in lakes and watercourses:

- If there is an obvious risk of damage to cables (e.g., harbour entrances, harbour basins, etc.), an application for an anchoring ban may be considered.
- In navigable channels and in the event of rocky bottom conditions, divers should be used in conjunction with routing to lay the cable properly and, if possible, to secure it.
- When routing cables in lakes, additional duct is not normally required when using an underwater cable. Under certain circumstances, ducts may also be a suitable alternative when routing in a lake. The duct is anchored to the bottom or routed in the lake bed. The duct is normally anchored with weights where there is a risk of it floating up to the surface. The cable can then be flushed into the duct.

- When routing lightly armoured underwater cable, the cable should be anchored to the bottom bearing in mind the cable's low specific weight.
- In order to facilitate marking out, the duct should be routed in a straight line between the duct's land attachments.
- When crossing a specifically marked navigable channel or in heavily trafficked channels, crossing should take place at right angles to the channel's or the maritime traffic's main direction.
- When crossing smaller watercourses, such as large ditches or streams, re-splicing to maritime cable is not normally required if the cable is routed in a duct intended for underwater routing.
- When crossing larger watercourses, such as rivers or canals where the water is often so deep that normal excavation cannot be performed, the cable is routed in the same way as when routing in lakes.

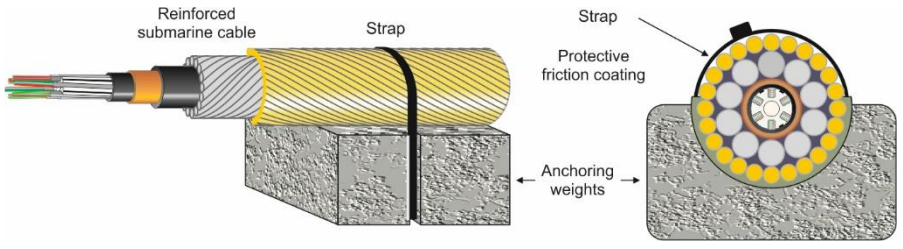
Example of routing with duct in water:

Ducts are routed on the bottom by anchoring them with weights. The weight of the weights is dimensioned according to the diameter of the ducts and with regard to the prevailing water conditions. The weight of the weights and the interval between them must be set out in the planning documentation. Ducts may need to be protected against external effects from e.g., bottom conditions by means of suitable Selected Sandfill, which must be set out in the planning documentation.



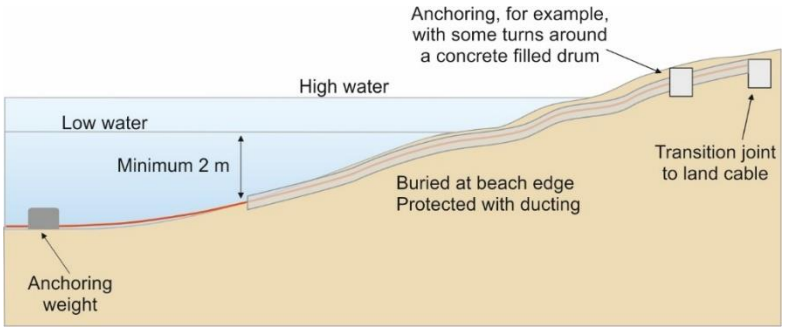
Example showing how a duct is routed on the bottom with the aid of weights

The duct is placed on a weight with a protective friction lining, and then secured with cable ties.



Example showing how a cable can be secured to a weight. The same principle applies to ducts.

From the land, the duct must be pressed or drilled out into the lake or excavated down where this is possible. The duct is routed at a recommended depth of approx. 2 metres below the low water level. This is to ensure that the duct is not affected by ice formation.



Example showing the routing of a duct 2 m below low water level

2.3.5.1 Extremely fast-flowing water

In extremely fast-flowing water, it is particularly important to select the correct weights to secure the duct to the bottom.

2.3.5.2 Checking routing in lakes or watercourses with regulated maritime traffic in accordance with the regulations of the Maritime Administration.

During or after routing, the duct must be checked by divers. During checking, particular attention must be paid to how the duct is anchored, sufficient routing at the banks, protection and sufficient space between weights. A report of the inspection must be prepared and documented.

MINIMUM REQUIREMENTS WHEN CHECKING ROUTING IN LAKES AND WATERCOURSES WITH REGULATED MARITIME TRANSPORT:

- Ducts or cables must be inspected by divers.
- A report of the inspection must be prepared.

2.3.6 Routing on poles

From a robustness perspective, routing on poles should be avoided.

When using a pole route, it is necessary to ensure that the pole route's cable corridor is cleared of trees and branches to minimise the risk of damage to the fibre optic cable.

If a pole route is being used for ducts, routing can take place in several different ways.

- Installation on separate poles (separate pole route).
- Joint construction with an electricity grid owner's pole routes for low and medium voltage.
- Utilise phase or earth wire in power line poles through joint construction with an electricity grid owner.
- Joint construction with a telecommunications operator's poles.
- Joint construction with the Swedish Transport Administration or other railway companies' poles.

MINIMUM REQUIREMENTS FOR ROUTING ON POLES:

- Ensure that the owner of the pole route has procedures for clearing the cable corridor to prevent damage
  from trees and branches.
- Guys must be present to counteract lateral forces in the event of branching or bends.

2.3.6.1 Joint construction

In the event of joint construction with another owner of poles, it is necessary for responsibility issues, demarcations and maintenance measures to be clarified and documented in an agreement between the owners.

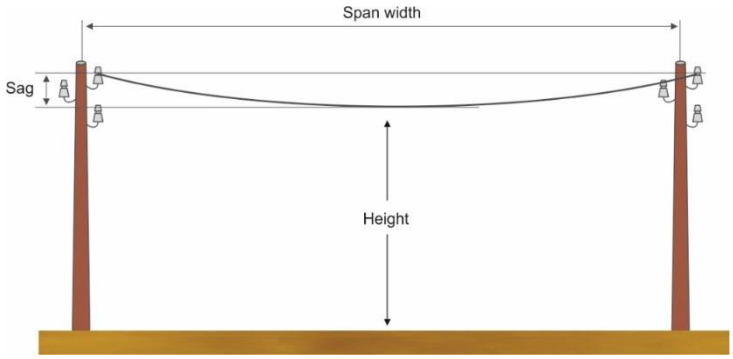
Consult with the relevant party in the event of joint construction to obtain information about which rules and regulations apply. It must be clear from the agreement who owns, maintains and is responsible for inspection, as well as the terms and conditions in the event of any transfer. There must also be a reference to the applicable safety requirements. Particular attention must be paid to authorisation for service and maintenance personnel.

MINIMUM REQUIREMENTS IN THE EVENT OF JOINT CONSTRUCTION:

- Agreements with the pole owner must be established.
- The pole owner's recommendation for Co-building / Co-location must be used.

2.3.6.2 Height above ground of overhead cables

The distance between cable and ground applies at maximum load and must be calculated from the surface of any snow cover.



Example of overhead cable

Requirements regarding height above ground of overhead cables:

- The minimum height above ground or vater of overhead cables must not be less than 3.5 metres. From the final pole to the building, however, the height may be less.
- In the case of land where vehicles may pass, such as arable land, agricultural land or park environment, the minimum height above ground must be 5 m. Consultation must be held with landowners before installation is carried out.
- The minimum height of the overhead cables over a public road or other area with passing traffic, the installation must be carried out in accordance with the Swedish Transport

Administration's instructions for management work within the road area or other road maintenance instructions. Responsible road maintenance requirements always apply before Robust fiber's instructions if the requirement is higher.

- When suspending an optical cable, EBR K30: 04 regarding co-assembly of optical fibre cable must be followed.
- An overhead line over an area with maritime traffic must be installed at a minimum height above normal high-water surface that the Swedish Maritime Administration or another authority prescribes as a sail-free height.
- When an overhead line crosses an electrified railway, it must be located at the height and in accordance with the instructions determined by the Swedish Electrical Safety Agency after consultation with the railway owner.
- When overhead line installation, the cable manufacturer's instructions on mounting accessories and installation methods must be followed.

MINIMUM REQUIREMENTS REGARDING INSPECTION OF OVERHEAD CABLE

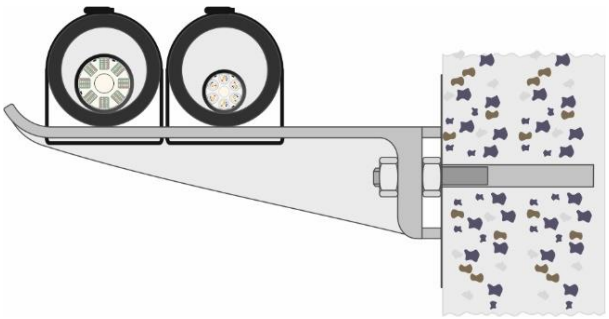
- Inspections are performed in accordance with the pole owner's and the supplier's instructions.

2.3.7 Installation at bridges

The location of ducts on bridges is determined by the road operator/bridge owner in consultation with the contractor.

MINIMUM REQUIREMENTS REGARDING FOR BRIDGE LAYING:

- The ducts must be securely attached and well protected.
- There must be a cable loop on at least one side of the bridge. Singel customer cables usually do not need to be looped.



Example of anchoring on a bridge

2.3.8 Routing in tunnels and culverts

When routing in a tunnel, ducting in the form of ducts is not needed.

MINIMUM REQUIREMENTS FOR ROUTING IN A TUNNEL:

- Material that is used must be classified for indoor use.
- Fibre optic cables or ducts must be placed on a cable ladder or clamped to the tunnel wall alternative, fibre optic cables and ducts can be installed with a catenary or wire span.
- . Fibre optic cables or ducts must be secured with e.g., cable ties, in which case at least every third cable tie must be made of metal to prevent the cable falling down in the event of a fire.
- If there is a risk of unauthorised entry, vandalism or pests, armoured fibre optic cables or ducts must be used.

Routing in tunnel

2.4 Fibre optic cables

2.4.1 Fibre optic cables, general

For cable designs and the choice of cable, you should generally refer to material suppliers. There are a few different fibre optic cable designs:

- Ribbon cable – the fibres are joined together in ribbon structures (4 or 8 fibres), making it possible to splice (weld) all the fibres at the same time. The ribbon is then placed in a plastic groove profile.
- Cables built up with tubes, where the fibres are protected in filled tubes located around a strain relief device.
- Cables with a central filled tube with fibres with or without external strain relief.
- Micro-cables are built up in a similar way to fibre optic cables, but with a more slender structure.
- Blow fibres are 1–12 fibres bundled with minimal external protection in the form of a sheath. If blow fibres are routed outdoors, only ducts intended for blow fibres may be used.

There are several standards for the colour coding of fibres in fibre optic cable. It is important to decide on a colour code and to use the same colour code throughout the fibre installation.

Colour code S12 is recommended for all fibre optic cables.

MINIMUM REQUIREMENTS REGARDING FIBRE OPTIC CABLES:

- Fibre optic cables must have single-mode fibres and must conform to the standard according to ITU-T G.652 or G.657.
- The fibre optic cable's strain relief must be adapted to the installation methods and the splicing units that are used in the fibre installation.

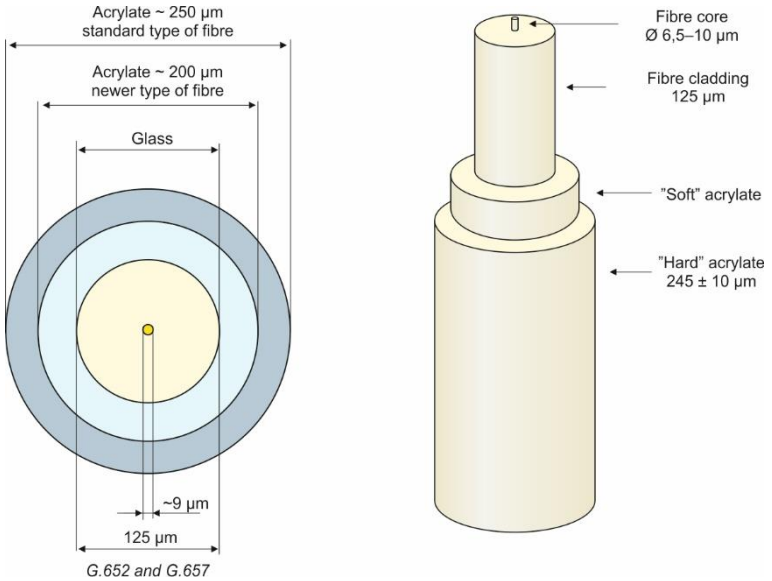
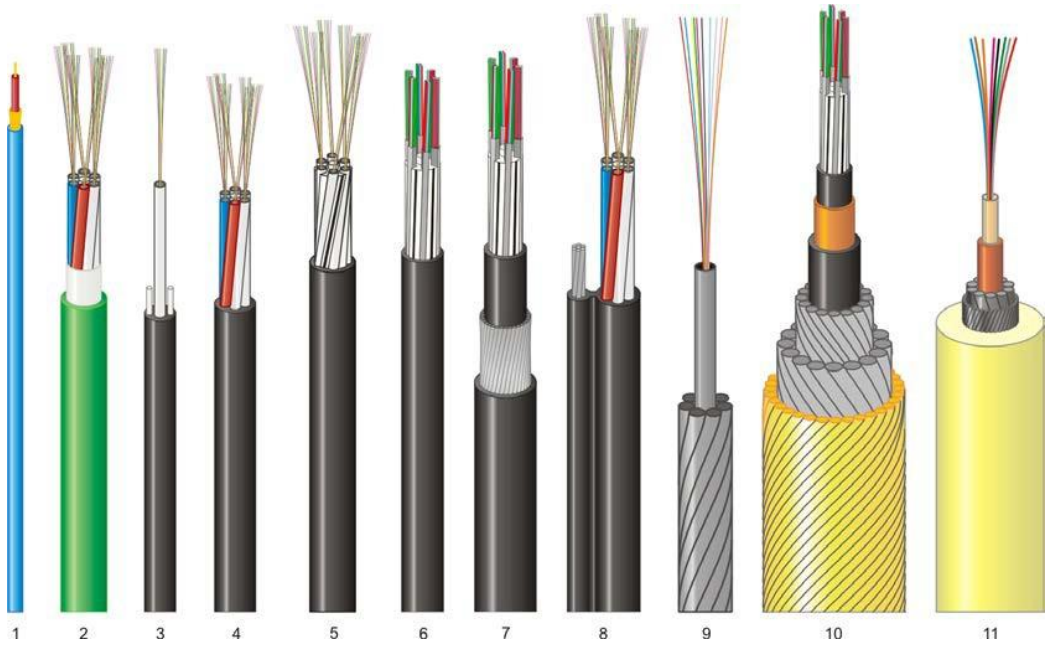


Image showing the structure of fibre optic cables G.652 and G.657.

Fibre optic cable with G.652 fibres is used in most standard cables. Fibre optic cables with fibres of typ G.657 are less bend-sensitive and are used primarily in access networks to individual customers.

Below are examples of various types of fibre optic cables.



Examples of various fibre optic cables

1. Patch cables, fitted with connectors at either end and normally used to connect networks to networks or active equipment to networks, usually between ODFs in ODF racks.
2. Concentric cable with fibres in duct. The cable is used to build networks in ducts or in a protected environment, e.g., indoors, in tunnels, within industrial buildings, etc. The green colour indicates that the cable is flame-retardant. This is not a standard colour for this purpose, although it has become a de facto standard.
3. Thin cable for outdoor application. Loose fibres or fibre ribbons centrally located in a grease-filled duct or cavity. Two thin strain relief devices are located on either side of the cable.
4. A very common cable. It must be routed in standard ducts. Between 4 and 16 secondary ducts containing loose fibres (normally 24 fibres in each duct) are cabled around a central strain relief device. The cavity between duct and duct and outer sheath is filled with filler to make the cable longitudinally watertight. This applies to all cables 4–11.
5. Cable with slotted core profile, in whose slots tubes with fibres are placed. The cable is considerably more resistant to radial pressure than those that are only cabled concentrically.
6. The same type of cable as before, but instead of secondary tubes there are fibre ribbons in the slots. This type of cable is used primarily in sections with a considerable demand for fibre. Fibre ribbons can be spliced considerably faster than individual fibres.
7. Here, cable number 6 has be supplied with robust reinforcement for burying or ploughing directly. The reinforcement comprises steel or aluminium wires.

8. Cable with integrated catenary for suspending between poles (telecom poles), with the max. span restricted to 50 metres. This model is generally referred to as a "figure of 8 cable".
9. The earth wire at the top of the lattice structure for high-voltage cables can be supplied with optical fibre. This type of cable is known as OPGW cable, as it is intended to connect the lattices to each other and to earth.
10. Underwater cables for coastal installations with a need for many non-reinforced fibres and with limited routing depth. Can be supplied with erbium-doped fibre amplifier, which is why the distance between transmitter and receiver can be in excess of 300 km. The heavy reinforcement with steel wire means that the cable is strong in relation to lighter anchors, as well as providing the weight to follow the contours of the sea-bed. Fibres of the type ITU-T G.655 may be appropriate.
11. Cable for ocean routing, where the routing depth can be up to 8–10 km. The extremely long routing distances mean that amplifiers are used. These are supplied with power through the inner copper duct. The fibre that is used is often ITU-T G.654 with extremely low attenuation.

Examples of micro-cables

1. An alternative to "blown fibre" is this 1.2 mm thick cable, which is used for blowing to individual end users.
2. Thin micro-cable with the fibres in a grease-filled tube surrounded by aramid yarn as strain relief. On the outside of the aramid yarn is a sheath made of flame-retardant polyethylene, FRPE.
3. This picture shows an unusual 48-fibre cable where the fibres are bundled in 12-fibre strands (bundles). The strands are identified through different coloured yarn that has been wound around each strand. All the strands are placed in a grease-filled plastic tube, which in turn is surrounded by aramid yarn as strain relief and an external flame-retardant sheath made of halogen-free PE.

4. Micro-cable with the same structure as a standard cable for routing in standard ducts. This picture shows a cable where each grease-filled tube has the same diameter as the centrally located strain relief device, resulting in six surrounding tube. The standard design is for each tube to contain 12 fibres, which is why the pictured cable contains 72 fibres. The number of fibres in each tube can be doubled.
5. In this cable, the central strain relief device has been made slightly thicker than the surrounding tube. In this case, it has been adapted for eight surrounding tube, producing a cable with 96 fibres. If the number of fibres in each tube is doubled, this produces a 192-fibre cable.
6. Same design as in the two previous cables but has a few plastic strands placed between the secondary tube to make a more circular cable.

Fibres in a fibre optic cable that are connected at both ends are known as fibre links. A fibre link starts and ends in a node, a connection point (at a customer) or a distribution point (connecting point), normally an ODF (Optical Distribution Frame). Each end of the fibre link is connected to an outlet installed in an ODF unit. The ODF is mounted in a rack or in a small box at a customer.

A connection comprises a fibre link, or two or more fibre links that are connected together (cross-connected).

2.4.2 Fibre optic cables for underground routing

MINIMUM REQUIREMENTS REGARDING FIBRE OPTIC CABLES TO BE ROUTED IN THE GROUND

- Fibre optic cables must be routed in ducts.
- The fibre optic cable must be approved for routing in ducts outdoors.
- The fibre optic cable must be executed with an identification system for the identification of individual fibres, e.g., through colour marking.
- The fibre optic cable must be longitudinally watertight.
- The fibre optic cable must be halogen-free.

2.4.3 Fibre optic cables, cable gutters and cable ladders for indoor routing

MINIMUM REQUIREMENTS FOR FIBRE OPTIC CABLES FOR INDOOR ROUTING:

- Ducts and fibre optic cables intended solely for outdoor use may not extend by more than 20 m into a building and must remain within the same fire cell, according to Boverket's (National Board of Housing, Building and Planning) CPR class Dca-s2, d2, a2, valid from 2017. After this, ducts and fibre optic cables classified for indoor use must be used.
- Cable gutters and cable ladders can be designed according to SS-EN 61537. Cable rails can be designed according to SS-EN 61534 series. Suspension devices in escape routes must be designed in material class A2-sl, do. (BSF 2018: 4)

2.4.4 Minimum requirements for pole routing

From a robustness perspective, routing on poles should be avoided.

Fibre optic cables of the following types are available for pole routing:

- wrapping around power lines
- integrated in earth wire (OPGW)
- suspended from catenary (figure of 8)
- with integrated catenary, which is self-supporting (ADSS)
- in microducts for pole routing.

MINIMUM REQUIREMENTS REGARDING FIBRE OPTIC CABLES WHEN ROUTING ON POLES

- If fibre optic cables are being routed on poles, this must be carried out with cables and attachments that are adapted according to the routing method.
- The pole owner's rules and instruction will apply and may vary depending on local regulations, the use of the pole route (electricity, telecommunications), etc.

2.4.5 Fibre optic cables for routing in water

Important parameters when routing fibre optic cable in water are water depth, presence of maritime traffic, anchoring, fishing, etc. See more under "Routing in lakes or watercourses".

MINIMUM REQUIREMENTS REGARDING FIBRE OPTIC CABLES FOR ROUTING IN WATER:

- Routing must take place using fibre optic cables that are adapted for routing in water.
- The fibre optic cable must be longitudinally watertight.

2.4.6 Fibre optic cables for routing in tunnels and culverts

MINIMUM REQUIREMENTS REGARDING FIBRE OPTIC CABLES WHEN ROUTING IN TUNNELS AND CULVERTS

- In culverts, road, rail and pedestrian tunnels, the fibre optic cable must be halogen-free and self-extinguishing.
- If there is a risk of unauthorised entry, vandalism or pests, armoured fibre optic cables or ducts must be used.

2.5 Cable management

2.5.1 General requirements

In general, during all routing of fibre optic cable, pulling/blowing/floating must take place in a controlled manner with regard to tensile forces and bend radii, in accordance with the cable manufacturer's instructions and using equipment intended for the purpose.

MINIMUM REQUIREMENTS HANDLING FIBRE OPTIC CABLE:

- Do not go below minimum permitted bend radius.
- Do not exceed maximum permitted tensile force.
- Do not exceed maximum permitted mechanical pressure.
- The ends of all non-connected cables must be sealed.
- The cable may not be handled at temperatures below that which has been specified. This means that, in certain cases, the drum has to remain in heated premises for some 24 hours before it can be transported. During transport, it should be covered so that the cable does not cool down.
- The laying of loops in the distribution points or optical fibre chambers shall be based on an assessment of future ground works, for example on larger groundworks, roads and in the vicinity of urban areas where settlements may take place.
- Loops, placement, length and documentation should be done according to the recommendations of the network owner.
- Loop must always be routed in optical fibre chambers, regardless of fibre optic cable type.
- Cable drums with fibre optic cable must be handled upright.
- The cable's flushing direction is marked on the cable drum and must be followed.
- When blowing micro-cable, a compressor with a moisture separator and the correct filter according to the compressor manufacturer must be used.

Cable dimensions: This table shows suitable matching for the dimension of fibre optic cable with suitable duct.

Cable outer diameter	Microduct with inner diameter 2.1	2.8	3.5	5.5	8	10	Standard duct with inner diameter 12	14	16	20	26	28	32	40
1.2	■	■	■											
1.8		■	■											
2.4			■	■										
3.9				■	■	■								
4.0					■	■	■							
5.4					■	■	■							
6.2					■	■	■							
6.4					■	■	■	■						
6.8						■	■	■						
7.5						■	■	■	■					
8.5							■	■	■	■				
9								■	■	■				
10								■	■	■				
11								■	■	■	■			
12									■	■	■			
13									■	■	■			
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23												■	■	
24												■	■	
25													■	■

2.5.2 Routing fibre optic cable in optical fibre chambers and cabinets

In order to position the fibre optic cable correctly in the optical fibre chamber or outdoor splice cabinet where a loop is to be created, careful preparation and handling are required. The cable's properties are changed if the cable is twisted, and this can easily happen during looping if this is not done correctly. Comply with the cable manufacturers instructions regarding looping. For example, some cable types may need to be looped in the form of a figure of eight. Checking whether the fibre optic cable is twisted can be performed by inspecting that the cable's longitudinal labelling is in the same direction. A cable length of approx. 20 metres is suitable as a loop length.

Micro-cable can be looped in the same way as standard cable. However, micro-cable is not as robust in the structure as standard cable, and extra care must therefore be taken when handling micro-cable.

MINIMUM REQUIREMENTS WHEN ROUTING FIBRE OPTIC CABLE IN OPTICAL FIBRE CHAMBERS AND OUTDOOR SPLICE CABINETS:

- The cable manufacturer's instructions regarding looping must be complied with.
- If individual fibres, fibre units, fibre ribbons or bundled fibres are used, these must never be looped freely in optical fibre chambers as there is a risk of fibre breaks and moisture damage. They must be looped in a splicing box.
- All fibre-optic cables for outdoor use must be able to cope with lying in water.

2.5.3 Routing fibre optic cable indoors

Where fibre optic cables are routed in public areas such as cellars, garages, etc., and there is a risk of unauthorised entry, vandalism or sabotage, security must be improved by the cables being routed as well concealed as possible using mechanical protection.

MINIMUM REQUIREMENTS WHEN ROUTING FIBRE OPTIC CABLE INDOORS:

- When there is a risk of unauthorised entry, vandalism or sabotage, indoor fibre optic cables must be protected mechanically with ducts or equivalent.

2.5.4 Splicing cables

MINIMUM REQUIREMENTS WHEN SPLICING FIBRE OPTIC CABLE:

- The fibres in the cable must be spliced by means of welding.
- The fibre splice must be protected in a splicing sleeve. The spliced fibres must then be placed in one or more fibre cassettes, which in turn must be protected by a splicing cabinet or splicing box.
- Do not go below the fibres' minimum bend radius. See the cable manufacturer's specification.
- The strain on the fibre optic cables must be relieved in a splicing box or splicing cabinet using integral strain relief for the cable in question, e.g., glass fibre rod or aramid yarn.

As far as possible, avoid a network design where splicing takes place in connectors. Connectors always produce more attenuation and reflection, which can affect the signal.

2.5.5 Splicing units

The fibre optic cable's splice is protected in a splicing unit. Splicing units in the form of splice boxes or splice cabinets are selected according to the environment in which they are placed, the number of fibres to be spliced, as well as the cables and any microducts that are to be connected.

Splice boxes are normally intended for direct routing in the ground or optical fibre chambers.

Splice cabinets are available for installation outdoors in an outdoor splice cabinet and for installation in an indoor environment.

A wall box for outdoor use is a splice cabinet and outdoor splice cabinet in one unit.

A facade box is a box located on the facade of a house and used for splicing fibre optic cable for the house.

Splice units can also include intermediate pieces and connectors.

MINIMUM REQUIREMENTS FOR SPLICING UNITS:

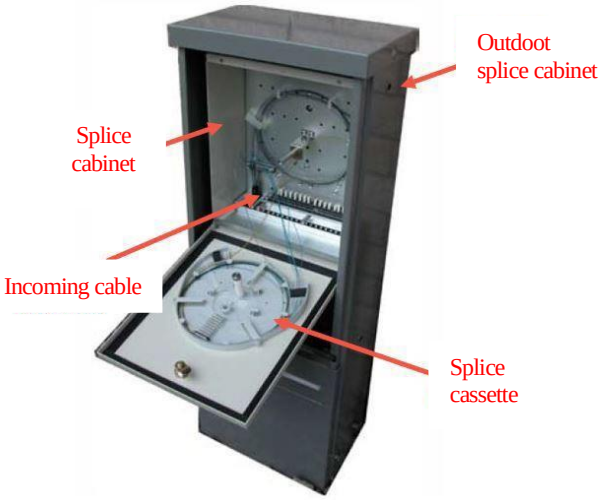
- Always follow the manufacturer's instructions regarding temperature, pressure sealing, strain relief, cable twist, bend radii, splice holders, etc.
- Splice unit located below ground level shall meet rating IP68.
- Splice unit located above ground level, without additional enclosure, should meet at least IP54.
- Splice unit located outdoors, without additional enclosure, should be UV resistant.
- Splice unit placed accessible to the public should be in class at least IK 8 and be able to be locked.
- Splice unit located above ground level with an IP rating lower than IP54, should be enclosed by external enclosure that meets at least a rating of IP34.
- Ensure that the sealing of the splice unit is sufficient, for example regarding pests and water penetration, for the environment in which the splice unit is located.
- Splice unit - Facade box placed accessible to the public should be at least class IK 7 and should not be able to be opened without tools.

Example of facade boxes

MINIMUM REQUIREMENTS REGARDING SPLICING CABINETS:

- Splice cabinets for outdoor routing above ground must be surrounded with an external enclosure that satisfies at least classification IP34. Ensure that the sealing of the splice cabinet is enough, eg. in respect of pests and water penetration, for the environment where the splice cabinet is located.
- When outdoors, splice cabinets must be installed in an outdoor splice cabinet or equivalent enclosure.
- Splice cabinets must be UV-resistant.
- Splice cabinets that are positioned so that they are accessible to the general public must be class IK 8.

Example of outdoor splice cabinet for outdoor use with splicing unit



Example of outdoor splice cabinet with splicing cabinet and splice cassette

2.5.6 Termination of cable in node

Termination means that the fibres in a fibre optic cable are made accessible via connectors in a connection panel. The connection panel is part of an ODF (Optical Distribution Frame).

Fibre optic cable classified for outdoor use must be re-spliced (transition joint or station joint) to fibre optic cables for indoor use if the indoor section exceeds 5 m, see point 2.4.3.

Transition joints are normally located outdoors in an intake chamber or outdoor splice cabinet.

Pre-connected indoor cable (known as stub cable) is often used from ODF to transition joint.

The indoor cable is terminated with optical connectors on the inside (line side) in an ODF unit. The fibres are thereby accessible for cross-connection or connection of active communication equipment on the front (connection panel) of the ODF unit.

2.5.6.1 ODF (Optical Distribution Frame)

In an ODF unit, the fibre optic cable is welded to preconnected pigtails or preconnected fan-outs. On the ODF unit's panel (front), intermediate pieces are installed where the connectors are connected. In this way, the fibres are made accessible for connection in connectors, for connecting equipment or cross-connection.

An ODF unit is often 19 inches wide and its height can range from 1U (height unit) up to 3U. An ODF can comprise everything from an individual ODF unit with a small number of connectors to covering many units in several racks where all fibre optic cables in the node are terminated.

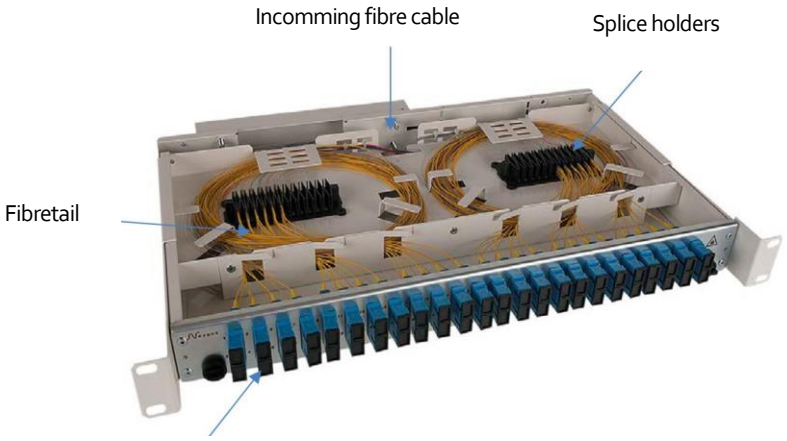
When selecting equipment for an ODF, certain basic functions as shown below must be satisfied to achieve a robust network.

MINIMUM REQUIREMENTS REGARDING ODF UNIT:

- The ODF unit must have protection in front of the connector panel.
- It must be easy to access the inner connectors for cleaning or replacing intermediate pieces, e.g., via a removable or swivelling front panel.
- The empty intermediate pieces, where no connector is installed, must be supplied with dust protection both inside the ODF unit and on the panel.
- Green intermediate pieces must never be used together with blue connectors or vice versa.

Recommendation

Different solutions and models in the same stand should be avoided as they can prevent work in the unit above or below.



Example of ODF unit

Examples of connecting cables (patch-cables)

MINIMUM REQUIREMENTS REGARDING ODF RACK:

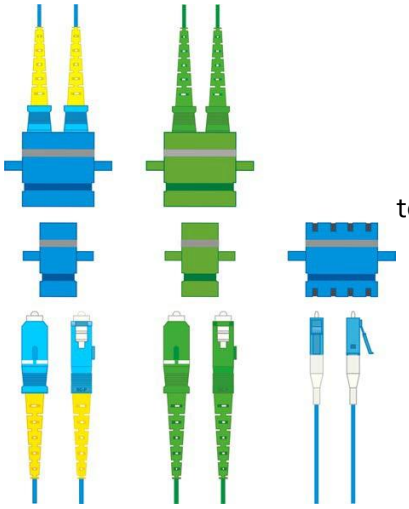
- ODF units with stub cable (prefabricated unit with connectors and fibre optic cable of various lengths) must be able to be installed in the rack. The stub cable is routed from the ODF rack, e.g., on cable ladders, up to a transition joint where it is welded to the incoming fibre optic cable.
- ODF racks must be placed so that incoming fibre optic cables that are routed indoors can be spliced directly inside the ODF unit.
- ODF racks must be designed so that future operational and maintenance work can easily be carried out, e.g., replacement, repair and supplementing in the ODF units.
- Cable routes must be present, and all connection cables must be located in cable holders. This requirement applies to the entire ODF, i.e. in panels within the same rack and between racks.
- ODF racks must be designed so that the handling of connection and connecting cables is rational in respect of radius restriction, order, excess length, quantity, switching, supplementing, etc.
- ODF racks must be designed so that cross-connection can take place within the same ODF rack or via designated transfer routes to another ODF rack or to racks with active equipment.

2.5.7 Optical connectors and cleaning

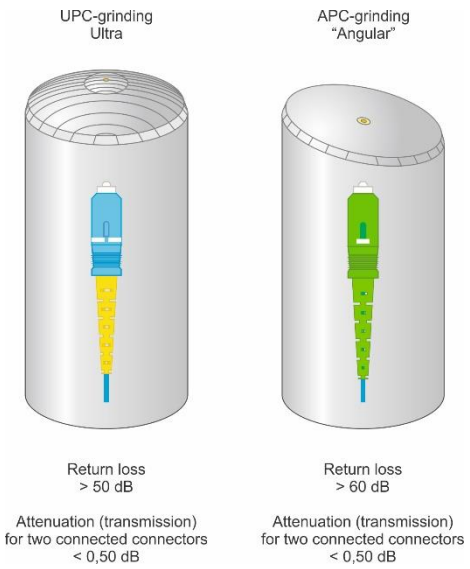
2.5.7.1 Optical connectors

There are several types of optical connectors. The most common connector types in broadband networks are LC (Lucent Connector) and SC (Subscriber or Standard Connector). In order to connect two connectors to each other, an intermediate piece is used.

The colour of the connectors describes the type of polishing used on the connector's end surface. The most common are UPC (blue, spherical polishing) or APC (green, 8° angled polishing). UPC is most common in broadband networks. APC is mostly used in cable TV networks, where it is important for the reflection of light to be minimised (high reflection attenuation).



Examples of optical connectors and intermediate pieces. From the left: SC connector UPC, SC connector APC, LC connector UPC with intermediate pieces.

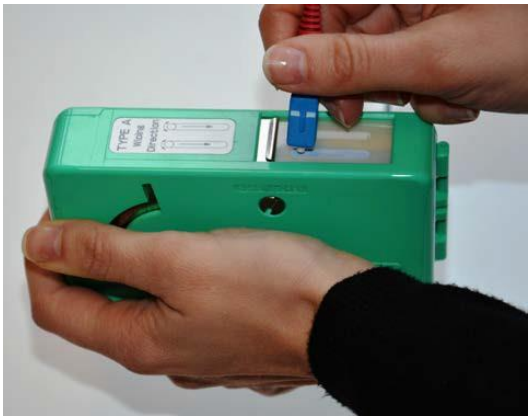


Different polishing of the connector ferrule. Specified attenuation values are quality parameters.

2.5.7.2 Cleaning

Optical connectors and intermediate pieces are normally only cleaned using dry methods (e.g., cleaning box/card and stylus/pen).

In exceptional cases, i.e. in the event of heavily soiled connectors, connectors can be cleaned using isopropanol. When cleaning with isopropanol, the connector must be dried immediately by cleaning using a dry method.



Cleaning fibre with cleaning cassette

2.5.8 Termination outdoors

ODF units or equipment open panels are not used outdoors in outdoor splice cabinets to create switch points, as this requires entirely sealed boxes.

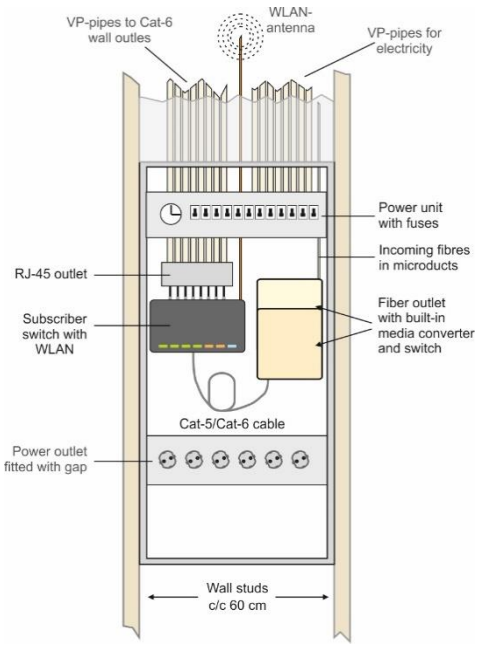
If switch points with optical connectors are placed out in the network, these should be located indoors or in special outdoor cabinets (environmental cabinets).

2.5.9 Termination in house

A house refers to a villa or terraced house as an individual dwelling. For the connection of apartment buildings, residential, commercial premises, office premises see recommendation "Robusta fastighetsnät".

After a fibre optic cable has been routed into a house, a seal is installed between duct and fibre optic cable.

Incoming fibre optic cables into houses are terminated in a fibre outlet alternatively a Facade box. Fiber outlets should be located in the immediate vicinity of a cable intake in the wall or in a "broadband space" in order to create a flexible connection point. From the outlet, a connection cable that is robust and adapted for installation is routed into the house to the active customer equipment.



Example of broadband space combined with distribution board in a house

MINIMUM REQUIREMENTS FOR TERMINATION IN A HOUSE:

- An incoming cable entering a house must be terminated in a standalone fibre outlet alternatively Facade box.
  Standalone also means a unit/plate on which a switch is installed and there is a separate space for fibre on the unit/plate.
- A separate CPE should be provided with the warning sign "Laser Warning"

2.5.9.1 Fibre outlet

The fibre outlet in a house is the property of the network owner. The fibre outlet should be designed so that the connector on a connected connection cable is not too visible and easily accessible.

A customer with the technical knowledge and a set of instructions should be able to disconnect and replace the patch cable without opening the fibre outlet. The patch cable must be in a robust version that is adapted for the purpose.

MINIMUM REQUIREMENTS FOR FIBRE OUTLETS IN A HOUSE:

- An outlet installed directly on a wall must be angled down, parallel with the wall.
- The intermediate piece must be physically protected against dust, even if the connector is removed.
- Fibre outlets in houses must be marked with the symbol "Laser warning" in accordance with section 2.6.5 Fiber outlet.
- When installing fibre outlets, the customer's alt. the manufacturer's instructions are followed.

2.5.10 Optical radiation

Optical radiation is principally a safety issue for those who handle optical connectors and cabling. Do not look into connectors if these are connected to a laser.

Laser radiation can damage vision. As the light may be invisible, warning labels must be present by fibre outlets to call attention to and warn about these risks. The invisible light does not trigger a blink reflect, which would protect the eye.

2.5.11 Delivery measurement of fibre connections

After installation, delivery measurement is conducted at the installation and a measurement report is prepared. Delivery measurement of fibre optic cables is performed to ensure that the physical installation and the documentation correspond, and to verify that minimum requirements in respect of e.g., attenuation are satisfied. An Excel calculation is available as an aid. See sub-appendix 2.1 Calculating attenuation.

2.5.11.1 Measurement methods

There are two common measurement methods for delivery measurement of newly installed fibre optic cables:

- Attenuation measurement, dB measurement
- OTDR measurement.

For Robust Fibre, OTDR measurement applies.

During OTDR measurement, an optical reflectometer is used (OTDR = Optical Time Domain Reflectometer). OTDR transmits a pulse of light, which is reflected in inhomogeneities, joints, connectors and end points.

OTDR is used to measure e.g., attenuation and connector reflections. OTDR is also used to find attenuation increases, e.g., in poor splices, pinching or defective cables. Always follow

the instrument manufacturer's instructions in respect of executing measurement.

2.5.11.2 Choice of OTDR instrument

The instrument's performance is selected on the basis of the type of connection being measured.

An OTDR instrument that is used in national networks can measure long distances with a high degree of accuracy, while an OTDR instrument that is used in connection networks requires a good resolution over short distance.

2.5.11.3 If a defective fibre optic cable is suspected

If it is suspected that the fibre optic cable has been subjected to external influences in conjunction with installation, e.g., damaged cable drum, pinching, etc., the fibres must be checked using one of the listed measurement methods.

2.5.12 Delivery measurement of passive fibre

MINIMUM REQUIREMENTS IN RESPECT OF DELIVERY MEASUREMENT OF PASSIVE FIBRE:

- Unidirectional OTDR measurement must be performed between the endpoints on all connections at 1310 nm and 1550 nm.
- One-way OTDR measurement should also be performed where there is only one contacted end.
- If the incoming optotical fiber to a house is terminated in a fiber outlet or in a facade box, it forms the end point of the connection. For termination in apartment buildings, see recommendation " Robusta fastighetsnät".
- The measuring instruments must be calibrated in accordance with the manufacturer's procedures.
- The measurement report must specify the measuring instrument, OTDR settings (measurement area, pulse, time and index of refraction (IoR)), as well as who has carried out the measurement.
- The measurement results from OTDR-measurements and OTDR measurements must be saved in original file format, e.g.,. .sor/trc/.msor.
- The limit values according to table 2.5.12.1 must not be exceeded.
- In OTDR measurement, the following shall:
    - the pulse width should always be as short as possible, however, the entire graph should always be able to be read without noise.
    - the measuring window is always set so that the entire curve is visible in the window, e.g. the distance is 3 km, the measurement window is set to the closest longer distance range.
    - Launch Cable is always used. The length should be adjusted taking into account the so-called "dead zone" in order to be able to measure the first contact.
    - correct time and date must be set.

Note:
If several cables to be spliced have different index of refraction, IOR, the network owner should specify the IOR to be used

2.5.12.1 Measurement results and limit values for fibre in cables

Measured values in the chapter are based on current standards ITU-T-G.652–201611 and ITU-T-

G.657–201611.

Table: Minimum limit values for fibre in cables (summary table)

Limit value for attenuation in routed optical fiber	
Limit value at 1310 nm	Max 0,40 dB/km
Limit value at 1550 nm	Max 0,30 dB/km
Limit value at 1625 nm*1	Max 0,40 dB/km
Spot attenuation change at 1550 nm or 1625 nm. Spot attenuation change refers to "spikes" greater than 0,05 dB.	0,05 dB
Fibre attenuation may at most exceed the factory measurement of the fibre by 0,03 dB/km vid 1310/(1550 or 1625) nm. Average valaue refers to the combined value of all the fibres in a section of cable	
Limit value at individual splice	
Max limit value, access network (<10 km)	0,25 dB
Limit value at connector	
Attenuation per interconnected connector	0,5 dB
Reflection attenuation UPC (ultra-polished connector)	min 50 dB
Reflection attenuation APC (angular-polished connector)	Min 60 dB
*1) When measuring activ access connection with filtered wavelength 1625 nm to single dwelling unit (SDU) connections.	

MINIMUM REQUIREMENTS regarding measurement results for access networks:
The value obtained for attenuation must be below the following theoretical calculation:
At 1310 nm: length x 0.40 + splice x 0.25 + 1.0 + 0.5 dB
At 1550 nm: length x 0,30 + splice x 0.25 + 1.0 + 0.5 dB

Explanation of the above abbreviations:
length = optical length (km) **splice** = number of splices
1.0 dB relates to losses in event of connection to ODF, 2x if 0.5 dB (including first splice after ODF)
0.5 dB estimated value to the combined measurement uncertainty in instruments with connectors.

As support for calculating the connection attenuation, an Excel calculation has been produced that can be downloaded from robustfibre.se under Instructions.

Note: Check the network owner's requirements before measuring.

2.5.13 Delivery measurement of active fibre

Active fibre refers to a connection that has an active CPE/Switch that signals at 1310 nm and 1550 nm on the fibre. Delivery measurement can then be conducted with a filtered wavelength of 1625 nm. Active measurement assumes that measurement is from one direction only.

MINIMUM REQUIREMENTS IN RESPECT OF DELIVERY MEASUREMENT OF ACTIVE FIBRE:

- Unidirectional OTDR measurement must be performed at 1625 alt. 1650 nm on active fibre connection. The measuring instruments must be calibrated in accordance with the manufacturer's procedures.
- OTDR measurement must be done according to the instrument manufacturer's instructions.
- The measurement report must specify the measuring instrument, OTDR settings (measurement area, pulse, time and index of refraction (IoR)), as well as who has carried out the measurement.
- The measurement results from attenuation measurements and OTDR measurements must be saved in a generally legible file format, e.g., Excel, .pdf or. sor for OTDR.
- The limit values according to table 2.5.12.1 must not be exceeded.
- Delivery measurement for an active fibre connection may only be used for single dwelling unit (SDU) connections.

2.5.13.1 Measurement results and limit values for fibre in cables
See Table 2.5.12.1 for minimum limit values for fibre in cables (summary table).
The following requirements regarding fibre in cables constitute input data during delivery measurement of an installed system.

MINIMUM REQUIREMENTS regarding measurement results for access networks:
The value obtained for attenuation must be below the following theoretical calculation:
At 1625 nm: length x 0.40 + splice x 0.25 + 1.0 + 0.5 dB

Explanation of the above abbreviations:
length = optical length (km) **splice** = number of splices
1.0 dB relates to losses in event of connection to ODF, 2x if 0.5 dB (including first splice after ODF)
0.5 dB estimated value to the combined measurement uncertainty in instruments with connectors

2.6 Labelling

The fibre installation must be labelled in a uniform manner.

MINIMUM REQUIREMENTS IN RESPECT OF LABELLING OF THE FIBRE INSTALLATION:

- All parts of the fibre installation must be labelled with unique designations.
- All labels must be adapted to existing environment. They must be age-resistant, UV resistant and be/exist in water for a long time. They must also withstand different types of liquids such as oil, benzene, alcohol, solvents etc.
- Labelling must correspond with the documentation's designation.
- Labelling must not contain plain text for security reasons, e.g., "Arboga-Köping" or the customer's name,
- The labelling must be scratch-proof.

2.6.1 Labelling and designation of ducts

MINIMUM REQUIREMENTS IN RESPECT OF LABELLING AND DESIGNATION OF DUCTS:

- When routing several ducts in the same trench, the ducts must be supplemented with various longitudinal colour markings or other weather and ageing-resistant labelling systems, in order to facilitate identification and documentation so as to avoid confusion.
- Any sub-duct must be supplied with an identification system for identifying individual ducts, e.g., colour marking.
- Ducts must be labelled at both inputs and outputs in optical fibre chambers and cabinets, at transitions from e.g., mast to cable ladder, as well as on either side of wall bushings.
- Ducts must be labelled at both inputs and outputs in wall bushings when connecting a building/property. Exceptions may be made if the duct is present for an individual customer connection, e.g., connection to a single dwelling unit.

Optical fibre chambers and cabinets are ideally labelled inside the door/hatch in order to prevent unauthorised parties from seeing the labelling.

Example of labelling of ducts

2.6.2 Labelling cables

MINIMUM REQUIREMENTS IN RESPECT OF LABELLING OF CABLES:

- Fibre optic cables must be labelled at both inputs and outputs in optical fibre chambers and cabinets, at transitions from e.g., mast to cable ladder, as well as on either side of wall bushings.

Example of labelling of fibre optic cable

MINIMUM REQUIREMENTS FOR THE MARKING OF CABLE/BLOWN FIBRES FOR HOUSE:

A cable/blown fiber to an individual user shall be identified via ducting color coding or by other agreed means.

2.6.3 Numbering and labelling of racks and panels

Rack numbering starts from the left-hand corner, viewed from the input (applies in smaller nodes). In large nodes, a site drawing must be created that shows the location and numbering of the racks.

A panel, e.g., an ODF unit, which is installed in a rack, will be designated according to where the upper left corner is positioned in relation to the layout of the rack.

Numbering of outlets in a panel must start from the upper left corner in each panel. Work on the basis of the manufacturer's label, if present. If there is no label, outlets must be numbered consecutively, e.g., 01, 02, 03, etc.

MINIMUM REQUIREMENTS REGARDING LABELLING OF RACKS AND PANELS:

- Each rack must be labelled with a unique designation.
- Each individual ODF unit must be labelled.
- The outlets' numbering must be labelled on the panel.

2.6.4 Splicing units

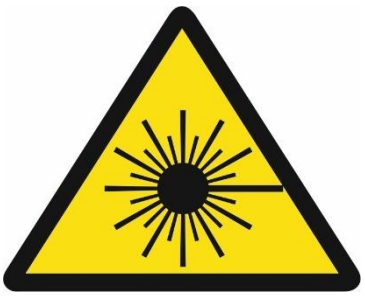
MINIMUM REQUIREMENTS REGARDING LABELLING OF SPLICING UNITS:

- On a splice cassette it must be clear which fibres / cables are in the cassette.
- Markings should not be included, for example, with covers or faceplates when they are removed.
- In the case of exposed fibre connectors, there should be a clear marking with "Warning for laser".

2.6.5 Fibre outlets

MINIMUM REQUIREMENTS FOR LABELLING FIBRE OUTLETS IN HOUSES:

- Fibre outlets in houses must be labelled with the "Warning: laser" symbol.



2.7 Safety

2.7.1 Locks

A distribution point may be designed in many different ways. A common feature of all types of distribution points is that they are locked with a key, card or similar system, so that unauthorised parties cannot enter the area. This consequently applies to nodes, optical fibre chambers, outdoor splice cabinets and splicing boxes, as well as other areas where there is access to end points or splices.

As regards optical fibre chambers, there are a great many different types of locks, e.g., lockable inner hatches or specific "opening tools". If a optical fibre chamber is placed below ground level, i.e. with Selected Sandfill above the optical fibre chamber cap, no locking device is required.

Locks such as "single-track", which can be opened with a chisel, or "triangle" locks are not approved from a robustness perspective.

MINIMUM REQUIREMENTS IN RESPECT OF LOCKING:

- Distribution points must be locked with an approved key, card or in a similar manner.

Below are examples of locks that are approved:

- EBR lock or "Stockholm lock".
- Padlock with key.
- Cylinder lock.
- Penta-head lock.

Examples of locks

Instructions for Robust Fiber

Appendix 3 Robust routing methods

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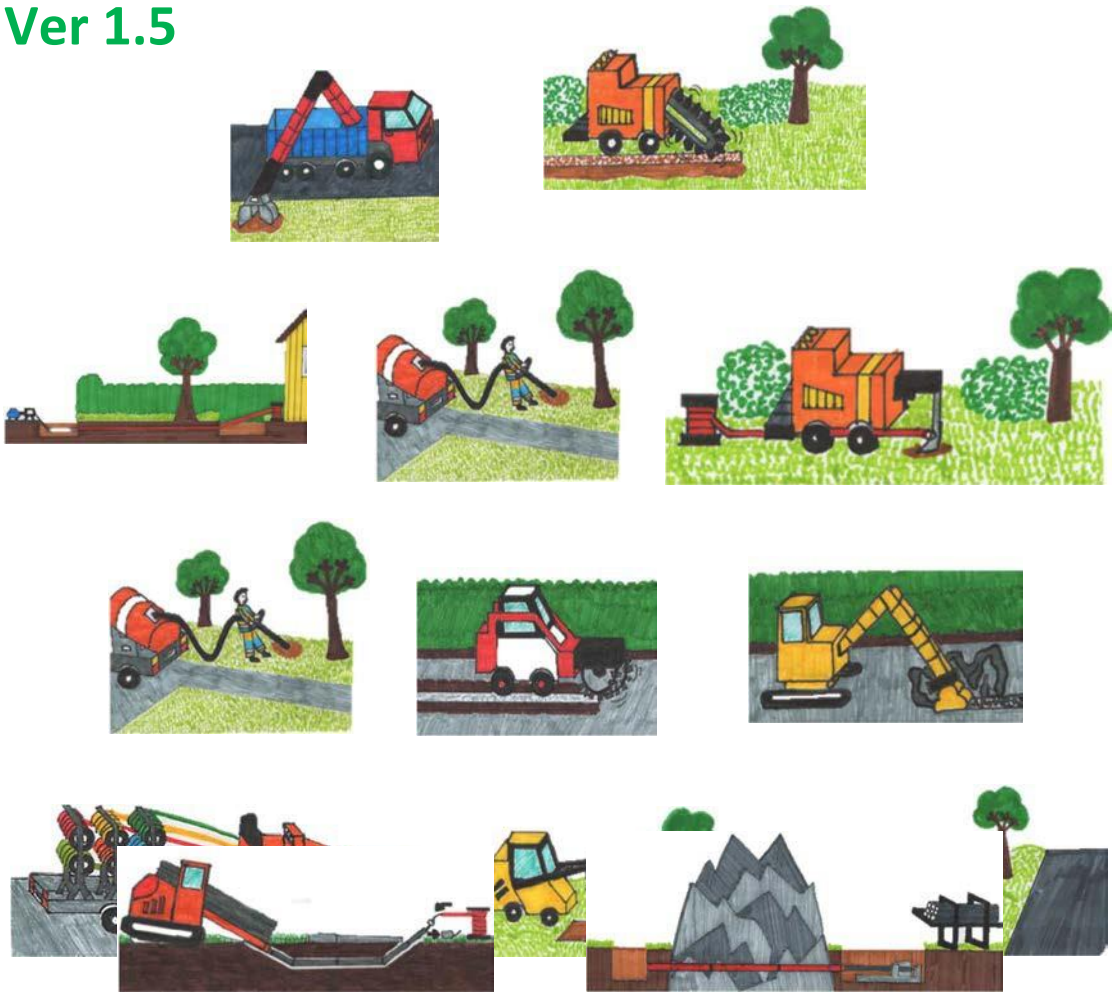


CONTENTS

1. Introduction 8

2. General 8

2.1 General advantages and disadvantages 9

2.2 Effective routing 10

3. General information for a fibre project 11

3.1 Staking / cable indication query 11

3.2 Prior survey on site 11

3.3 Collocation 11

3.4 Permits and land issues 11

3.5 TA plan 13

3.6 Work environment 13

3.7 Environment 14

3.8 Subsequent survey on site 15

3.9 Warranties 15

3.10 Consultation with County Administrative Board 15

3.11 Drainage in farmland 16

3.12 Trees, roots and vegetation 16

4. Excavation-free methods 17

4.1 Microtrenching 17

4.1.1 Method 17

4.1.2 Machinery 17

4.1.3 Tools 17

4.1.4 Suitable environment 18

4.1.5 Advantages 18

4.1.6 Restrictions (Disadvantages) 18

4.1.7 Excavation 18

4.1.8 Excavated material 19

4.1.9 Duct bedding 19

4.1.10 Backfilling 19

4.1.11 Refilling 19

4.1.12 Restoration 19

4.1.13 Environmental impact 19

4.1.14 Duct type 19

4.1.15 Duct routing 19

4.2 End milling 21

4.2.1 Method 21

4.2.2 Machinery 21

4.2.3 Tools 22

4.2.4 Suitable environment 22

4.2.5 Advantages 22

4.2.6 Restrictions (Disadvantages) 23

4.2.7 Excavation 23

4.2.8 Excavated material 23

4.2.9 Duct bedding 23
4.2.10 Backfilling 23
4.2.11 Refilling 24
4.2.12 Restoration 24
4.2.13 Environmental impact 24
4.2.14 Duct type 25
4.2.15 Duct routing 25
4.3 Ploughing 26
4.3.1 Method 26
4.3.2 Machinery 26
4.3.3 Tools 26
4.3.4 Suitable environment 27
4.3.5 Advantages 27
4.3.6 Restrictions (Disadvantages) 27
4.3.7 Excavation 27
4.3.8 Excavated material 27
4.3.9 Duct bedding 28
4.3.10 Backfilling 28
4.3.11 Refilling 28
4.3.12 Restoration 28
4.3.13 Environmental impact 28
4.3.14 Duct type 28
4.3.15 Duct routing 28
4.4 Chain excavation 29
4.4.1 Method 29
4.4.2 Machinery 29
4.4.3 Tools 29
4.4.4 Suitable environment 30
4.4.5 Advantages 30
4.4.6 Restrictions (Disadvantages) 30
4.4.7 Excavation 30
4.4.8 Excavated material 30
4.4.9 Duct bedding 30
4.4.10 Backfilling 30
4.4.11 Refilling 30
4.4.12 Restoration 30
4.4.13 Environmental impact 31
4.4.14 Duct type 31
4.4.15 Duct routing 31
4.5 Suction excavation 32
4.5.1 Method 32
4.5.2 Machinery 32
4.5.3 Tools 32
4.5.4 Suitable environment 33
4.5.5 Advantages 33
4.5.6 Restrictions (Disadvantages) 33
4.5.7 Excavation 33

4.5.8 Excavated material....33
4.5.9 Duct bedding....33
4.5.10 Backfilling....33
4.5.11 Refilling....33
4.5.12 Restoration....33
4.5.13 Environmental impact....34
4.5.14 Duct type....34
4.5.15 Duct routing....34
4.6 Pressing....35
4.6.1 Method....35
4.6.2 Machinery....35
4.6.3 Tools....35
4.6.4 Suitable environment....35
4.6.5 Advantages....36
4.6.6 Restrictions (Disadvantages)....36
4.6.7 Excavation....36
4.6.8 Excavated material....36
4.6.9 Duct bedding....36
4.6.10 Backfilling....36
4.6.11 Refilling....36
4.6.12 Restoration....36
4.6.13 Environmental impact....36
4.6.14 Duct type....37
4.6.15 Duct routing....37
4.7 Impact mole....38
4.7.1 Method....38
4.7.2 Machinery....38
4.7.3 Tools....38
Example of impact mole....39
4.7.4 Suitable environment....39
4.7.5 Advantages....39
4.7.6 Restrictions (Disadvantages)....39
4.7.7 Excavation....39
4.7.8 Excavated material....39
4.7.9 Duct bedding....39
4.7.10 Backfilling....39
4.7.11 Refilling....39
4.7.12 Restoration....40
4.7.13 Environmental impact....40
4.7.14 Duct type....40
4.7.15 Duct routing....40
4.8 Directional drilling....41
8.1 Method....41
4.8.2 Machinery....42
4.8.3 Tools....42
4.8.4 Suitable environment....43
4.8.5 Advantages....43

4.8.6 Restrictions (Disadvantages) 44
4.8.7 Excavation 44
4.8.8 Excavated material 44
4.8.9 Duct bedding 44
4.8.10 Backfilling 44
4.8.11 Refilling 44
4.8.12 Restoration 44
4.8.13 Environmental impact 44
4.8.14 Duct type 45
4.8.15 Duct routing 45
4.9 Hammer drilling 46
4.9.1 Method 46
4.9.2 Machinery 46
4.9.3 Tools 46
4.9.4 Suitable environment 47
4.9.5 Advantages 47
4.9.6 Restrictions (Disadvantages) 47
4.9.7 Excavation 47
4.9.8 Excavated material 47
4.9.9 Duct bedding 47
4.9.10 Backfilling 47
4.9.11 Refilling 47
4.9.12 Restoration 48
4.9.13 Environmental impact 48
4.9.14 Duct type 48
4.9.15 Duct routing 48
5. Excavation methods 49
5.1 Excavation with excavator (Traditional excavator) 49
5.1.1 Method 49
5.1.2 Machinery 49
5.1.3 Tools 49
5.1.4 Suitable environment 49
5.1.5 Advantages 50
5.1.6 Restrictions (Disadvantages) 50
5.1.7 Excavation 50
5.1.8 Excavated material 51
5.1.9 Backfill masses 51
5.1.10 Restoration 51
5.1.11 Environmental impact 51
5.1.12 Duct type 51
5.1.13 Duct routing 51
5.2 Manual excavation 52
5.2.1 Method 52
5.2.2 Machinery 52
5.2.3 Tools 52
5.2.4 Suitable environment 52
5.2.5 Advantages 52

5.2.6 Restrictions (Disadvantages) 52
5.2.7 Excavation 52
5.2.8 Excavated material 53
5.1.9 Backfill masses 53
5.2.10 Restoration 53
5.2.11 Environmental impact 53
5.2.12 Duct type 53
5.2.13 Duct routing 53

1. INTRODUCTION

The document *"Instructions for Robust Fiber"* comprises one main document and a number of appendices.

This appendix, Robust routing methods, contains descriptions of various methods that are used to route fibre installations. The appendix is structured in the form of a template, with a number of points recurring for each method.

The aim of the appendix is that it should describe the methods that are used in a fibre installation project and that are used to facilitate the choice of methods.

Minimum requirements within the following areas are defined in the appendix:

- Backfill height in accordance with *"Instructions for Robust Fiber"*.
- Requirements regarding ground-penetrating radar or physical inspection by means of excavation before starting work.

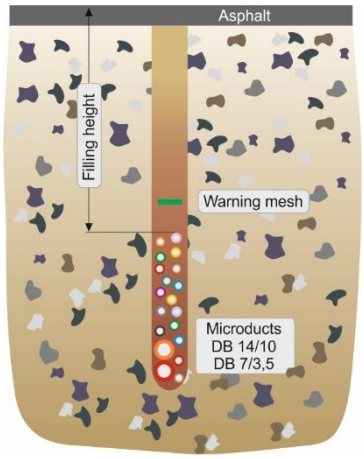
2. GENERAL

Below is a description of approved methods according to *"Instructions for Robust Fiber"*.

The requirements regarding backfill height will always apply in order for the method to be approved.

Backfill height

In this document, the term backfill height is used throughout. This refers to the distance between the top edge of the uppermost duct to the top of the finished surface.



Example of backfill height for microtrenching

General information about various methods

The appendix describes two main approaches within the methods for routing fibre networks: excavation-free methods and methods for traditional excavation. Both approaches have advantages and disadvantages, and it is therefore important to use the methods that are best suited to the area in which the fibre installation is to be routed. The choice of method depends e.g.,, on the type of land in the area, the land owner's regulations, as well as access to machinery and various machine types in the local area.

Some methods are more volume-dependent than others. It is sometimes not worthwhile transporting another machine to the site to be used on a specific section, rather it may be more efficient to use the machines that are already on site, despite the fact that the price per metre for the actual trench will be higher.

2.1General advantages and disadvantages

Below are a number of advantages and disadvantages of excavation and excavation-free methods:

Excavation methods

Advantages:

- Considerable access to machinery of various sizes.
- Flexible.
- Same machine for positioning optical fibre chambers and cabinets.

Disadvantages:

- Slow routing in relation to excavation-free methods.
- Extensive restoration.
- Disruption in respect of closures to traffic and residents.

Excavation-free methods

Advantages:

- Rapid routing.
- Little impact on traffic and residents.
- Little restoration.
- Flexible passage past major obstacles such as roads and watercourses.

Disadvantages:

- Specially adapted machinery for each method.
- Some methods are only appropriate for a small number of ducts.

2.2 Effective routing

In order for a project to be effective, various methods should be utilised. In asphalt, the most effective method might be end milling, while traditional excavation or ploughing might be more effective in green spaces. Planning is the key to achieving the most effective routing. In this respect, it is particularly important to go out in the field and to look at the actual conditions in order to see how routing can be performed most effectively, e.g., by end milling certain sections in asphalt in combination with traditional excavation in green spaces in other sections.
There is no right or wrong. The different methods work well in different situations. Combining methods according to the prevailing conditions is usually the most effective way of routing the fibre installation.

Example of effective routing where different methods have been used

Advice for effective routing:

- Handling of excavated material during the project.
  Plan optical fibre chambers so that the material is handled effectively without unnecessary transport.

- Avoid unnecessary setup costs.
  Plan and conduct work requiring special machinery at the same time. For example, all directional drilling can be performed at one time, ideally in good time before other routing of ducts has reached the locations where drilling is being performed.

- Ground excavation
  Ensure that ground excavation is complete when routing backbone networks in a street. This applies in particular in the event the property owner is excavating on his own plot.
  Select an effective method for ground excavation or combine several methods, such as ploughing, impact mole, spade, directional drilling, etc.

- Investigate the potential to use existing ducts on building land.

3. GENERAL INFORMATION FOR A FIBRE PROJECT

3.1 Staking / cable indication query

Local regulations and procedures determine how staking and cable indication queries are to take place and be ordered through *Appendix 8 Ledningskollen* and any other local procedures.

Staking is conducted by the party that owns cables or by its appointed representative. Alternatively, the cable owner supplies data for the staking of existing cables.

It is the contractor's responsibility to determine the exact position of the cable before staring excavation.

As part of improving collaboration between network owners, authorities, cable operators and other players in the industry, a collaboration project "Grävallvar" is also being run with the aim of reducing digging damage on the cable networks (https://gravallvar.se/).

3.2 Prior survey on site

Before starting work, a survey should be conducted on site alongside the client (controller), contractor and land owner/road operator.
An analysis is conducted of the work area's surface layer along those sections where earthworks are planned, as well as in locations where outdoor splice cabinets, cable chambers and technical shelters are intended to be placed (*Site*). The analysis is reported and documented with film and photographs. The report is attached to the prepared land agreement. Well documented material facilitates surveys after implementation.

3.3 Collocation

The potential for collocation should be investigated and in certain cases may also be demanded by the land owner/road operator. This is an effective method, as several parties can share the excavation cost. Specific terms and conditions apply in the event of collocation, and agreement regarding these terms and conditions is reached between the parties on a case-by-case basis. The minimum requirements regarding collocation must be in accordance with "*Instructions for Robust Fiber*" or higher. Ensure that the correct material is used and that routing is performed correctly by the contractor.

3.4 Permits and land issues

In order to route cables in a municipality, the client (network owner) must enter into a land agreement with the local authority. This regulates aspects such as permission to route cables in municipal land, restoration and future maintenance.

For areas outside of municipal land where cables pass, a land agreement must be entered into with the relevant land owner. The network owner is responsible for obtaining land agreements. The network owner may engage another party to carry out this work, e.g., the contractor.

Different stakeholders can administer permits differently and have different requirements regarding e.g., the information that is to be attached with the application for a permit. Rules are regulations are often local and differ depending on where in the country they

apply as well as who is issuing the permit (e.g., authority, land owner or road operator).

Examples of the requisite permits and agreements that may be required in a project:

- General land agreement with the local authority regarding the right to have cables in municipal land.
- Land agreements between the network owner and the landowners/plot owners. The agreement shall include the agreed cable position and, where applicable, where the connection of the house will take place. There are different types of land agreements, such as "markupplåtelseavtal, nyttjanderättsavtal, och ledningsrätt".
- Permits/decisions to dig from municipal and/or state road owners, ("Ledningstillstånd" Swedish Transport Administration) /track owners (railway)/ landowners, describing where to place new cables, restoration requirements and the duration of the installation work.
- In some cases, the above may need to be supplemented with a start-up permit (opening notification) with landowners/road owners e.g. a municipality or a road association/community.
- Co-location Agreement - Regulates the terms and conditions of co-location.
- TA plan according to the regulations of the road manager. For the Swedish Transport Administration see Permission for the placement of telecommunication lines.
- Permission from the Swedish Transport Administration regarding the placement of telecommunication lines. The conditions for traffic and protective devices are obtained together with the decision on Permission for the placement of telecommunication lines. For further information, see the Swedish Transport Administration's publication "Ledningsarbete inom det statliga vägområdet".
- Building consents
- Permits from pole route owners.
- Consultation with the Country Administrative Board and/or the local authority regarding culture and the environment (watercourses, archaeological sites, alleys, unsuitable land, unique vegetation, cultural monuments).
- Consultation with the County Administrative Board if, outside areas with a detailed plan, buildings are to be erected, extensions made, other facilities carried out or other such measures are taken that may adversely affect traffic safety within a distance of twelve meters from a road area (Road Act 47§).

Agreement templates can be obtained from e.g., the Federation of Swedish Farmers, the Swedish Broadband Forum and Byanätsforum.

In general, all those who work on or beside roads must have received approved training "Work on Roads" – Level 1.

Local authorities and land owners often have different regulations that must be followed.

Some items that often differ between different land owners/road operators and that have to be checked by the parties in each contract are:

- Handling of restoration requirements, e.g.,
  - layer thickness
  - type of material
  - type of fraction
  - local regulations
  - references to national regulations and sector requirements (AMA, TRVK, etc.).
  - who has to carry out the restoration and the size of the areas to be restored.
- Local requirements regarding routing depth and backfill height.
- Permitted routing methods/excavation methods for the contract.
- Charges for future maintenance.
- Whether charges exist for the duration of the cable work, as well as for each permit application that is submitted in respect of excavation and TA plans.
- Whether planned standard-raising measures exist (*asphalt laying programme*) in the area where the cable work is to be performed.
- Ongoing charges for the right to route cables in municipal land, often as a sum per year and metre of laid cable.
- Handling of restoration that is performed long after the work has been carried out, e.g., asphalt and grass in the winter.

3.5 TA plan

A traffic arrangement plan (TA plan) includes details about roadworks and how they are to be signalled. The TA plan regulates which road signs, road closures and protective arrangements are to be present at the road work site, and must include sketches regarding how the contractor should create a safe workplace for road users and personnel. The Roads Act, which deals with public roads, construction and operation, states that measures may not be carried out within a road area without the permission of the road management authority.

A TA plan must be drawn up in accordance with regulations from private, municipal or national road operators and in accordance with applicable legal requirements. For the Swedish Transport Administration, the requirements for traffic and protective devices are set out in a conditional appendix to the decision on Permission for the placement of telecommunication lines. All those who work within a road or street area must always ensure that there is a TA plan for the workplace, and that it has been drawn up in accordance with applicable permits and legal requirements.

3.6 Work environment

The principal (client or network owner) has basic responsibility for the work environment. Responsibility for the work environment may be delegated to another party by agreement. In the case of a fibre installation project, the network owner may agree in writing with a contractor regarding taking over the role of principal.
The principal is responsible for appointing a Construction work environment coordinator for planning and design (BAS-P) and a Construction work environment coordinator for execution (BAS-U). The principal is also responsible, together with the BAS-P, for drawing up a Work environment plan.
The Work environment plan must be present at the workplace and all those who work at the site must be aware of the Work environment plan and must know where it is.

3.7 Environment

Machinery and vehicles must be environmentally classified, approved, CE marked and inspected.

The Swedish Transport Agency is responsible for matters relating to exhaust regulations, noise regulations for work machines and provisions regarding vehicle fuel.
The exhaust requirements for tractors and work machines have been introduced jointly in the EU. These rules are set out in directives 97/68/EC (for work machines) and 2000/25/EC (for tractors). The directive for work machines also covers small, petrol-driven engines for e.g., lawn mowers, chainsaws, etc.

Environmental considerations must be a factor when choosing the fibre routing method. A few things to consider:

- Minimise transport of e.g., excavated material and relocation of machinery.
- Plan the storage of excavated material during the project in order to reduce transport.
- If possible, select machinery with low emissions.
- Contaminated excavated material must be transported to a landfill site.
- The work area must be kept clean and any soiling must be prevented. Waste water, clay, concrete or chemicals may not be diverted to storm drains.
- Sort residual products at source and make sure that land and water are not contaminated with petrol, oil or equivalent.
- Contractors are responsible for cleaning streets/roads that have been soiled due to the work.
- Bear in mind noise levels, particularly in the case of machinery that is stationed at the same location for an extended period, e.g., compressors.
- Exercise vigilance during activities that generate a large amount of dust.

In certain areas and cities there are specific environmental requirements, e.g., when working for the Swedish Transport Administration and within Stockholm, Gothenburg and Malmö. Always check applicable local rules and regulations.

Some routing methods are more effective from an environmental perspective than others. Skanova has ordered a masters dissertation, which has been carried out by Shan Solivan at the Royal Institute of Technology.

The work can be found here: *Life Cycle Assessment on fibre cable construction methods*
http://kth.diva-portal.org/smash/get/diva2:839631/FULLTEXT01.pdf

The conclusion is that the method with the least potential environmental impact is ploughing in green spaces, and it is generally best to avoid routing in asphalt. In asphalt, the methods that produce the least excavated material are the most environmentally friendly, such as groove cutting.

3.8 Subsequent survey on site

When the fibre installation is completed and restoration of the work area has been conducted, a new survey is conducted on site by representatives of the client and the contractor, as well as affected land owners/road operators.
The representative of the client should contact affected land owners/road operators before this takes place in order to obtain any opinions about how the contractor has conducted the implementation and restoration.

The review is reported and documented with film and photographs in order to demonstrate any differences between before and after execution. The report is signed by the relevant land owner and the Inspector attaches the report to the final inspection report.

3.9 Warranties

Local regulations for restoration vary between different local authorities, land owners and road operators. Always check applicable local rules and regulations.

With certain land owners, the contractor itself can perform the restoration and then provides a warranty. At others, the land owner itself will conduct restoration, and the client will often also have to pay a fee for future maintenance.

The warranty period is regulated in AB 04 General conditions of contract for building and civil engineering works and building services, Chapter 4 Section 7, as well as ABT 06 General conditions of contract for design and construct contracts for building, civil engineering and installation works, Chapter 4 Section 7.

AB 04 states that the Warranty period is 5 years for the contractor's work performance and 2 years for materials and goods.

ABT 06 states that the Warranty period is 5 years for the contract. For specific material or specific goods (makes) prescribed by the client, the Warranty period is 2 years.

However, these terms in AB 04 / ABT 06 can be changed in agreements, so other warranty periods may apply in individual cases.

3.10 Consultation with County Administrative Board

According to Chapter 12 Section 6 of the Environmental Code, specific instructions regarding consultation must be followed when working in natural and cultural areas. This applies for example at watercourses, archaeological sites, alleys, unsuitable land, unique vegetation, cultural monuments, nature reserves, etc.
Consultation according to Chapter 12 Section 6 of the Environmental Code is handled by the County Administrative Boards. More information can be obtained from the Country Administrative Board in the relevant county.

3.11 Drainage in farmland

When routing in farmland, particular consideration must be given to the drainage in the land. Prior to excavation, the land owner must be asked about the depth at which the land's drainage is located and must specify the depth at which the fibre installation's ducts may be routed.
This is particularly important when ploughing, as it is difficult to see whether existing drainage is damaged during the work.

3.12 Trees, roots and vegetation

Local regulations must be complied with, although it is generally not permitted to excavate within a tree's drip zon. The principal is responsible for trees and plants that are affected by the work not sustaining damage.

- When working close to roots or other vegetation, it is important to take care. Manual excavation or suction excavation should ideally be used when there is a risk of damaging vegetation.
  - Avoid compacting and driving heavy vehicles close to trees.
  - Avoid storing material close to trees.

Trees or bushes may not be felled without the land owner's consent. Any required pruning of trees and bushes must be carried out in a professional manner.

4. EXCAVATION-FREE METHODS

4.1 Microtrenching

Also known as micro-ditching or groove cutting.

MINIMUM REQUIREMENTS IN CASE OF MICROTRENCHING:

- The contractor must define the depth of existing infrastructure, ideally performed using ground-penetrating radar or physical inspection by means of excavation.
- Backfill height in accordance with *"Instructions for Robust Fiber"*

4.1.1 Method

The machine has a unit with a sawblade which, at a high blade rotation speed, cuts through the surface layer and underlying layers. The outer edge of the sawblade comprises segments containing diamonds. The material that is cut away is broken down into sand/dust.
This method requires careful staking and planning, as everything in the sawblade's way is cut off. Ground-penetrating radar must be used before the machine, or a physical inspection by means of excavation must be performed before starting the work, to ensure that there is no risk of damaging existing cables.

Example of ground-penetrating radar

4.1.2 Machinery

Specially adapted machinery with a unit for the sawblade.
A trailer carrying duct (drums) is normally used, which is pulled after the machine. A smaller cutting machine that departs from the main line in towards properties.

Compacting machine when refilling with sand. The machine has a wheel that is guided in the cut groove and uses pressure to compact the refill material in the groove.
When refilling with foam concrete (aerated concrete), a special machine is used to perform refilling. No compaction is required when the cut groove is filled with foam concrete.

A sweeping machine may be required to clean the asphalt around the cut groove prior to sealing. Machine for sealing (bitumen pot) the cut groove.

4.1.3 Tools

Sawblades are available in various dimensions. For example, a sawblade with a diameter of 1 m can cut to a depth of approx. 38 cm.

Blade diameter	Excavation depth (approximate)
800 mm	28 cm
900 mm	32 cm
1000 mm	38 cm

Examples of sawblades

4.1.4 Suitable environment

Hardened surface (asphalt).
Also works well in rock to some extent.

4.1.5 Advantages

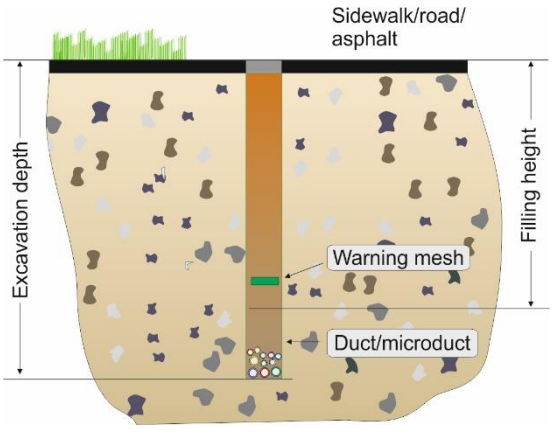
- Little impact on the street, resulting in small road closures.
- Suitable for large excavation lengths in asphalted surfaces.
- Rapid routing, which ensure less disruption for residents and road users.
- Can be used all year round and also works well in frozen ground. This method actually works better in frozen ground, as there is less risk of material falling down into the cut groove when it is frozen.
- Can route microducts without problems. As the groove is narrow, there are more or less no problems routing microducts flat.

4.1.6 Restrictions (Disadvantages)

- Large turning radius when cutting with blade.
- Small wheels on the machine can damage the ground.
- The method can give off a lot of dust.
- The method is noisy.
- Stipulates considerable demands regarding staking.
- An excavator may be required at intersections with other cables, as well as when positioning cabinets/optical fibre chambers.
- The narrow cut groove limits the number of microducts that can be routed in the same groove before reaching the ceiling for the backfill height.

4.1.7 Excavation

The cut groove is 15–30 mm wide, depending on the width of the sawblade. The excavation depth is up to approx. 40 cm and is dependent on the diameter of the sawblade.



Examples of excavations

4.1.8 Excavated material

The excavated material is turned into finely crushed sand or rock dust. The material is placed to one side and swept up, before then being removed.

4.1.9 Duct bedding

There is no duct bedding. The bottom is sufficiently smooth without duct bedding.

4.1.10 Backfilling

Backfill must comprise 2–5 mm of dry sand.
Foam concrete (aerated concrete) is also used as backfill material. In the winter, refrigerant is mixed with the foam concrete to prevent freezing.

4.1.11 Refilling

Refilling must comprise 2–5 mm of dry sand, which is compacted in the cut groove. Foam concrete (aerated concrete) is also used for refilling.

4.1.12 Restoration

The surface is restored using bitumen in the cut groove. Asphalting is not required.

Example of restoration after microtrenching

4.1.13 Environmental impact

Relatively small machines and rapid routing produce low emissions. A small volume of excavated material needing to be transported to/from the routing site results in low emissions from transport.

Work environment:

- This method is dusty and noisy.

4.1.14 Duct type

Smaller ducts in dimensions up to approx. 18 mm.
Routing of single ducts (individual microducts) works well as the cut groove is narrow, and there is consequently little risk of the ducts not ending up flat.

4.1.15 Duct routing

Ducts are routed with a duct layer directly from the machine. Drums holding duct may be present on the machine or on a trailer being pulled after the machine.

Search wire is laid in the bottom or directly above the ducting. Marking mesh or other marking (e.g., coloured concrete) is laid in the refill material above the ducts.

4.2 End milling

Also known as infratrenching or minitrenching

MINIMUM REQUIREMENTS REDGARDING END MILLING:

- Ground-penetrating radar must be used or a physical inspection by means of excavation.
- Backfill height in accordance with Instructions for Robust Fiber.

4.2.1 Method

The ground is milled with a milling wheel with carbide bits.
The machine has a unit with a milling wheel that rotates at a relatively low speed. The milling wheel passes through the surface layer and underlying layers. The material that is milled away is broken down into gravel/sand.
This method requires careful staking and planning, as everything in the milling wheel's way is cut off. Ground-penetrating radar must be used before the machine, or a physical inspection by means of excavation must be performed before starting the work, to ensure that there is no risk of damaging existing cables.

Example of end milling

4.2.2 Machinery

Specially adapted machinery with a unit for the milling wheel. Alternatively, an excavator with the unit mounted on the excavator's arm is used.
A trailer carrying duct (drums) is normally used, which is pulled after the machine. A smaller cutting machine that departs from the main line in towards properties.

Machine for refilling. The excavated material from the milling operation is normally reused for refilling. Compacting machine with compacting wheel is used to compact the refill material. The machine has a wheel that is guided in the milled groove and uses pressure to compact the material in the groove.
Face mill for milling down the asphalt edge alongside the milled groove in order to obtain a better attachment surface when laying asphalt on top. A sweeping machine may be required to clean the surface prior to asphalting.
Machine for asphalting and bonding the asphalt edge.

Example of machine with milling wheel

4.2.3 Tools

Milling wheel with carbide bits.
Milling wheels are available in various dimensions. For example, a milling wheel with a diameter of 1 m can mill down approx. 38 cm.
A suitable milling wheel size for FTTH is a diameter of 0.8–1.4 m.

Milling wheel diameter	Excavation depth (approximate)
800 mm	28 cm
900 mm	32 cm
1000 mm	38 cm

Examples of milling wheel

4.2.4 Suitable environment

Hardened surface such as asphalt. Gravel roads and green spaces also work well. The method can also be used in soft soil types.

4.2.5 Advantages

- Little impact on the street, resulting in small road closures.
- Suitable for large excavation lengths in asphalted surfaces.
- Rapid routing which produces less disruption for residents and road users.
- Can be used all year round and also works well in frozen ground. The method actually works better in frozen ground, as there is less risk of material falling down into the milled groove when it is frozen.

- Can route a large number of ducts of various dimensions.
- Possible to conduct collocation with other cable owners, e.g., street lighting.
- Also works well when turning around e.g., street corners.

Example of end milling around a street corner

4.2.6 Restrictions (Disadvantages)

- Risk of stones spraying up, depending on ground conditions. The edge of the asphalt can then be destroyed.
- Face milling around the milled groove is required in order for restoration to be successful.
- Edge cutting of asphalt edges may be required after milling.
- The method can give off a lot of dust.
- The method is noisy.
- Places considerable demands for staking (ground-penetrating radar must be used or physical inspection by means of excavation before starting work).
- An excavator may be required at intersections with other cables, as well as when positioning cabinets/optical fibre chambers.

4.2.7 Excavation

The milled groove is approx. 28–150 mm wide and is dependent on the width of the milling wheel. The excavation depth is up to approx. 45 cm and is dependent on the diameter of the milling wheel.

4.2.8 Excavated material

The material is placed to one side of the milled groove and reused for refill. Stones are removed and new backfill material is obtained.

4.2.9 Duct bedding

There is no duct bedding. The bottom is sufficiently smooth without duct bedding.

4.2.10 Backfilling

Excavated material is normally reused as backfill. May need to be supplemented with 0–18 mm rock dust.

4.2.11 Refilling

Excavated material is normally reused for refilling. May need to be supplemented with 0–18 mm rock dust. The groove is compacted with a compactor wheel.

Example of compactor wheel

4.2.12 Restoration

Restoration is performed by face milling the surface 10–20 cm on either side of the milled groove. Other local requirements regarding restoration may occur and must then be followed.

Asphalt is brushed clean prior to asphalting. Asphalting takes place over the milled groove and the face milled area beside the groove. Asphalt edges are sealed with cement.

Final result after restoration in the case of end milling

4.2.13 Environmental impact

Relatively small machines and rapid routing produce low emissions. Little transport of excavated material to/from the routing site.

Work environment:

- This method is dusty and noisy.

4.2.14 Duct type

All dimensions of ducts up to approx. 110 mm.
Less suitable for single ducts (microducts) over extended distances due to the width of the milled groove. There is a risk of single ducts ending up in waves, which can make fibre blowing more difficult. This method is more suitable when routing multi-ducts.

4.2.15 Duct routing

Ducts are routed with a duct layer directly from the machine. Drums holding duct may be present on the machine or on a trailer being pulled after the machine. Ducts can also be routed manually in the milled groove after milling.

Search wire is laid in the bottom or above the duct. Marking mesh is placed in the refill material above the ducts.

4.3 Ploughing

MINIMUM REQUIREMENTS WHEN PLOUGHING:

- In the case of stony ground, the duct must be further protected with e.g., an outer protective duct or by using thicker walls for the duct.
- Backfill height in accordance with "*Instructions for Robust Fiber*"

4.3.1 Method

A machine has a plough with a blade that is driven down into the ground. The machine pulls the blade, either static or vibrating, through the ground. Duct runs through a laying tube behind the blade and is routed at the same time as the blade is pulled through the ground. The plough's blade creates only a narrow groove in the ground, and as a result there is usually no need for refilling or restoration, as the groove closes up on its own.
In order to make ploughing easier, a frost hook can sometimes be used to pre-plough before ploughing in the ducting.

There are also pulling ploughs. With these, the plough pulls the duct through the ground. Pulling ploughs are only suitable for short distances.

Example of ploughing

4.3.2 Machinery

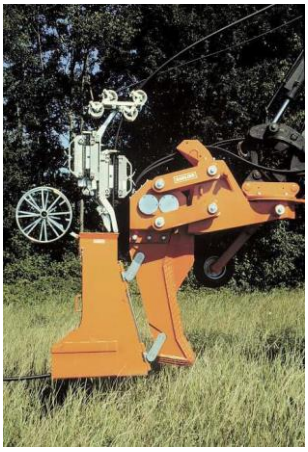
Machines of various sizes are available that have been specially adapted for ploughs. It is also possible to connect a plough to an excavator or backhoe loader.
The size of the machine is adapted to the space, the depth and the environment where ploughing is taking place. Machines range from approx. 0.6 tonnes up to 25 tonnes.
It is also possible to winch a plough for short distances.

4.3.3 Tools

Cable ploughs:
Routing of ducts takes place by the ducts being wound directly from a cable drum and placed in the ground through a laying tube directly behind the plough.

- Static plough: The plough is pulled behind a machine.
- Vibrating plough: The plough is pulled behind a machine at the same time as it vibrates, thereby reducing friction against the ground. This makes it easier to move stones.

Ploughs are available in various sizes that are suitable for various depths and dimensions of ducts.



Example of static plough and vibrating plough

Pulling ploughs:

Routing takes place by the duct being pulled through the ground from a particular point with the aid of the plough.

- Plough that pulls duct through the ground. Suitable for building land, but only for short distances.

4.3.4 Suitable environment

This method can be used in soft surfaces and soil types.
In certain cases, it is also possible to plough in roads if the asphalt is cut away first.

4.3.5 Advantages

- Rapid routing.
- Little damage to other cables as the method must not be used close to existing cables.
- Cost-effective routing.

4.3.6 Restrictions (Disadvantages)

- Not good in the case of stony ground, ground containing roots, by existing cables or drains, and cannot be used in hard ground.
- Difficult to see whether existing cables or drains have been damaged in conjunction with routing.
- In the case of stony ground, the duct must be further protected with e.g., an outer protective duct or by using thicker walls for the duct.

4.3.7 Excavation

It is recommended to perform pre-ploughing prior to routing ploughing. Pre-ploughing can be performed e.g., using a frost hook.
The backfill height in the event of ploughing must be at least in accordance with "*Instructions for Robust Fiber*".

4.3.8 Excavated material

Large stones and roots are removed.

4.3.9 Duct bedding

There is no duct bedding.

4.3.10 Backfilling

Gravel can be added in the furrow in order to backfill around ducts more effectively.

4.3.11 Refilling

Large stones are removed.

4.3.12 Restoration

The furrow can be pressed down with the machine's bucket or wheel/caterpillar track.

4.3.13 Environmental impact

Little environmental impact with extremely effective routing.

Work environment:

- Risk to the person conducting routing of duct in the furrow when the machine is being operated.

4.3.14 Duct type

This method is suitable for routing hoses of all dimensions intended for direct routing in the ground.
Less suitable for single ducts (microducts) over extended distances in the furrow. There is a risk of single ducts ending up in waves, which can make fibre blowing more difficult. This method is more suitable when routing multi-ducts or thicker dimensions of ducts.

When ploughing in ground in which there are stones, ducts with a greater wall thickness or double ducts must be routed, for example a 16/12 duct routed in a 40/32 duct.
It is up to the contractor to determine when there is sufficient protection for the fibre optic cable.

4.3.15 Duct routing

Ducts are routed directly during ploughing via a laying tube installed on the plough.
Drums of duct are transported on the machine.

Crossings with existing cables are exposed by creating a pit around them before crossing takes place. The furrow can be sanded in conjunction with pre-ploughing to make the furrow easier to plough and to establish backfill around the ducts and thereby less risk of damage to the ducts.
Ducts must be wound in accordance with the manufacturer's instructions.

Search wire is laid in the bottom or above the duct. Marking mesh is placed in refill material above the ducts.

4.4 Chain excavation

Also known as milling excavation.

MINIMUM REQUIREMENTS IN THE CASE OF CHAIN EXCAVIATION:

- Backfill height in accordance with *"Instructions for Robust Fiber"*

4.4.1 Method

The ground is dug up with scoops (blades) that are mounted on a chain.
Can be a specially adapted machine or a unit installed on an excavator or backhoe loader.
This method requires careful staking and planning.

Example of chain excavation with a smaller machine

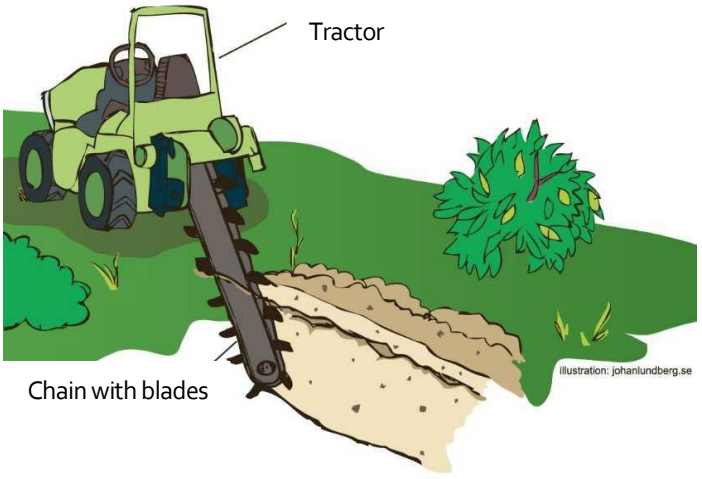
4.4.2 Machinery

Machinery is available that is specially adapted with a unit for milling excavation. Units are also available for installation on an excavator or backhoe loader.
Machinery is available in various sizes, from small machines suitable for building land around properties to large machines for e.g., farmland.

Trailer with drums for ducts.
Machinery for refilling and restoration.

4.4.3 Tools

- Unit with chain that has scoops (blades).
- Refilling blade for filling in the milled groove.



Example of chain excavation

4.4.4 Suitable environment

This method works well in soft soil types, e.g., building land around properties, fields, along forest roads, etc.

4.4.5 Advantages

- Rapid routing.
- Potential to see damaged drains and cables (compared to ploughing).
- Potential to route a large number of ducts of various dimensions.
- Good method for collocation with other cable owners.

4.4.6 Restrictions (Disadvantages)

- Risk of stones spraying up, depending on ground conditions (personal injury).
- The method is noisy.
- Does not work in stony ground, moraine, rock, asphalt or hard surfaces.
- An excavator may be required at intersections with other cables, as well as when positioning cabinets/optical fibre chambers.

4.4.7 Excavation

The excavated trench is between 100–250 mm wide.
Depending on the machine, the excavation depth is up to approx. 100 cm (there are machines that can manage considerably deeper).

4.4.8 Excavated material

Placed to one side and used for refilling. Stones are transported away.

4.4.9 Duct bedding

Not normally required as the bottom is smooth.

4.4.10 Backfilling

Excavated material is normally reused as backfill.

4.4.11 Refilling

Excavated material is normally reused for refilling.

4.4.12 Restoration

The excavated material is pushed back into the excavated trench, which is then compacted by the machine.

4.4.13 Environmental impact

Rapid routing with relatively small machines and little need for transport results in low emissions.

Work environment:

- The method is noisy.
- Risk of stones spraying up.

4.4.14 Duct type

All dimensions up to approx. 110 mm.
Less suitable for single ducts (microducts) over extended distances in the milled groove. There is a risk of single ducts ending up in waves, which can make fibre blowing more difficult. This method is more suitable when routing multi-ducts or thicker dimensions of ducts.

4.4.15 Duct routing

Can be routed with a duct layer directly from the machine. Drums on the machine or on a following trailer. Ducts can also be routed manually after the machine.

Search wire is laid in the bottom or above the duct. Marking mesh is placed in refill material above the ducts.

4.5 Suction excavation

MINIMUM REQUIREMENTS IN THE CASE OF SUCTION EXCAVIATION:

- Backfill height in accordance with "Instructions *for Robust Fiber*"

4.5.1 Method

Powerful suction that draws material up out of the ground.
Suitable method for making holes or excavating close to trees with roots or other sensitive cables.

In order to facilitate suction, water can be applied to loosen up the material.
This method is suitable for cleaning around existing ducts via suction.
Take care if the duct is damaged, as this can entail a risk of material being drawn into the duct.

Example of suction excavation by existing cables

4.5.2 Machinery

Special machine that resembles and works like a large vacuum cleaner.
There are various models, where the smallest machines can fit on a trailer, up to large machines that require a truck.
Can also apply water from a water tank in order to loosen up the soil, which makes suction easier.

4.5.3 Tools

- Suction hose with various types of nozzles

Examples of suction excavation

4.5.4 Suitable environment

Only works in soft soil types.
Excellent method around sensitive ducts (gas, electricity, water, etc.), roots and close to building walls. Can suction up material following other methods, e.g., in the case of microtrenching.

4.5.5 Advantages

- Good method when positioning cabinets and optical fibre chambers.
- Easy to collect excavated material.
- Excavation around sensitive cables, roots and vegetation.
- Good for making small excavation holes or pits.
- Suitable for cleaning existing ducts and optical fibre chambers.

4.5.6 Restrictions (Disadvantages)

- Difficult if the material is too coarse.
- Does not work in frozen ground.
- The size of the container limits the amount that can be suctioned up before emptying is required.

4.5.7 Excavation

Excavation is performed by means of suction through a nozzle. The nozzle can be changed for different needs. Used to make holes or suction around other cables or roots.

4.5.8 Excavated material

Ends up in a container that is installed on/by the machine.

4.5.9 Duct bedding

Not applicable.

4.5.10 Backfilling

Not applicable.

4.5.11 Refilling

Excavated material is used for refilling. Emptied from the machine back into the hole.

4.5.12 Restoration

Restoration of pit by means of refilling.

4.5.13 Environmental impact

The environmental impact is small with relatively small machines.

Work environment:

- This method is relatively noisy.

4.5.14 Duct type

Can be used when positioning cabinets and optical fibre chambers.

4.5.15 Duct routing

Not a method for routing ducts.

4.6 Pressing

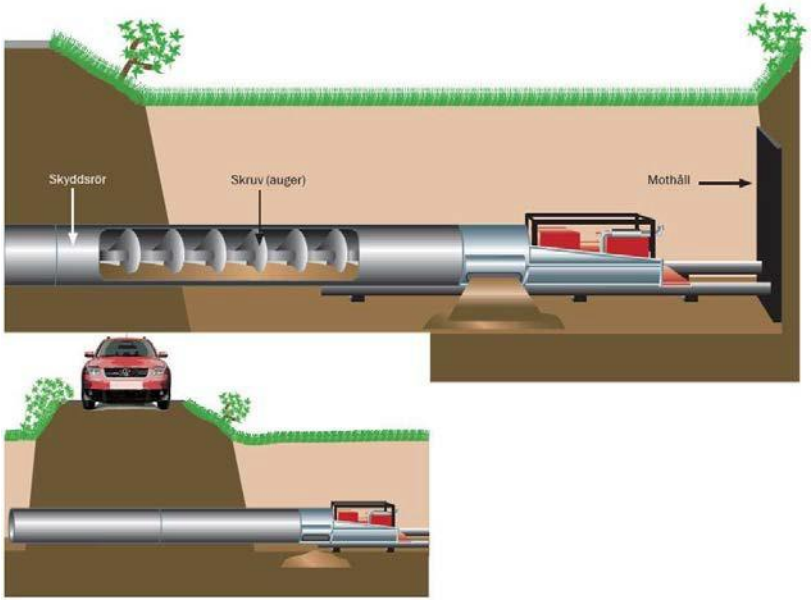
Can also be referred to as auger boring (auger pressing).

MINIMUM REQUIREMENTS WHEN PRESSING:

- Backfill height in accordance with *"Instructions for Robust Fiber"*

4.6.1 Method

Presses a steel duct (casing duct or protective duct) from one point to another. The casing duct remains in the ground and ducts are then placed in it.
This method works well up to approx. 15 metres. It is not possible to steer or change direction during pressing. A bank or pit is required at either end in order to access with the machine.



Example of auger boring

4.6.2 Machinery

For smaller dimensions and short distances, e.g., under a wall, an excavator with a normal bucket or a specially adapted tool for pressing will work.
Specially adapted rigs designed solely for pressing are also available, as shown above. Usually used in large dimensions.

4.6.3 Tools

Casing duct made of steel that is pressed through the ground.
Diameters of up to approx. 200 mm are available for fibre installations. Casing ducts are available in several different dimensions. Avoid using ducts that are not intended for use as casing ducts.

4.6.4 Suitable environment

Soft soil types.
Works well under small roads, pedestrian and cycle paths, under walls, etc.

4.6.5 Advantages

- Fast, simple routing. There are often already machines on site that can handle pressing.
- Simple restoration solely of pits.
- Little traffic disruption during routing.
- Does not affect the road surface and entails no risk of future bumps.

4.6.6 Restrictions (Disadvantages)

- Cannot be steered and there is no control of direction (risks coming up in the middle of a road).
- Only works over short distances.
- The casing duct must be intended for the purpose. Not appropriate to use ducts intended for purposes other than pressing.
- Does not work in stony ground, as there is a risk of the casing duct turning if it hits a stone.
- There must not be any other cables in the ground.

4.6.7 Excavation

Pits are made at either end. Check with the land owner or road operator where pits may be dug. For example, there may be a requirement regarding a certain distance from the road.

4.6.8 Excavated material

Placed beside the pit and used for refilling.

4.6.9 Duct bedding

Not applicable.

4.6.10 Backfilling

Not applicable.

4.6.11 Refilling

The pits are refilled using existing material.

4.6.12 Restoration

The pits are restored using existing material.

4.6.13 Environmental impact

Has little environmental impact.

Work environment:

- Risk of collapse into pits and crushing injuries.

4.6.14 Duct type

Ducts in the casing duct in dimensions up to approx. 110 mm.

4.6.15 Duct routing

Duct is pushed or pulled through the casing duct.
It is recommended to fill the casing duct with ducts immediately after installation. Search wire is routed in the casing duct.

4.7 Impact mole

MINIMUM REQUIREMENTS WHEN ROUTING WITH AN IMPACT MOLE:

- Backfill height in accordance with *"Instructions for Robust Fiber"*

4.7.1 Method

Compressed air-driven impact mole with a piston that drives the mole through the ground. The compressed air hose follows along behind the impact mole.
Duct can be pulled along directly behind the impact mole or the impact mole can be reversed with duct from the other direction.
Suitable for short distances up to approx. 15 metres.
A pit is dug first at either end. The impact mole is then placed in one pit and targeted at the other pit. It is important to target correctly from the outset in order to end up in the pit at the other end, as the impact mole cannot be steered.

Routing with impact mole

4.7.2 Machinery

- Compressor for driving.
- Excavator for digging pits.

Example of impact mole with peripheral equipment

4.7.3 Tools

Impact moles are available in diameters ranging from approx. 50 mm up to approx. 150 mm. The length varies from approx. 700 mm up to approx. 1500 mm.

In order to route a 110 mm duct, a 130 mm impact mole is required.

Example of impact mole

4.7.4 Suitable environment

Soft soil types.
Works well over short distances such as under pedestrian and cycle paths, walls, building land around properties, under paved garage entrances and patios, etc.
Larger impact moles can be operated in coarser material. The smaller the impact mole, the finer the material. As a rule of thumb, the routing depth must be at least 10 times the diameter of the impact mole.

4.7.5 Advantages

- Fast and simple method.
- The shortest route can be selected.
- There are often machines already on site.
- Simple, minimal restoration.
- Does not affect the road surface (no future bumps).

4.7.6 Restrictions (Disadvantages)

- Cannot be steered.
- Not possible to measure the depth.
- Not possible to route marking mesh at a distance above ducts.
- Must not be used close to other cables.
- Can create bump in the ground surface if routed too shallow.
- Does not work in stony ground.

4.7.7 Excavation

Pits at either end.

4.7.8 Excavated material

Used for refill material in the pits.

4.7.9 Duct bedding

Not applicable.

4.7.10 Backfilling

Not applicable.

4.7.11 Refilling

Excavated material in pits.

4.7.12 Restoration

Only restoration of pits.

4.7.13 Environmental impact

Little environmental impact as only pits are dug.

Work environment:

- Risk of collapse into pits.

4.7.14 Duct type

Works well for ducts up to approx. 110 mm.

4.7.15 Duct routing

Duct can be pulled directly behind the impact mole or the impact mole can be reversed and pull duct on the way back.
A good method is to pull a thicker duct directly with the impact mole. A microduct is then placed in the thicker duct, and fibre optic cable is blown into the microduct.

Search wire is laid along with ducts. Marking mesh is pulled along and laid above the ducts.

4.8 Directional drilling

There are three categories that are used for directional drilling:

- Directional drilling (traditional). Used in soft soil types.
- Directional drilling with roller type bit (also known as AT drilling *).
  Used in mixed material, e.g., moraine.
- Directional drilling with pneumatic hammer. Used in rock.

(*) AT stands for All Terrain. Despite this, the method is not suitable for all material, such as excavated stone and eskers.

Approx. 90% of all directional drilling takes place in soft soil types (traditional directional drilling).

MINIMUM REQUIREMENTS FOR DIRECTIONAL DRILLING:

- Measurement must be conducted to ascertain position and depth. (X and Y coordinates). The depth of laying with a reasonable number of measuring points shall be indicated in a drilling protocol.
- Backfill height in accordance with "*Instructions for Robust Fiber*".

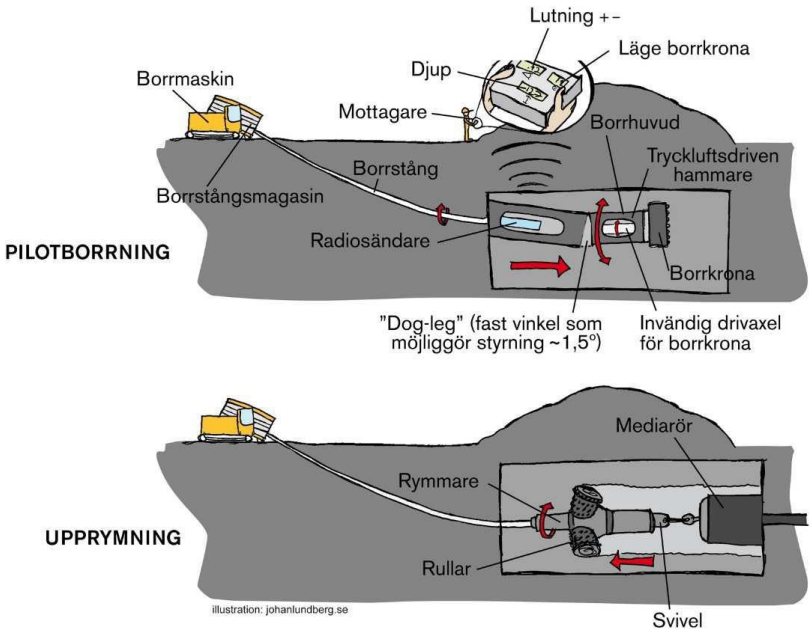
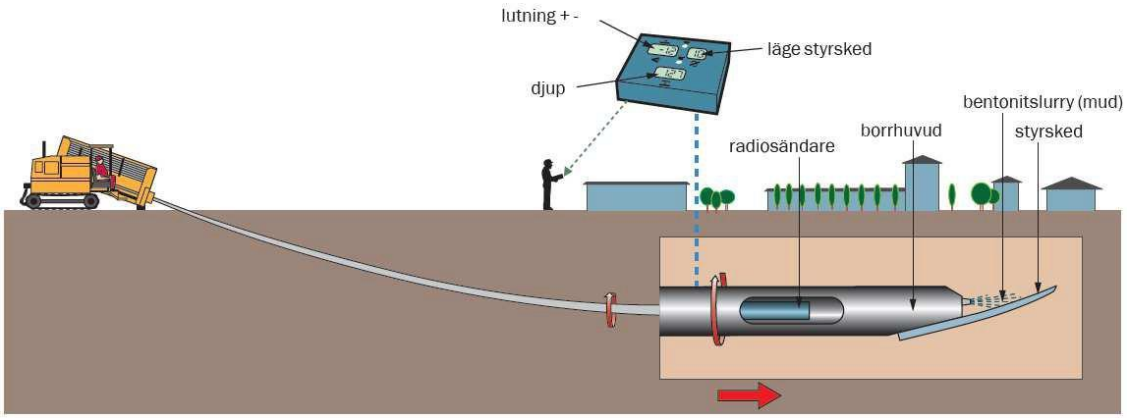


Illustration showing AT drilling (Note: Swedish example)

8.1 Method

Normal traditional directional drilling is described here.
A pilot rod is drilled forwards in the ground along a predetermined line. The position of the drill head is checked with a built-in radio transmitter and guided with an angled steering head. After drilling, the pilot rod is pulled back again. A hole opener is then installed on the pilot rod, which is used to widen the drill hole at the same time as pulling the media duct (duct) into the drilled hole.
It is possible to use this method over distances of up to approx. 1,500 metres.

In the case of directional drilling, it is important to measure the location of the actual duct, not that of the pilot. The position of these can vary quite considerably.



Example of directional drilling (Note: Swedish example)

4.8.2 Machinery

- Special drilling machines for horizontal directional drilling. The size of the machine is measured in terms of pulling force (tonnes).
- Excavator for pits.
- Truck with mixer and pump for drilling fluid (bentonite slurry).
- Sludge suction device for suctioning drilling fluid.
- Compressor (for pneumatic hammer).

Example of directional drilling

4.8.3 Tools

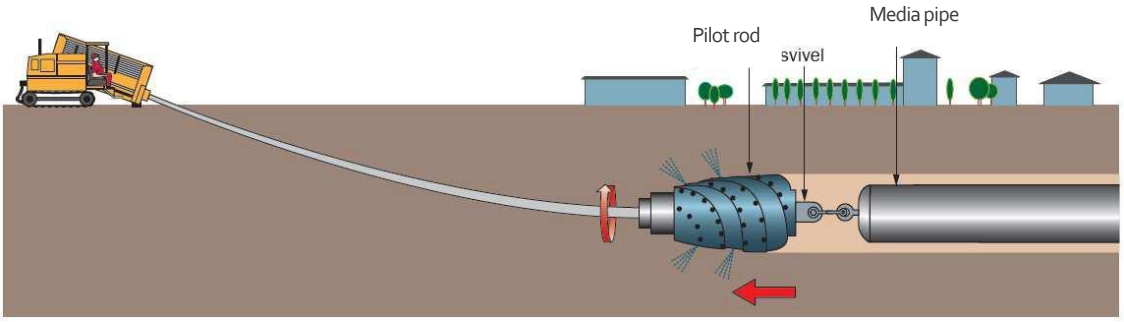
Different tools depending on drilling method.

- Different drill bits depending on method, e.g., roller type bit.
- Drilling head (steering head)
- Hole opener
- Pneumatic hammer
- Search tools for determining position during drilling
- DGPS for measuring position in XYZ axes.

Example of drill bit

Pilot rod with steering head

Hope opener installed on pilot rod



Example of directional drilling when the media duct (duct) is pulled back with a hole opener.

4.8.4 Suitable environment

- Directional drilling (traditional) in soft soil types.
- Directional drilling with roller type bit / AT drilling in mixed material, e.g., moraine.
- Directional drilling with pneumatic hammer in rock.

This method is very suitable for use when passing under roads, watercourses, railways, sensitive environments (parks, trees, nature areas, near animals, archaeological sites). Very well suited for creating land attachments when routing in lakes and watercourses.

4.8.5 Advantages

- Drilling below farmland in order not to disturb the layers of soil.
- When crossing roads to ensure little disruption and no impact on the surface layer.
- Drilling beneath sensitive areas (plants, animals, parks, etc.).
- Possible to conduct routing without a water court ruling when drilling below the bottom of watercourses.
- Rapid routing.
- Small drilling rigs suitable on building land.
- Collocation with other cable owners.

4.8.6 Restrictions (Disadvantages)

- Expensive setup cost for short distances and individual drilling operations.
- Ducts cannot be accessed afterwards if drilling performed at depth.
- Stipulates demands regarding ducting dimensions (tensile strength) in the case of extended distances.
- Considerable demands regarding location of other cables.
- Severe cold, as the drilling fluid freezes below approx. -15°C.
- The machine and pits take up a relatively large amount of space.
- Handling drilling fluid that should be collected.

4.8.7 Excavation

Pits are required at either end. The size and depth of the pits depends on the type of machine being used and the incline and depth of drilling.
It is possible to drill approx. 500–700 mm below a hardened surface (asphalted) and below roadbeds without affecting the surface layer.

4.8.8 Excavated material

Reused for refilling.

4.8.9 Duct bedding

Not applicable.

4.8.10 Backfilling

Not applicable.

4.8.11 Refilling

Refilling of pits with existing material.

4.8.12 Restoration

Restoration of pits.

4.8.13 Environmental impact

Little in relation to other methods.
Possible to avoid long excavation distances where excavations have previously detoured around obstacles.

Work environment

- The method is noisy.
- Risk of collapse into pits.

4.8.14 Duct type

All lengths and dimensions.
Requires considerable tensile strength for ducts over extended distances.

4.8.15 Duct routing

Duct is pulled back after drilling with pilot rod.

Search wire is laid along with ducts.

Marking mesh is laid above the ducts.

4.9 Hammer drilling

Also known as casing drilling.

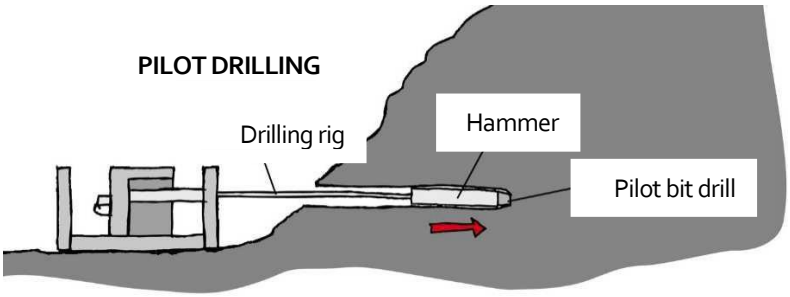
MINIMUM REQUIREMENTS FOR HAMMER DRILLING:

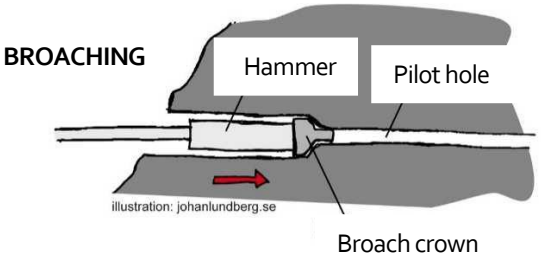
- Measurement must be conducted to ascertain position and depth. (X and Y coordinates). The depth of laying with a reasonable number of measuring points shall be indicated in a drilling protocol.

4.9.1 Method

A compressed air-driven hammer drills through the rock and pulls along a casing (protective duct). This method is dry, i.e. no drilling fluid is required. Used from diameters of approx. 130 mm up to approx. 1200 mm.

Casings are made of steel and form the outermost ducting, in which ducts are then routed.



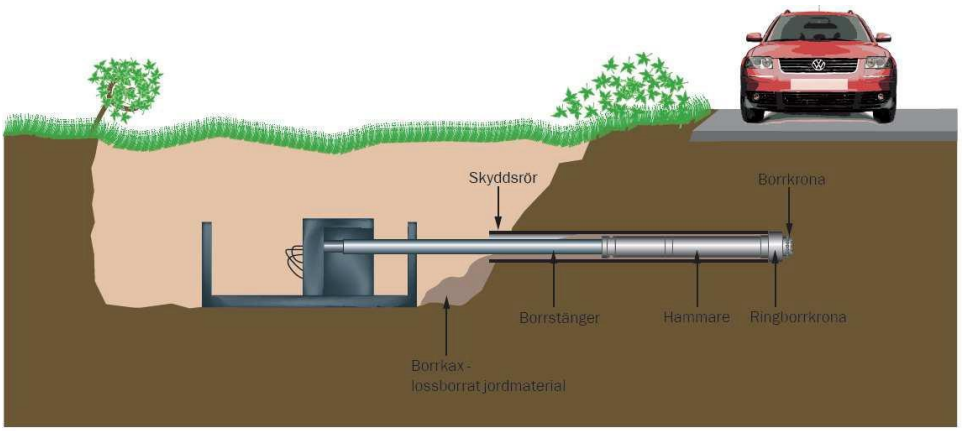


4.9.2 Machinery

- Horizontal beam with counterhold and powerful compressor. Often a specially built machine.
- A truck with a crane is required to lift the machine into place.
- Excavator for pits at either end.

4.9.3 Tools

Down-the-hole hammer (piston hammer) that strikes a pilot bit.



Example of hammer drilling. (Note: Swedish example)

4.9.4 Suitable environment

Works well in solid rock, moraine, excavated stone and in land containing boulders.

4.9.5 Advantages

- Passes through most things, apart from steel.

4.9.6 Restrictions (Disadvantages)

- Cannot be steered.
- The max. length is approx. 40 m.
- Long setup time prior to drilling.
- Large pits at the ends.

4.9.7 Excavation

Pits at either end.

4.9.8 Excavated material

Reused for refilling pits.
Gravel excavated from the drill hole is transported away or used for refilling pits. The volume is approx. 1.7 times larger than the volume of the drill hole.

4.9.9 Duct bedding

Not applicable.

4.9.10 Backfilling

Not applicable.

4.9.11 Refilling

Refilling of pits with existing material.

4.9.12 Restoration

Restoration of pits.

4.9.13 Environmental impact

Work environment:

- The method is noisy.
- When drilling in pure rock, a large amount of dust can be created.
- Risk of collapse into pits.

4.9.14 Duct type

All dimensions up to approx. 110 mm.

4.9.15 Duct routing

Duct is pushed or pulled through the casing. Search wire and marking mesh are placed in the casing.

5. EXCAVATION METHODS

5.1 Excavation with excavator (Traditional excavator)

MINIMUM REQUIREMENTS FOR EXCAVIATION:

- Backfill height in accordance with "*Instructions for Robust Fiber*".

5.1.1 Method

An excavator with a bucket digs a trench, a particular section, or just a pit.
The excavated material is placed alongside or transported away. Local rules and regulations exist regarding the handling of excavated material and must be complied with.

In the trench, duct bedding is created on which ducts are placed. The trench is then refilled and the surface is restored according to applicable procedures and regulations.

The method is used for positioning optical fibre chambers and cabinets.

5.1.2 Machinery

Machines are available with wheels or tracks (caterpillar). Machines with wheels are normally used on hardened surfaces in order not to damage the surface. The excavator may have a trailer for handling excavated material.
The size of the machine is adapted to the space and the environment where excavation is taking place. Machines range from approx. 0.6 tonnes up to approx. 25 tonnes.
Different types of machines are available, such as backhoe loaders that provide considerable flexibility, as well as revolving excavators that have high excavation capacity and are available with wheels or tracks.

Machine for edge-cutting of asphalt. Truck for transporting excavated material.

5.1.3 Tools

A number of different buckets suitable for various types of excavation are available for excavators. Examples of buckets: cable bucket, meshred bucket, depth bucket and grading bucket.
Tools for cable routing should not have teeth in order to reduce the risk of damage to existing cables.

Examples of buckets

5.1.4 Suitable environment

This method can be used in all types of open trenches and surfaces. Not in solid rock.

5.1.5 Advantages

- Suitable close to other cables.
- Suitable for deep excavations.
- Suitable where the ground is not smooth, e.g., at ditch edges and inclines.
- Good for collocations where several cable types are to be routed in the same trench.
- Suitable for wide trenches or trenches where various widths are required.
- Good in varying land conditions.
- Easy to create pits.
- Good when positioning cabinets and optical fibre chambers.
- Good when excavated material is to be transported away by truck.

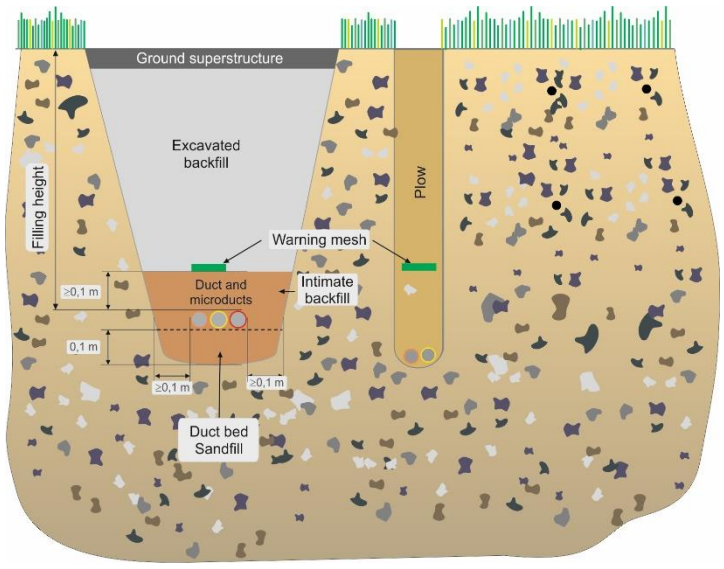
5.1.6 Restrictions (Disadvantages)

- Confined areas where access with a machine is difficult.
- Can cause damage to the ground when operating the machine in soft ground.
- This can result in the need for extensive restoration despite the fact that the trench is narrow.
- In the case of fibre routing, narrow cable trenches are normally required, yet with traditional excavation the cable trench is often unnecessarily wide.
- Has a considerable impact on the surrounding area, including traffic closures and disruption for road users.

5.1.7 Excavation

Any asphalt is removed prior to excavation. The asphalt can be milled or cut in a straight line to make restoration easier.
The asphalt must be cut beyond the intended trench edge (15 cm beyond trench edge recommended). Comply with the land owner's and road operator's regulations as well as rules relating to edge cutting.

Adapt the width of the trench so that there is room for a compactor in the trench.
The backfill height must be in accordance with the table in *"Instructions for Robust Fiber"*.



Example of excavation

5.1.8 Excavated material

The material is reused as far as possible. Stones and asphalt are transported away.
During the period excavation is in progress, excavated material is handled in accordance with local regulations.
Store material taken from the various layers of the excavation separately in order to reuse the material for refilling.

5.1.9 Backfill masses

When positioning optical fibre chambers, the manufacturer's instructions must be followed. Duct bedding must also be present below chambers.

The filling masses for the shaft must be handled in accordance with the Instructions for Robust fiber, Appendix 2 Robust networks, section Backfill masses.

5.1.10 Restoration

The ground must be restored to its original condition.
Face milling of the surface beyond the width of the trench in asphalt may be required prior to re-asphalting.

5.1.11 Environmental impact

Any contaminated material that is discovered must be transported to a landfill site, e.g., asphalt.

Work environment:

- Risk to excavation technicians who are in the trench when the excavator is digging.

5.1.12 Duct type

This method is suitable for routing all types of ducts intended for direct routing in the ground.
Less suitable for single ducts (microducts) over extended distances in the trench. There is a risk of single ducts ending up in waves, which can make fibre blowing more difficult. This method is more suitable when routing multi-ducts or thicker dimensions of ducts.

5.1.13 Duct routing

Ducts are routed at the bottom of the duct bedding.
Ducts must be wound in accordance with the manufacturer's instructions. Ducts must be kept straight and tensioned prior to refilling.
Perform compaction prior to blowing in a fibre optic cable.

Search wire is laid in the bottom or above the duct. Marking mesh is placed in refill material above the ducts.

5.2 Manual excavation

MINIMUM REQUIREMENTS WHEN ROUTING WITH MANUAL EXCAVIATION:

- Backfill height in accordance with *"Instructions for Robust Fiber"*

5.2.1 Method

A pit is dug by hand using e.g., a spade, and the excavated material is placed to the side of the pit. Ducts are installed in the trench, the land is refilled and restored. Excavation with a spade, crowbar or pickaxe does not require any machinery, only manual force. Machines may be used to refill and restore the pit.

5.2.2 Machinery

Manual.

5.2.3 Tools

Tools are available in several variants and for different purposes, e.g., spade, shovel, pointed hoe, pickaxe and crowbar.

Examples of tools

5.2.4 Suitable environment

This method can be used in soft surfaces. Used for example close to existing cables, close to house walls, by outdoor splice cabinets, on building land and when positioning cabinets and optical fibre chambers.

5.2.5 Advantages

- Suitable close to other cables.
- Good in confined areas.
- Good in sensitive ground and close to vegetation.
- Suitable for small trenches.
- Good when positioning cabinets and optical fibre chambers.
- Can be performed without prior knowledge.

5.2.6 Restrictions (Disadvantages)

- Difficult in the case of hard surfaces.
- Not possible in frozen ground.
- Not suitable for long distances.
-

5.2.7 Excavation

Flexible and easy to adapt.

5.2.8 Excavated material

Reuse excavated material as far as possible. During the period excavation is in progress, excavated material is handled in accordance with local regulations.
Store material taken from the various layers of the excavation separately in order to reuse the material for refilling.

5.1.9 Backfill masses

When positioning optical fibre chambers, the manufacturer's instructions must be followed. Duct bedding must also be present below chambers.

The filling masses for the shaft must be handled in accordance with the Instructions for Robust fiber, Appendix 2 Robust nets section Backfill masses.

5.2.10 Restoration

The ground must be restored to its original condition.

5.2.11 Environmental impact

Very little environmental impact.
Contaminated excavated material must be transported to a landfill site.

Work environment:

- Use ergonomically designed tools.

5.2.12 Duct type

This method is suitable for routing all types of ducts intended for direct routing in the ground as well as for positioning of cabinets and optical fibre chambers.

5.2.13 Duct routing

Ducts are routed at the bottom of the duct bedding.
Ducts must be wound in accordance with the manufacturer's instructions. Ducts must be kept straight and tensioned prior to refilling.

Search wire is laid in the bottom or above the duct. Marking mesh is placed in refill material above the ducts.

Instructions for Robust Fiber

Appendix 4 Robust sites and nodes

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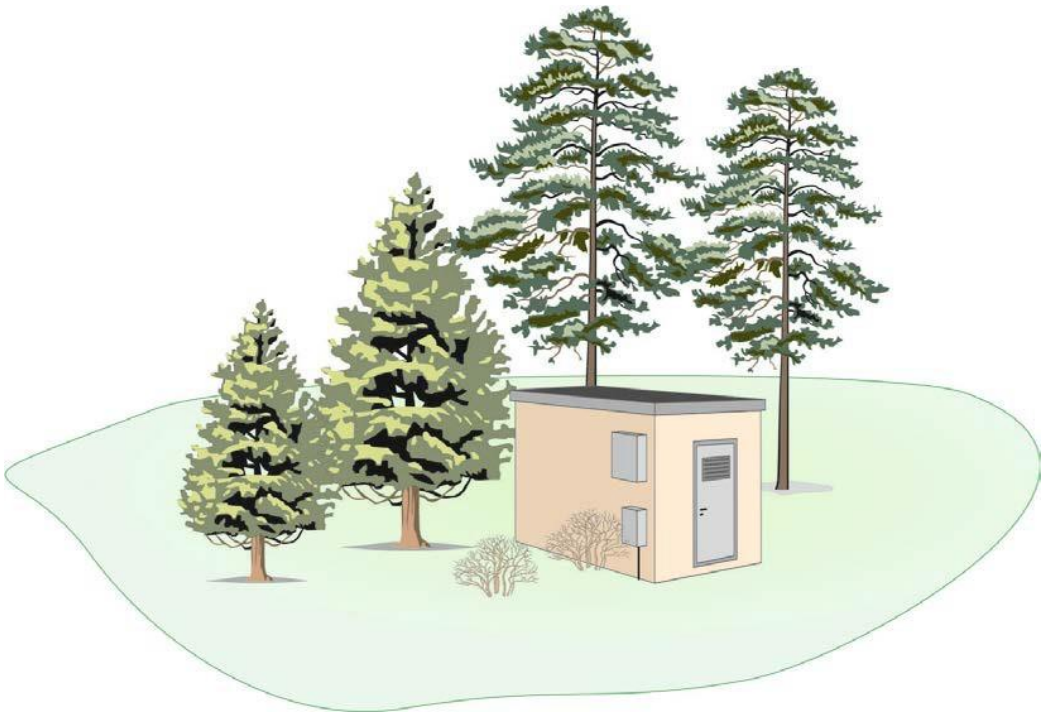


CONTENTS

1. Introduction **4**

2. Sites and nodes **5**

2.1 Classification of sites and nodes 5

2.1.1 Classification 5

2.2 Establishing sites and nodes 6

2.2.1 Location 7

2.2.2 Building consents and permits 7

2.2.3 Type of site or node 8

2.2.4 Design of sites and nodes 10

2.2.5 Electrical installation 13

2.2.6 Electrical safety 14

2.2.7 Environment and climate regulation 14

2.2.8 Dust, dirt and moisture 15

2.2.9 Safety (mechanical protection) 16

2.2.10 Alarms 17

2.2.11 Biological damage 18

2.2.12 Fire protection 18

2.2.13 Maintenance plan 19

2.2.14 Other 19

2.2.15 Compilation of requirements and recommendations for sites and nodes 20

1. INTRODUCTION

The document "*Instructions for Robust Fiber*" comprises one main document and a number of appendices.

This appendix, Robust sites and nodes, contains minimum requirements regarding how a robust site or node should be installed. The appendix also contains recommendations and examples of the possible appearance both outdoors and indoors.

The appendix begins with the classification of sites and nodes based on The Swedish Post and Telecom Agency's regulations and general advice on security in networks and services and then goes through various requirements and recommendations that apply to a robust site and node.

Minimum requirements within the following areas are defined in the appendix.

- Location
- Building consents and permits
- Type of site and node
- Design of sites and nodes
- Electricity supply
- Electrical safety
- Environment and climate regulation
- Dust, dirt and moisture
- Safety (mechanical protection)
- Alarms
- Biological damage
- Fire protection
- Maintenance plan
- Signs

2. SITES AND NODES

To gain a good understanding of the content of this chapter, it is good to know the difference between a site and a node.

Site

Site refers to the physical space. For example, this might be a technical shelter, an outdoor cabinet, one/more buildings or a room.
Sites incorporate e.g. the following functions:

- Shell protection.
- Electrical system.
- Auxiliary power system.
- Climate system.

Node

Node refers to a distribution point (connection point) where traffic flows are forwarded, concentrated and/or distributed. A node is located in a site.
The node has e.g. the following components:

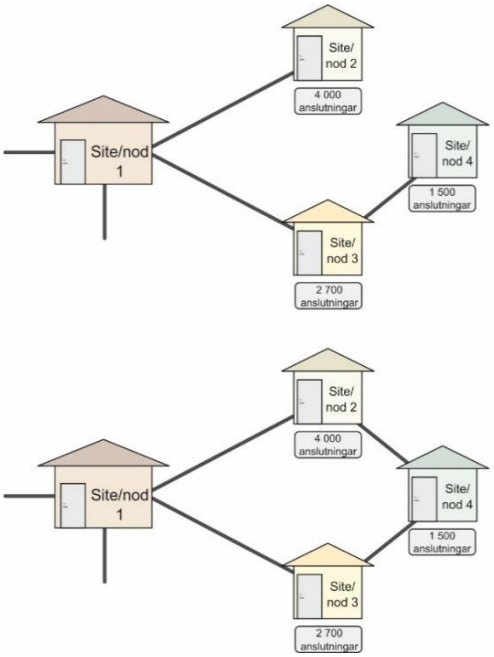
- ODF rack.
- ODF units.
- Patch (connecting) cables.
- Active communication equipment (routers, switches, etc.).

2.1 Classification of sites and nodes

2.1.1 Classification

In order to read more about requirements that apply to the classification of sites and nodes with the aim of achieving operational reliability for a fibre installation, in line with the relevant ordinance, please refer to PTS Security Regulation.

A management model for reliability, with templates showing how the network owner can handle operational reliability, can be found at the Swedish Local Fibre Alliance, www.ssnf.org.



Site	Klass	Ansl.
1	C	8 200
2	D	4 000
3	D	4 200
4	E	1 500

Site	Klass	Ansl.
1	C	8 200
2	C	8 200
3	C	8 200
4	D	5 500

Example of classification of nodes and sites

2.2 Establishing sites and nodes

Factors to consider

Here is a review of areas with special factors to consider when constructing a new site or node.

Before the work of planning the design of the sitens/node, a check shall be carried out for any need for reinforcement measures for events that may deviate from normal and that may involve serious disturbances in important societal functions.

Factors to consider in enhanced safety

För komplettering av anläggningar med krav på förstärkt säkerhet används dokumentet *Anläggningar med förhöjd säkerhet*, *Bilaga 1-Robust site för samhällsviktig digital infrastruktur* samt *Bilaga 2 Passiv säker fysisk förbindelse.*

Bilaga 1 Robust site för samhällsviktig digital infrastruktur definierar ett antal säkerhetsnivåer med kompletterande åtgärder för Site och nod med inriktning på skydd och funktioner för förlängd drifttid vid allvarliga störningar.

Bilaga 2. Passiv säker fysisk förbindelse utgör en anvisning med krav för hur det fysiska skyddet för elektronisk kommunikation ska kompletteras mellan siter och mellan site och användarnod för att kunna motstå allvarliga störningar. Kraven omfattar krav vid nybyggnation samt vid ombyggnad av fysiska anläggning.

For the complete versions see:

https://www.ssnf.org/nat-i-varldsklass/robust-digital-infrastruktur.

Note. An existing facility must have undergone a risk and vulnerability analysis (RSA). An existing facility that is being upgraded will undergo a renewed RSA. Threat directories and RSA for Site and Node as well as Robust secure physical connection can be found under:

https://www.ssnf.org/nat-i-varldsklass/robust-digital-infrastruktur

2.2.1 Location

The location of the fibre installation's sites and nodes is determined during the planning phase.

MINIMUM REQUIREMENTS REGARDING LOCATION:

- Outdoor cabinets must be positioned in locations that are well protected from snow clearance operations.
- Sites must never be located close to watercourses or in dips where there is a risk of flooding.

Recommendations for location:

- In the first instance, locate the site in a building intended for telecommunications. This can be done by erecting a separate building or by placement with another network owner.
- Avoid placement in buildings for which another party is responsible and where the premises are not intended to be used for telecommunication. For this reason, placement in schools, homes for the elderly, club premises, etc., must be avoided as far as possible.
- Outdoor cabinets should in the first instance be placed in a shady location.
- Select a location where the cable distances are optimised for connection up to the node, from the end customer and to other nodes.
- Position the node where the option of several connection paths exists, with a view to redundancy Both for fibre optic cables and for the electricity mains.
- For fibre alliances, it is good to position the node where it is possible to connect to several network owners.

2.2.2 Building consents and permits

When a new site is to be established, local provisions and permits have to be managed.

MINIMUM REQUIREMENTS IN THE CASE OF ESTABLISHMENT:

- Building consents are generally always required when establishing a new site.
- The landowner's consent (e.g., land agreements and easements for roads) must be obtained in order to position the site in the intended location.

Local provisions that may occur:

- Requirements regarding the appearance of the facade, choice of materials and colours.
- Requirements regarding noise levels (the site's climate system, the equipment's fans and auxiliary power systems can produce noise that is considered disturbing). Noise protection or requirements for a different location may be demanded.

2.2.3 Type of site or node

A site or node can be executed in various ways and in different forms. Below are a few examples.

2.2.3.1 Climate cabinet

Also known as an outdoor cabinet or environmental cabinet.

Climate cabinets are common in small networks and where few connections are terminated. They are less suitable for the placement of active equipment due to the lack of space, climate regulation and the work environment.

The installation depth for equipment in a cabinet is often critical, as the equipment may require a considerable depth, e.g., UPS.

MINIMUM REQUIREMENTS REGARDING CLIMATE CABINET:

- The climate cabinet must have at least IP class 54.

Example of outdoor cabinet

2.2.3.2 Technical shelter

It is an advantage to select a technical shelter instead of a climate cabinet. The technical shelter provides more space and the potential to work indoors, which creates a better work environment during service and maintenance.

The technical shelter's appearance and function can be adapted according to the client's wishes. They are available in different sizes, from one rack location up to the required number. The technical shelter is well suited for all types of fibre installations and can be dimensioned so that other parties can be offered placement. They can be placed on a cast foundation or stand on plinths.

Example of a technical shelter

MINIMUM REQUIREMENTS REGARDING TECHNICAL SHELTER:

- The technical shelter must be designed for the Nordic climate (e.g. cope with snow loads, cold conditions and heat).

2.2.3.3 Utilise part of an existing building.

When utilising an existing building, an area can be adapted for the fibre installation in e.g. a cellar.

Enter into a clear agreement with the property owner regarding placement and electricity supply. Being forced to move a node requires a great deal of work and therefore constitutes a major expense. It is important therefore to take care regarding the agreement's terms and conditions as well as its duration.

MINIMUM REQUIREMENTS WHEN USING EXISTING BUILDING:

- Ensure that access to the space is guaranteed, if possible, 24 hours a day. Ideally with a separate door from the outside.

2.2.3.4 Placement in another party's site

Site space can be hired from another network owner for placement of your own node. This could be in an existing telecommunications exchange, for example.

MINIMUM REQUIREMENTS FOR PLACEMENT:

- Ensure there is access 24 hours a day and make sure that affected personnel have permission to be in the area.
- Enter into an agreement with the property owner regarding the supply of electricity, with the required output level, as well as ensuring that the correct climate is maintained.

2.2.4 Design of sites and nodes

The site's fittings and physical space requirements are dependent on the amount of connections that are to be terminated, whether active equipment is to be placed there, and whether other parties are to be given the opportunity to place equipment in the space. When designing the fittings, it is important to consider several things.

MINIMUM REQUIREMENTS FOR A SITE:

- A site must be dimensioned in order to handle auxiliary power systems based on customer requirements and the site's function in the network.
- A site must be equipped with a climate system.
- A site must have a non-return valve in the floor drain (where present).
- In Site located below ground level, electronics and sensitive equipment must be placed at least 20 cm above the floor.
- A risk analysis shall be performed for a Site located below ground level and for the site with and retracted water-sewage and district heating pipes. Measures in the event of a confirmed risk may include, for example, moving the site, introducing automatic shutdown of water pipes, humidity sensors and instructions for shutting off water pipes

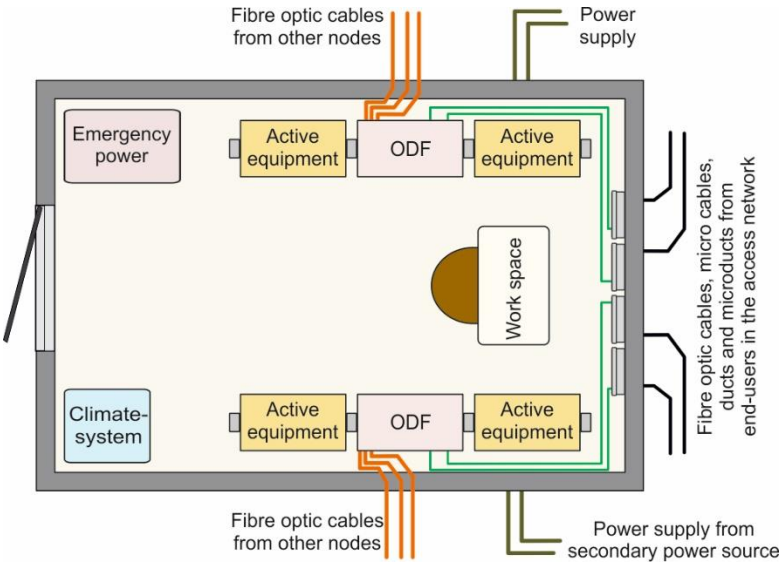
MINIMUM REQUIREMENTS FOR A NODE:

- A node must have sufficient space for racks that are dimensioned for the connections that may be terminated in the space
- A node must have sufficient space for the active communication equipment that will be placed in the space
- A node must be planned to ensure that mutual location of heat-generating equipment does not heat up other equipment, but rather that the heat is removed

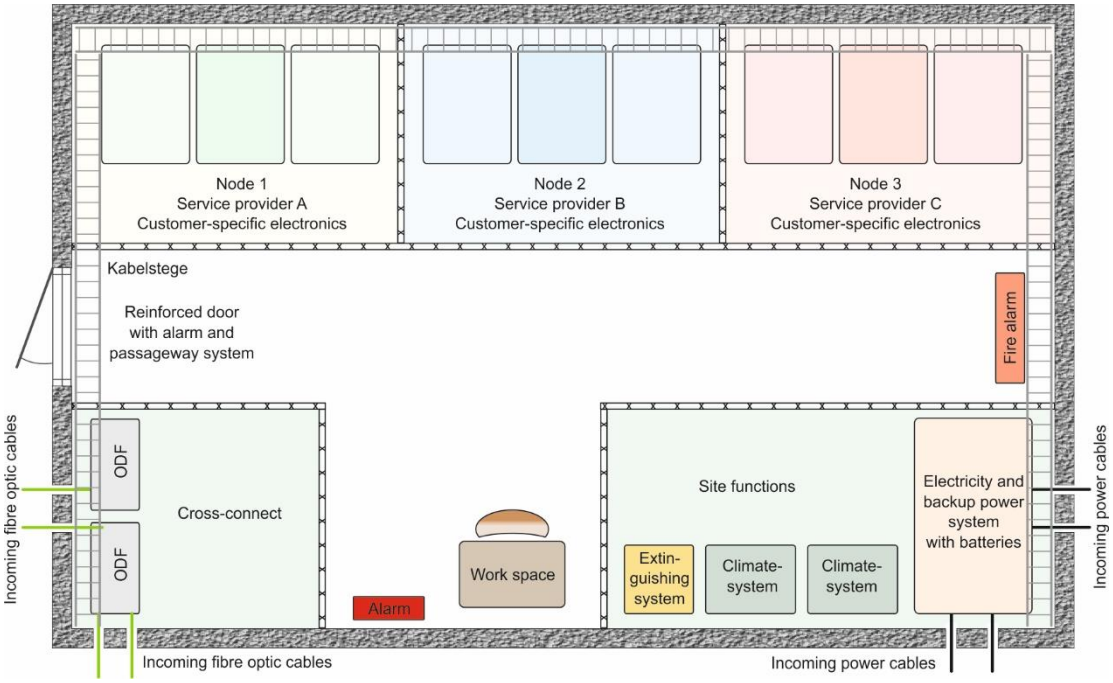
Recommendations for fittings:

- Space for a work space is something that is often forgotten, but that makes service and maintenance work easier.
- Position equipment to optimise the area within the space.
- Position and design installation routes to ensure good order in the space and the potential for smooth service and maintenance work.
- Separate power and fibre optic cables in installation routes. Despite the fact that fibre optic cables are not affected by electricity, service and maintenance are made easier by separating the cables.
- There should not be any heating, water or sewage pipes passing through the space, in order to minimise the risk of water damage.

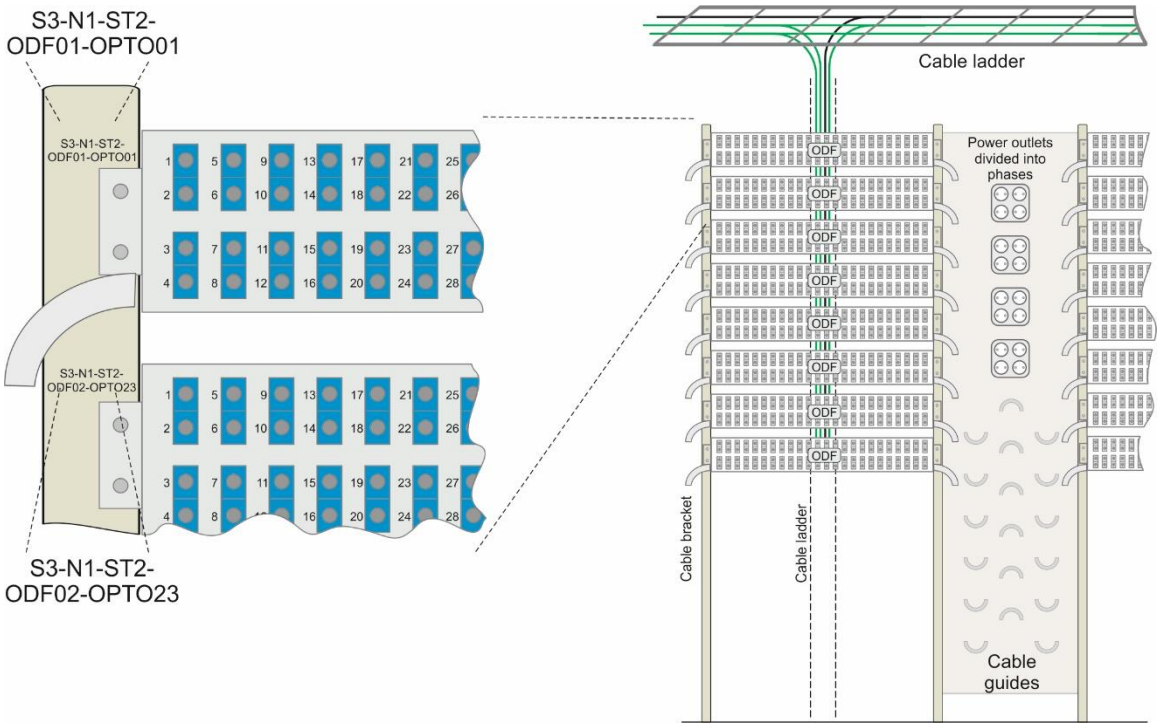
Examples of nodes:



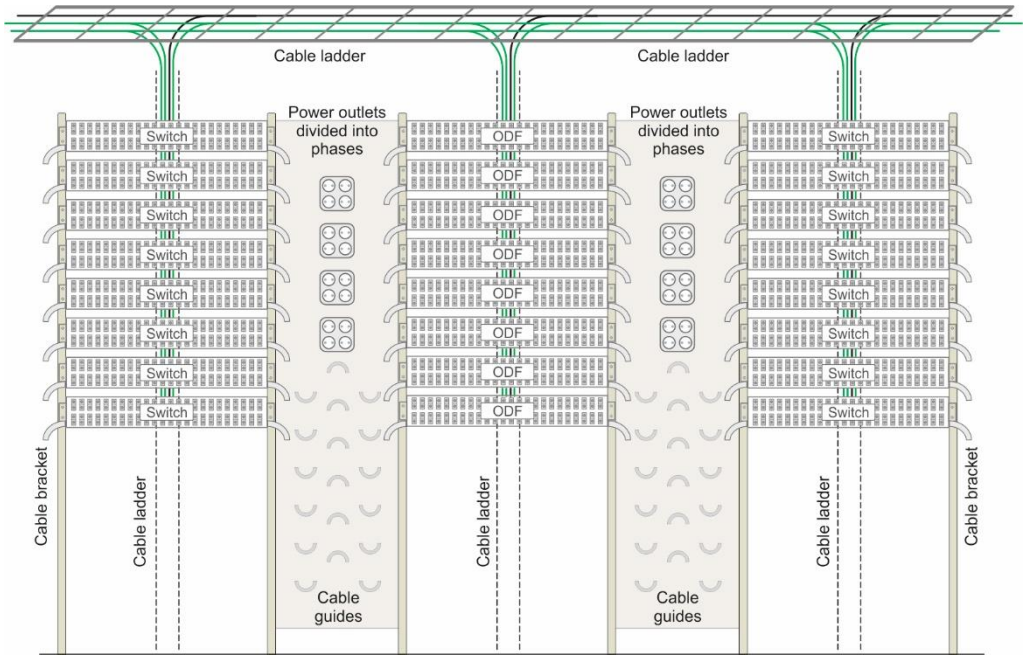
Example of a technical shelter



Example of larger site with several nodes



Example of rack labelling



Example of rack placement

2.2.5 Electrical installation

The electrical installation in sites and nodes must be handled in accordance with applicable laws and regulations.

2.2.5.1 Electrical system

Depending on the site's function and classification, redundant connections to the electricity mains may be required.

MINIMUM REQUIREMENTS REGARDING ELECTRICAL SYSTEM:

- Distribution boards in the site must be adapted for 230/400 V as a TN-S system.
- Distribution boards must be grouped and fused for each group.
- Service outlets must be supplied with RCBOs.

Recommendations:

- At racks, electric outlets must be installed so that they are easily accessible and evenly distributed between three phases.
- In larger sites and nodes, the installation must be supplied with residual current devices.

2.2.5.2 Auxiliary power systems

Auxiliary power systems supply sites and nodes with electrical power in the event of interruptions in incoming electrical power supplies. This could e.g. be a generator that is powered by a motor (permanently installed or portable), a fuel cell or a UPS with batteries. An auxiliary power system must be present when stipulated by PTS Security Regulation or customer requirements.

MINIMUM REQUIREMENTS REGARDING AUXILIARY POWER SYSTEMS:

- Auxiliary power systems must be dimensioned for an operating time in accordance with requirements in PTS Security Regulation or from connected customers.
- Where there is a UPS with batteries, the site must have an externally accessible intake for connecting the auxiliary power unit (emergency power generator).
- When installing with UPS, there must be a ByPass function

Recommendations:

- In the event of racks, electric outlets from the auxiliary power system must be easily accessible and clearly labelled.
- Damage that may arise in conjunction with over-voltage and short interruptions can be countered through appropriate fusing and systems for equipotential bonding. A UPS is suitable for this.
- When connecting an emergency power generator, the incoming supply to the site should be a TN-C system. After the emergency power generator, the internal electrical system in the site is then converted to a TN-S system.

2.2.6 Electrical safety

2.2.6.1 Lightning protection

Disruption caused by lightning is common. It is therefore important to protect the site and the equipment placed there against disruption caused by lightning.
Avoid using ducts containing metal connected to nodes as these conduct current.

MINIMUM REQUIREMENTS FOR LIGHTNING PROTECTION:

- The site must be properly earthed.
- The site must be equipped with over-voltage protection and RCDs.

2.2.6.2 Equipotential bonding

Equipotential bonding is used to connect all conducting units to each other at a common point so that they thereby receive the same potential. This minimises problems in respect of earth currents, galvanic isolation, static electricity and improves lightning protection within the site.

MINIMUM REQUIREMENTS FOR EQUIPOTENTIAL BONDING:

- All conducting parts are connected directly to the main equipotential bonding.
- The main equipotential bonding is connected to earth.
- All incoming conducting parts must be connected to the main equipotential bonding.

2.2.6.3 EMC (electromagnetic compatibility)

Electromagnetic radiation can arise in the vicinity of electrical installations, fan motors, lift motors, distribution boards, etc. If the equipment is poorly/incorrectly earthed, stray currents can occur that can give rise to interference.

MINIMUM REQUIREMENTS FOR EMC:

- Installed equipment must satisfy the applicable standard for CE marking according to the EU-EMC directive.

2.2.7 Environment and climate regulation

It is very important to keep the temperature and humidity at the correct level within the site. Heat damage can arise in electronic equipment if it is installed in an environment with a raised temperature. Cold damage can arise in the winter if equipment is located in areas that do not have sufficient heating, e.g. optical connectors and certain cables can be affected in cold conditions. Condensation can arise when the humidity is too high, while static electricity can arise when the humidity is too low. Below are examples of climate systems.

Heating element

In certain cases, a heating element may be sufficient. Applies primarily in areas with a low ambient temperature.

Fan

Temperature-controlled fan for the removal of surplus heat or blowing in of cold outside air.

Free cooling

Free cooling uses colder ambient air for cooling. Fans force in cold air, through filters, producing overpressure in the site. Warm air is evacuated at the opposite end of the site. Free cooling is a good choice when the ambient temperature is normally lower than the temperature in the site, and ensures low energy consumption during normal operation. Free cooling can be supplemented with another cooling unit for occasions when the ambient temperature is high.

Example of free cooling unit

Air heating pump

Works both as a heating and cooling unit, providing an even climate all year around.

MINIMUM REQUIREMENTS FOR CLIMATE REGULATION:

- A climate system must be present so that temperature and humidity are kept within the limit values that apply to the equipment placed in the node.
- A cooling system must be located so that leaks of liquid or condensation cannot reach the installed equipment.
- Drainage from the cooling system must be led out of the area.

Recommendations for climate systems:

- Select a climate system that can be controlled and monitored remotely.
- Dimension the auxiliary power system for the climate system as well, or ensure in some other way that the climate can be maintained at the correct level for a limited period.
- Plan for the potential for an emergency cooling system or bear in mind the need for a redundant climate system.

2.2.8 Dust, dirt and moisture

Dust, other dirt and moisture can damage active equipment in the site and make the connection of optical connectors difficult. Dust can also cause heating problems, as dust particles in the fans gradually impair air circulation over time, resulting in overheating of the active equipment.

MINIMUM REQUIREMENTS FOR FILTERS:

- Filters must be installed in all valves and supply air routes. Filters that are at least EU3 classified are recommended.

Water damage can arise as a result of e.g. flooding, damaged equipment or carelessness. Moisture can cause damage and disruptions to active equipment, electrical cables and connectors (optical and electrical).

MINIMUM REQUIREMENTS FOR MOISTURE PROTECTION:

- A site or node in a building must be fitted with raised thresholds where there is a risk of flooding.

2.2.9 Safety (mechanical protection)

The shell protection for a fibre installation is important. Installations can be protected to some extent through locks and alarms. The choice of cable routes and their protection are also important. The safety measures you implement will in practice be a matter of weighing up between the current threat situation, the significance of the site and the cost of implementing safety measures. The safety issues are also important when insuring the installation.

Recommendations for safety:

- In a site where space has been granted to another party, it is recommended that the site owner's own equipment (power supply, climate system, etc.) and nodes (communication equipment, ODF units, etc.) be located separately from equipment that is owned by the other party that is hiring space from the site owner.
- Parties that hire space for the placement of their own equipment cabinets or that hire space for placing equipment in equipment cabinets that are owned by the site owner, are themselves responsible for the protection of their own cross-connection points and equipment.

2.2.9.1 Burglar protection

Mechanical burglar protection refers to physical/mechanical measures that are implemented to prevent burglaries in node spaces.

MINIMUM REQUIREMENTS FOR BURGLAR PROTECTION:

- Doors to the area with direct access from outside must be made of steel.
- Doors in the existing building must be secured with e.g. a bolt, trailing edge strengthening device or equivalent protection.
- Only personnel authorised by the site owner may have access to the area.
- Keys must not be stored in the area.

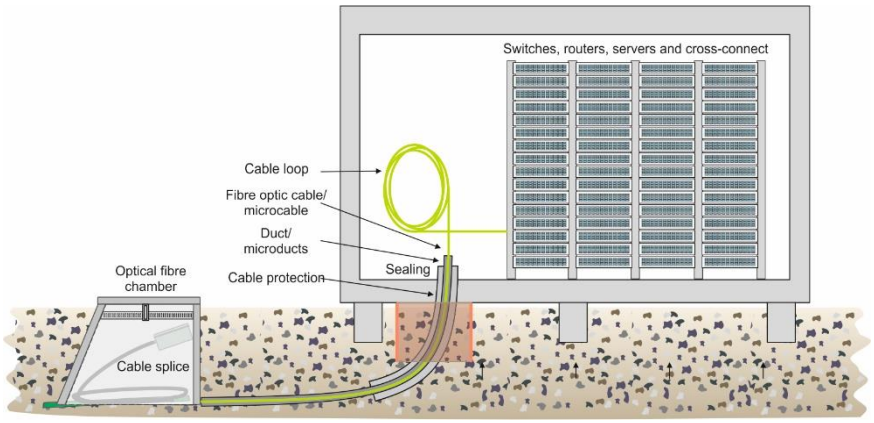
You can find out more about burglar protection from the Swedish Theft Prevention Association.

2.2.9.2 Sabotage protection

Sabotage protection refers to the measures that are implemented to impede or prevent sabotage to the fibre installation. Where there is a risk that incoming cables might be subjected to sabotage or other external effects, the cables must be supplied with a protective arrangement that impedes or prevents this.

MINIMUM REQUIREMENTS FOR SABOTAGE PROTECTION:

- Accessible cables must be protected against sabotage.
- For sites that do not have a cast foundation, the protection between the ground and the underside of the floor must be designed so that it covers at least three sides around incoming cables. The protection must be buried at a depth of at least 25 cm and must be anchored in the floor. It may be executed as a robust protective pipe, a steel plate (at least 1.5 mm) that covers at least three sides of the ducts, or other equivalent protection.
- If possible, towing and lifting eyelets must be removed from technical shelters or climate cabinets.
- Shelters or containers must be securely anchored to the ground, e.g. through properly buried plinths or concrete beams.



Example of cable intake

2.2.10 Alarms

Alarms refer to specific functions for obtaining information about the status of the site.

2.2.10.1 Burglar alarm

The purpose of a burglar alarm is to increase the security of monitored buildings.

MINIMUM REQUIREMENTS IF A BURGLAR ALARM IS PRESENT:

- Alarms must be transmitted to the operations centre and/or a surveillance company.

Recommendation regarding burglar alarm:

- In the event a burglar alarm is tripped, a buzzer signal should sound as a preliminary warning before the alarm siren is engaged (approx. 30 seconds).

The burglar alarm can be extended with an assault alarm to increase personal safety.

2.2.10.2 Operation alarm

An operation alarm refers to a function for receiving alarms from equipment in the site.

Examples of functions that can be monitored via an operation alarm:

- Climate (temperature, humidity).
- Water (moisture and flooding).
- Incoming power supply (power failure).
- Auxiliary power system (battery status).
- Entry alarm (unlocked door).
- Climate system (temperature, humidity).

MINIMUM REQUIREMENTS FOR OPERATION ALARM:

- There must be a function for receiving operation alarms.

As regards requirements for monitoring communication services, see the Operational reliability regulations.

2.2.10.3 Access control

Access control systems are a good way for the site's owner to see which individuals have been on the site. For personal safety, it is also good to know that a person is or has been on the site. This also provides the potential to follow up faults or defective installations.

Examples of access control systems include:

- Signed out key.
- System with cards or tags.
- System with dialled code.

2.2.11 Biological damage

Biological damage refers to damage that can arise due to pests (e.g. rodents, ants or insects).
A good form of protection against insect attacks is to install filter devices at the site's ventilation openings.

MINIMUM REQUIREMENTS FOR PROTECTION AGINST BIOLOGICAL DAMAGE:

- Where fibre optic cables or ducts are exposed to pests, such as rodent attacks, they must be protected with rodent protection, e.g. by means of additional metal reinforcement or pipes and fibre optic cables treated with repellent.
- Ducts must be sealed so that pests cannot travel through them.

2.2.12 Fire protection

Boverket's building regulations (BBR) handle regulations relating to fire protection. The level of the site's fire protection is determined by the risk analysis that is performed in conjunction with the establishment of the site. Also consult with the insurance company regarding which fire protection will apply and whether fire alarms are required.

MINIMUM REQUIREMENTS REGARDING FIRE PROTECTION:

- The site's surrounding surface (e.g., walls, floor, roof, doors and windows) must satisfy fire class EI 30 on both sides as a minimum.
- Building materials used in a site must be approved by the terms of use are checked with the insurance company relevant to the site.

Recommendation regarding fire alarm:

- In order to avoid the site being disabled by means of e.g. corrosive gases or water vapour penetrating the site due to a fire in the surroundings, the site should be built as a sealed unit with the exception of the ventilation system.

2.2.12.1 Fire extinguishing equipment

MINIMUM REQUIREMENTS REGARDING FIRE EXTINGUISHING EQUIPMENT:

- Personnel who work in the site or node must have access to hand-held CO_2 extinguishers of at least 5 kg in the premises.
- When there are premises or a building for an emergency power generator, this area must be supplied with powder extinguishers.

You can read more about fire protection and extinguishing equipment at the Swedish Fire Protection Association.

2.2.13 Maintenance plan

Some equipment requires recurring maintenance. For this reason, a maintenance plan must be drawn up containing a list of the maintenance that has to be carried out and when it has to be done.
PTS Security Regulation specify that structured work on operational reliability must be conducted in the long term, continually and systematically.

MINIMUM REQUIREMENTS FOR A MAINTENANCE PLAN:

- Sites and nodes must have a maintenance plan.
- In addition to that specified in PTS Security Regulation, the maintenance plan must include regular inspection of filters, climate systems, electrical systems, locks and access control systems according to the manufacturer's instructions and, if necessary, clearance of snow, brushwood and grass.

2.2.14 Other

The presence of signs outside the site must be limited so that interest in the site or node is kept to a minimum. However, there should be a sign giving telephone numbers that the public can call if they notice that something or someone is acting unusually at the site.

MINIMUM REQUIREMENTS FOR SIGNS:

There should not be any signs specifying the site's owner etc.

2.2.15 Compilation of requirements and recommendations for sites and nodes

Compilation of requirements and recommendations for sites and nodes					
X MINIMUM REQUIREMENTS R RECOMMENDATIONS • Action based on risk analysis and customer requirements	SITE/NODE CLASS **A**	**B**	**C**	**D**	**E**
2.2.3 Type of site					
Outdoor cabinet (Climate cabinet, Environmental cabinet)				X	X
Technical shelter	X	X	X	X	X
Building (technical premises)	X	X	X	X	X
2.2.2 Building consents and permits					
Building consents are generally always required when establishing a new site.	X	X	X	X	X
The land owner's consent (e.g. land agreements for roads) must be obtained in order to position the site in the intended location.	X	X	X	X	X
2.2.1 Location of Site					
Outdoor cabinets must be positioned in locations that are well protected from snow clearance operations.				X	X
Sites must never be located close to watercourses or in dips where there is a risk of flooding.	X	X	X	X	X
Outdoor cabinets should in the first instance be placed in a shady location.				R	R
2.2.1 Location of Node					
In the first instance, locate the node site in a separate building intended for telecommunications.	X	X	R	R	R
Select a location where the cable distances are optimised for connection up to the node, from the end customer and to other nodes.	R	R	R	R	R
Position the node where the option of several connection paths exists, with a view to redundancy Both for fibre optic cables and for the electricity mains.	R	R	R	R	R
For fibre alliances, it is good to position the node where it is possible to connect to several network owners.	R	R	R	R	R
2.2.3.1 Climate cabinet					
The climate cabinet must have at least IP class 54.				X	X
2.2.3.2 Technical shelter					
The technical shelter must be designed for the Nordic climate (e.g. cope with snow loads, cold conditions and heat)	X	X	X	X	X
2.2.3.3 Existing building (technical premises)					
Adapt a space for the fibre installation	X	X	X	X	X
Ensure that access to the space is guaranteed 24 hours a day. With a separate door from the outside.	X	X	X	X	X
2.2.3.4 Placement of node in another party's site					
Ensure there is access 24 hours a day and make sure that affected personnel have permission to be in the area.			X	X	X
Enter into an agreement with the property owner regarding the supply of electricity, with the required output level, as well as ensuring that the correct climate is maintained.			X	X	X
2.2.4 Design of site					

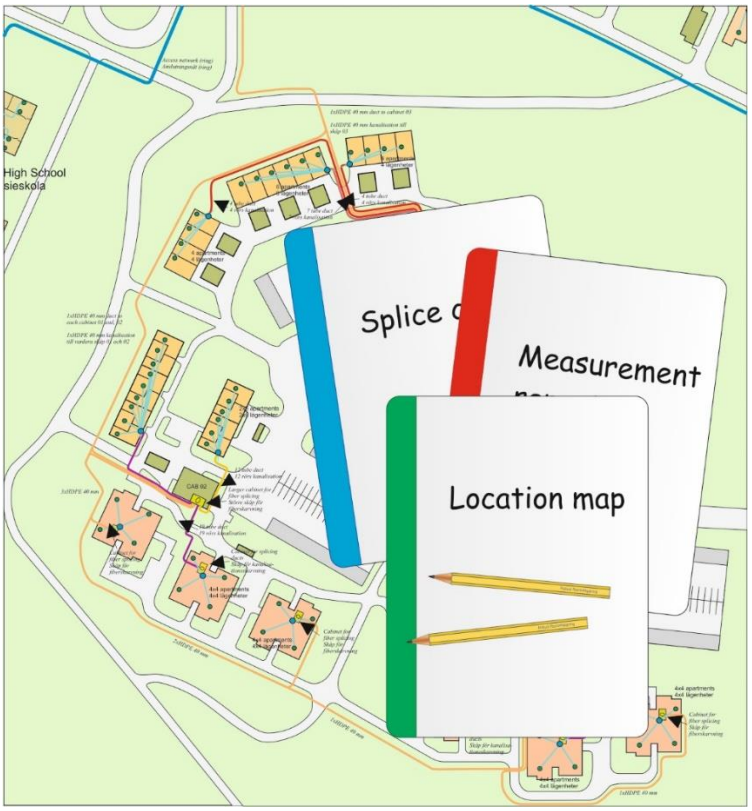
A site must be dimensioned in order to handle auxiliary power systems based on customer requirements and the site's function in the network.	X	X	X	X	X*
A site must be equipped with a climate system.	X	X	X	X	X*
A site must have a non-return valve in the floor drain (where present).	X	X	X	X	X
The site must have automatic shut-off of water pipes present in the space.	X	X	X	X	X
Space for a work space is something that is often forgotten, but that makes service and maintenance work easier.	R	R	R	R	R
Position equipment to optimise the area within the space.	R	R	R	R	R
Position and design installation routes to ensure good order in the space and the potential for smooth service and maintenance work.	R	R	R	R	R
Separate power and fibre optic cables in installation routes. Despite the fact that fibre optic cables are not affected by electricity, service and maintenance are made easier by separating the cables.	R	R	R	R	R
There should not be any heating, water or sewage pipes passing through the space, in order to minimise the risk of water damage.	R	R	R	R	R
2.2.4 Design of node					
A node must have sufficient space for racks that are dimensioned for the connections that may be terminated in the space	X	X	X	X	X
A node must have sufficient space for the active communication equipment that will be placed in the space	X	X	X	X	X
A node must be planned to ensure that mutual location of heat-generating equipment does not heat up other equipment, but rather that the heat is removed	X	X	X	X	X
2.2.5.1 Electrical system					
Distribution boards in the site are adapted for 230/400V as a TN-S system and supplied with residual current devices	X	X	X	X	X
The site must be fitted with residual current devices	X	X	R		
Distribution boards must be grouped and fused for each group.	X	X	X	X	X
Service outlets must be supplied with RCBOs.	X	X	X	X	X
At racks, electric outlets must be installed so that they are easily accessible and evenly distributed between three phases.	R	R	R	R	R
2.2.5.2 Auxiliary power system					
Auxiliary power systems must be dimensioned for an operating time in accordance with requirements in PTS Security Regulation or from connected customers.	X	X	X	X	X*
Where there is a UPS with batteries, the site must have an externally accessible outlet for connecting the auxiliary power unit (emergency power generator).	X	X	X	X	X*
In the event of racks, electric outlets from the auxiliary power system must be easily accessible and clearly labelled.	R	R	R	R	R
Damage that may arise in conjunction with over-voltage and short interruptions can be countered through appropriate fusing and systems for equipotential bonding. A UPS is suitable for this.	R	R	R	R	R
When connecting an emergency power generator, the incoming supply to the site should be a TN-C system. After the emergency power generator, the internal electrical system in the site is then converted to a TN-S system.	R	R	R	R	R
2.2.6.1 Lightning protection					
The site must be properly earthed.	X	X	X	X	X

The site must be equipped with over-voltage protection and RCDs.	X	X	X	X	X
2.2.6.2 Equipotential bonding					
All conducting parts are connected directly to the main equipotential bonding.	X	X	X	X	X
The main equipotential bonding is connected to earth.	X	X	X	X	X
All incoming conducting parts must be connected to the main equipotential bonding.	X	X	X	X	X
2.2.6.3 EMC					
Installed equipment must satisfy the applicable standard for CE marking according to the EU-EMC directive.	X	X	X	X	X
2.2.7 Environment and climate regulation					
A climate system must be present so that temperature and humidity are kept within the limit values that apply to the equipment placed in the node.	X	X	X	X	X
A cooling system must be located so that leaks of liquid or condensation cannot reach the installed equipment.	X	X	X	X	X
Drainage from the cooling system must be led out of the area.	X	X	X	X	X
Select a climate system that can be controlled and monitored remotely.	X	X	X	R	R
Dimension the auxiliary power system for the climate system as well, or ensure in some other way that the climate can be maintained at the correct level for a limited period.	X	X	X	X	X
Plan for the potential for an emergency cooling system or bear in mind the need for a redundant climate system.	X	X	X		
2.2.8 Dust, moisture and dirt					
Filters: Filters must be installed in all valves and supply air routes. Filters that are at least EU3 classified are recommended.	X	X	X	X	X
Moisture protection: A site or node in a building must be fitted with raised thresholds where there is a risk of flooding.	X	X	X	X	X
2.2.9 Safety					
In a site where space has been granted to another party, it is recommended that the site owner's own equipment (power supply, climate system, etc.) and nodes (communication equipment, ODF units, etc.) be located separately from equipment that is owned by the other party that is hiring space from the site owner.	X	X	X		
Parties that hire space for the placement of their own equipment cabinets or that hire space for placing equipment in equipment cabinets that are owned by the site owner, are themselves responsible for the protection of their own cross-connection points and equipment.	X	X	X	X	X
2.2.9.1 Burglar protection					
Doors to the area with direct access from outside must be made of steel.	X	X	X		
Doors in the existing building must be secured with e.g. a bolt, trailing edge strengthening device or equivalent protection.	X	X	X		
Only personnel authorised by the site owner may have access to the area.	X	X	X	X	X
Keys must not be stored in the area.	X	X	X	X	X
2.2.9.2 Sabotage protection					
Accessible cables must be protected against sabotage.	X	X	X	X	X
For sites that do not have a cast foundation, the protection between the ground and the underside of the floor must be designed so that it covers at least three sides around incoming cables. The protection must be buried at a depth of at least 25 cm and must be anchored in the floor. It may be executed as a robust protective pipe, a steel plate (at least 1.5	X	X	X	X	X

mm) that covers at least three sides of the ducts, or other equivalent protection.					
If possible, towing and lifting eyelets must be removed from technical shelters or climate cabinets.			X	X	X
Shelters or containers must be securely anchored to the ground, e.g. through properly buried plinths or concrete beams.			X	X	X
2.2.10.1 Burglar alarm					
Alarms must be transmitted to the operations centre and/or a surveillance company.	X	X	R	R	
In the event a burglar alarm is tripped, a buzzer signal should sound as a preliminary warning before the alarm siren is engaged (approx. 30 seconds).	X	X	R	R	
2.2.10.2 Operation alarm	X	X	X	X	X
There must be a function for receiving operation alarms.	X	X	X	X	X
2.2.10.3 Access control	X	X	X	X	X
2.2.11 Biological damage					
Where fibre optic cables or ducts are exposed to pests, such as rodent attacks, they must be protected with rodent protection, e.g. by means of additional metal reinforcement or pipes and fibre optic cables treated with repellent.	X	X	X	X	X
Ducts must be sealed so that rodents cannot travel through them.	X	X	X	X	X
2.2.12 Fire protection					
The site must satisfy fire class EI 30 as a minimum.	X	X	X	X*	X*
In order to avoid the site being disabled by means of e.g. corrosive gases or water vapour penetrating the site due to a fire in the surroundings, the site should be built as a sealed unit with the exception of the ventilation system.	X	X	X	X*	X*
2.2.12.1 Fire extinguishing equipment					
Personnel who work in the site or node must have access to hand-held CO_2 extinguishers of at least 6 kg in the building.	X	X	X	X	X
When there are premises or a building for an emergency power generator, this area must be supplied with powder extinguishers.	X	X	X	X	X
2.2.13 Maintenance plan					
Sites and nodes must have a maintenance plan.	X	X	X	X	X
In addition to that specified in PTS Security Regulation, the maintenance plan must include regular inspection of filters, climate systems, electrical systems, locks and access control systems according to the manufacturer's instructions and, if necessary, clearance of snow, brushwood and grass.	X	X	X	X	X
2.2.14 Other					
There should not be any signs specifying the site's owner etc.	X	X	X	X	X

Instructions for Robust Fiber
Appendix 5 Documentation

Ver 1.5



CONTENTS

1. Introduction 4

2. Documentation 5

2.1 General requirements 5

2.2 Scope 6

2.3 Requirements regarding documentation that must be included 7

2.3.1 Network overview 7

2.3.2 Ducting 8

2.3.3 Fibre optic cables 11

2.3.4 Sites and nodes 16

2.3.5 Land agreement 18

2.4 Documents that should be included 19

2.4.1 Distribution point drawing 19

2.4.2 Distribution point card 20

2.4.3 Site drawing 21

2.4.4 Cross-section drawing for trench 21

2.5 Management of documentation 22

1. INTRODUCTION

The document "*Instructions for Robust Fiber*" comprises one main document and a number of appendices.

This appendix, Documentation, contains minimum requirements for how a robust fibre installation should be documented and which parts should be included in the documentation. The appendix also contains recommendations and examples of the possible appearance.

Minimum requirements within the following areas are defined in the appendix.

- General requirements
- Network overview
- Ducting drawing
- Location map
- Survey files
- List of items
- Ducting drawing on private building land
- Registration
- Cable drawing
- Cable specification
- Splicing plan
- Panel card
- Measurement report
- Rack layout drawing
- Access information
- Land agreement
- Management of the documentation

2. DOCUMENTATION

2.1 General requirements

The documentation must generally contain information that

- describes the complete network,
- facilitates robust operation of the fibre installation.

Furthermore, the documentation must

- be able to be transferred between different editable digital formats,
- contain the information that is required in the event of a transfer of ownership of the fibre installation.

The documentation must be prepared in an editable digital format.
For example, the documentation may be available in a system intended for the documentation of fibre installations. Alternatively, different parts of the documentation may comprise different file formats, such as Excel, Word, etc. Files of the type .pdf must not be used as originals as they are not editable.

The network's constituent parts must have uniform names.
The names of a network's constituent parts may differ between different network owners. Regardless of the names of the various constituent parts in a network, the network owner must nevertheless have uniform designation for them based on their function in the network. The structure and the designations must make it possible for the documentation to be supplemented in the event of any future changes to the network.

MINIMUM REQUIREMENTS, GENERAL

An individual constituent in a fibre installation must be documented so that:

- It cannot be confused with other parts thanks to being allocated a unique designation.
- It can be located on site by means of the geographic location and/or section being clearly set out in the documentation.
- Drawings and pictures clearly describe the structure and format of the fibre installation, as well as how other constituents are connected.
- Properties that are significant for the function of a constituent part in the network are set out.
- There is a description of how the constituent can be accessed in the event of faults as well as during modification, operation and maintenance work.
- Designations and other data are accessible, searchable and can be clearly presented from an operation, maintenance and marketing perspective.

Consequences in the event of any damage must be able to be surveyed and assessed rapidly by means of the documentation specifying or indicating:

- A fibre optic cable's unique designation and its transfer route in the ducting network.
- A fibre link's unique designation, the cable(s) in which it is found and the location of its termination points.
- A connection's unique designation and the fibre links it comprises.
- Which connection(s) constitutes a unique customer connection.
- A customer connection's link to the relevant customer agreement.
- Agreed SLA when the connection is, or is part of, a leased connection, so that a prioritisation list can be drawn up during troubleshooting.

2.2 Scope

MINIMUM REQUIREMENTS, SCOPE

- The documents that are described below must be present as individual constituents or be incorporated in documentation systems.

The following must be included in the documentation:

Network overview	Schematic overview of the network's geographic extent
Ducting drawing	Schematic drawing of ducting (nodes, optical fibre chambers, cabinets and ducts)
Location map	Shows the geographic extent of the ducting, measured on a digital base map
Survey files	Coordinates for introduction on a Location map
List of items	List of ducting items for survey file
Location drawing, building land	Planning drawing and approval of duct routing on private building land
Cable drawing	Schematic drawing that provides an overview of the fibre optic cables and how they are connected
Cable specification	Specification of fibre optic cable
Splicing plan	Detailed drawing that shows fibre optic cables' splices and terminations. Can also be a connection table.
Panel card	List of terminations of fibre optic cables in ODF, as well as their connections.
Measurement report	Measurement report from delivery measurements in the form attenuation measurements and/or OTDR measurements.
Rack layout drawing	Drawing that shows what is in the rack and in which position it is located
Access information	Information about keys (pass cards, codes, gate locks) contact persons and route description to site or node
Land agreement	Various agreements about the right to route ducts on another party's land. The following documents should

	also be included in the documentation:
Distribution point drawing	Schematic drawing of the ducts in a distribution point
Distribution point card	Specification of distribution point
Site drawing	Schematic drawing of site and node area
Cross-section drawing for trench	Schematic drawing showing a cross-section of a trench with buried ducts

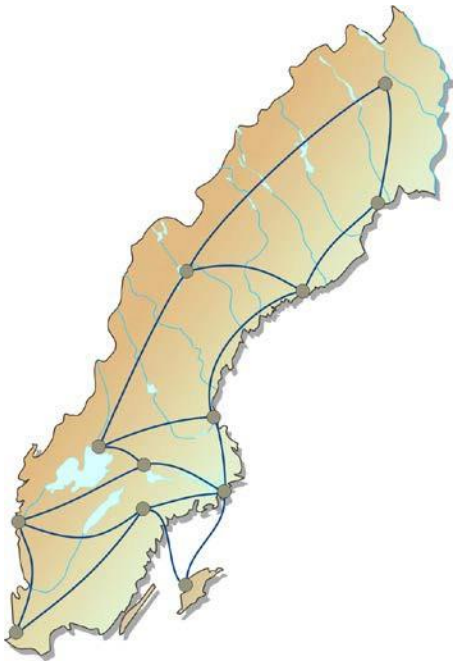
2.3 Requirements regarding documentation that must be included

2.3.1 Network overview

MINIMUM REQUIREMENTS, NETWORK OVERVIEW

- A network overview must be drawn up.

The network overview provides a schematic overview of the network's geographic extent and the locations it reaches, as well as how these are connected to each other. The network overview is normally used for marketing purposes in order to describe the extent of the network.



Example of network overview

2.3.2 Ducting

MINIMUM REQUIREMENTS, DUCTING

The documentation must comprise the following documents:

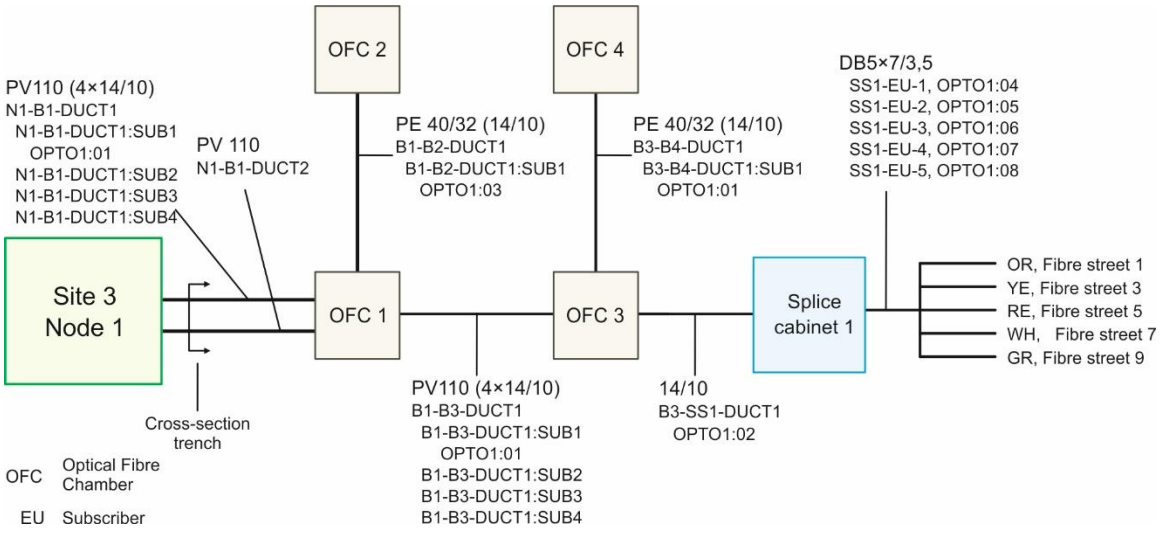
- ducting drawing
- location map
- survey file
- list of items
- ducting drawing, private building land

2.3.2.1 Ducting drawing

MINIMUM REQUIREMENTS, DUCTING DRAWING

- Ducting drawing must be produced.

Ducting drawing is a schematic drawing that shows nodes, optical fibre chambers and connection cabinets, as well as the ducts that connect them. Sub-ducting must also be shown on the drawing.
In those cases where ducting contains several ducts in the same trench, the identity of each duct must be clear by means of the duct's colour code and/or labelling at either end. Colour codes or labelling of sub-ducts and microducts must also be presented.



Example pf ducting drawing

2.3.2.2 Location map

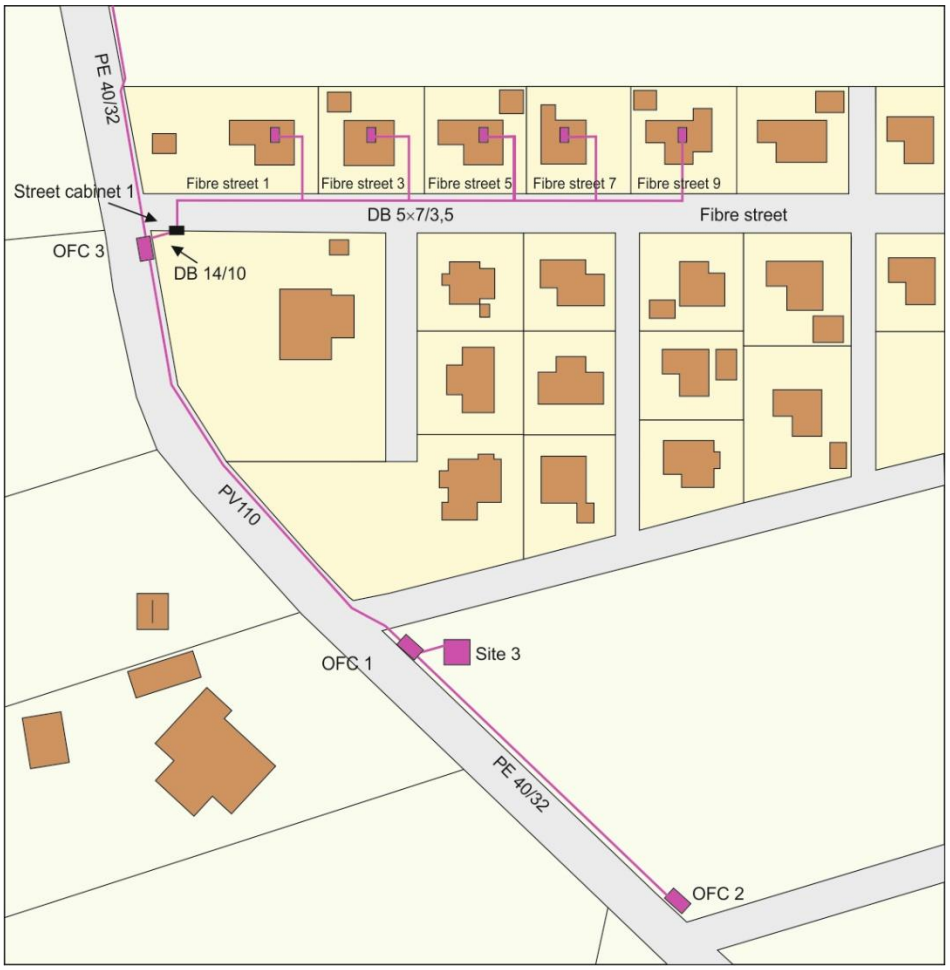
MINIMUM REQUIREMENTS, LOCATION MAP

- Location map must be produced.

The location map shows the geographic extent of the ducting on a digital base map. The location map is used e.g. during excavation work where cables in the work area need to be identified and indicated.

A survey file containing coordinates and a list of items constitute the basis for the location map.

The coordinate system that is used must be specified
(e.g. WGS 84, RT 90 2.5 gon V, SWEREF 99 TM or SWEREF 99 (local zone)).



Example of location map

2.3.2.3 Survey file

Below is an example of a list of measured coordinates that has been created during geodetic position measurement of the ducting. Z indicates the height in metres above sea level (in principle) and can be used to determine the flatness of the ducting's routing.

No.	X	Y	Z
0001	6403406.196	1272605.785	17.916
0002	6403402.562	1272608.213	17.677
0003	6403400.5	1272611.273	17.555
0004	6403399.576	1272614.513	17.717

2.3.2.4 List of items

Example of list of surveyed items

No.	Item	X	Y	Z
0042	C2	6405249.313	1271802.695	30.194
0043	E2	6405249.395	1271802.762	30.05
0044	H2	6405249.461	1271802.589	30.154
0045	C2	6405249.213	1271802.648	30.13

Examples of items:
C2 = Duct
E2 = Switch cabinet
H2 = Optical fibre chamber

MINIMUM REQUIREMENTS IN THE CASE OF SEARCH WIRE

- Where search wire has been used, the documentation must also contain information showing the points at which the search wire is accessible.

2.3.2.5 Location drawing, private building land

MINIMUM REQUIREMENTS, LOCATION DRAWING

- Location drawing must be produced, with agreed position for cable routing on private building land.

The location drawing must show where on the plot the cable connects, where it is to be routed on the plot, and also show where connection to the house takes place. The drawing is created in consultation with the plot owner. The drawing should be signed by both network owner (or contractor) and house owner at the time of planning.

In the event of significant changes in the actual cable position, the landowner shall be informed of the deviations.

Drawings should also be produced in cases where the house owner is excavating on his own plot. The plot owner must have his own specimen or a copy.

See example at the end of the appendix

2.3.2.6 Register fibre installation

MINIMUM REQUIREMENTS, REGISTRATION

- The fibre installation must be registered.

The fibre installations must be registered in accordance with *Appendix 8 Ledningskollen* or in accordance with local procedures and regulations.

2.3.3 Fibre optic cables

MINIMUM REQUIREMENTS, FIBRE OPTIC CABLES

The documentation must comprise the following documents:

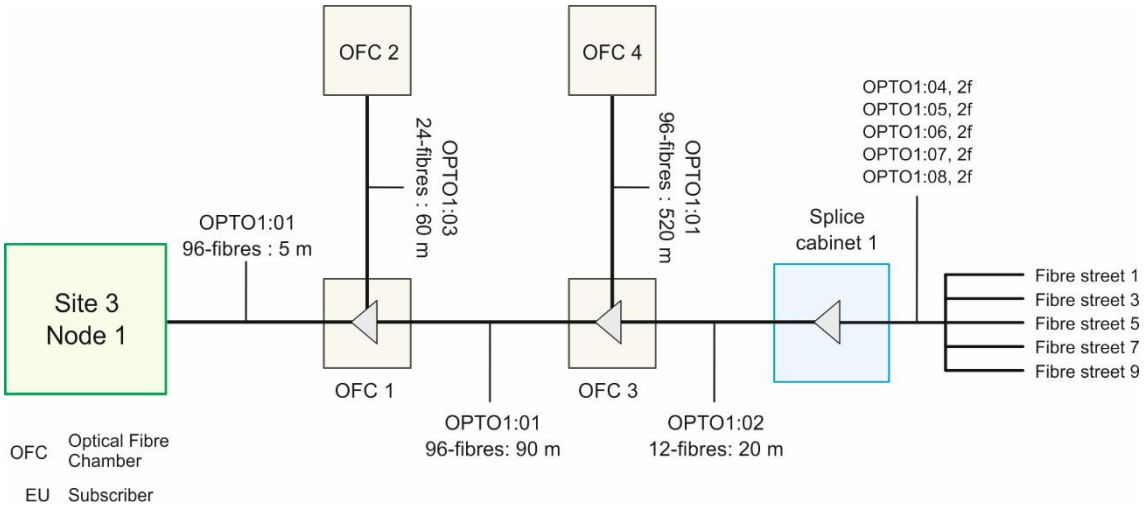
- cable drawing
- cable specification
- splicing plan (connection table)
- panel card
- measurement report

2.3.3.1 Cable drawing

MINIMUM REQUIREMENTS, CABLE DRAWING

- A cable drawing must be present.
- It should be stated in which duct a cable is placed.

The cable drawing is a schematic drawing that provides an overview of the fibre optic cables and how they are connected via distribution points and terminations.



Example, cable drawing

2.3.3.2 Cable specification

MINIMUM REQUIREMENTS, CABLE SPECIFICATION

- A cable specification must be present.

The cable specification is a specification of the individual fibre optic cable, with information about e.g. the cable's designation, the manufacturer's designation, the number of fibres and the length of the fibre optic cable.

Details	Information
Designation	OPTO1
Type of cable according to ITU-T	ITU-T G.652.D
Number of fibres	96
Manufacturer's designation	XYZ 1234-9876-96
Technical specification	See document ABC-0345-96
Carried out by contractor, date	Optodragarna AB, 01/04/2016
Length	684 m
Splicing points and splicing boxes	See document DEF-0678-87
Measurement report	See document GHI-987-654

Example of cable specification

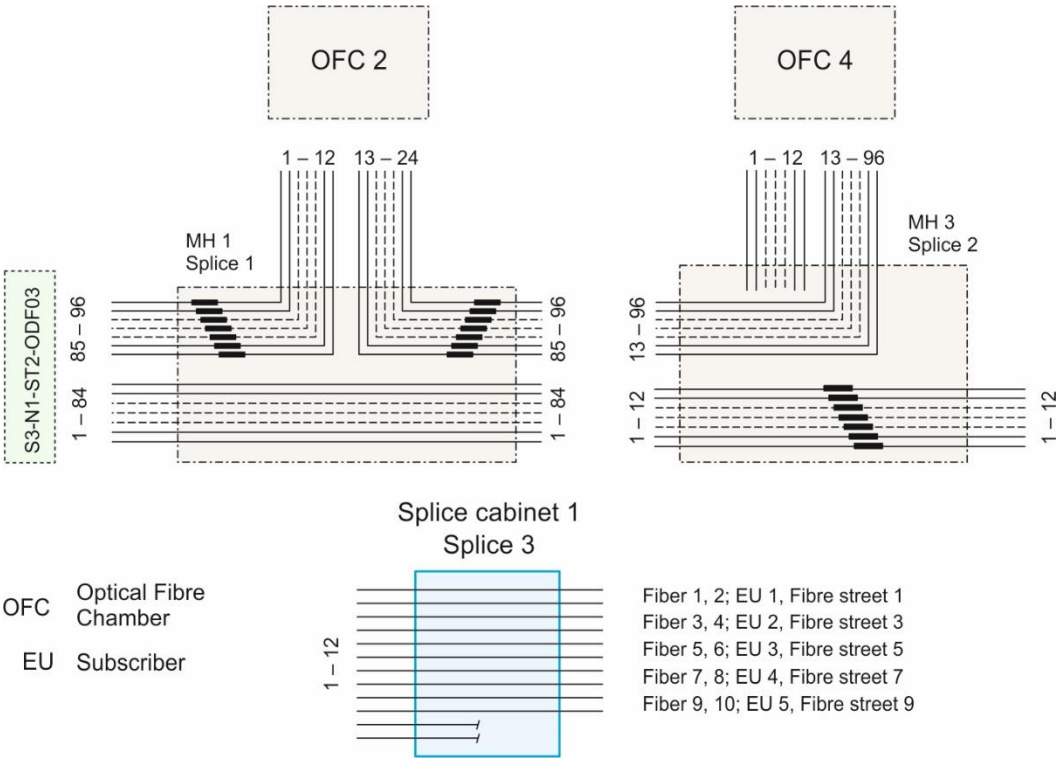
2.3.3.3 Splicing plan

MINIMUM REQUIREMENTS, SPLICING PLAN

- A splicing plan must be drawn up.

The splicing plan is a detailed drawing or a connection table that shows fibre optic cables' splices and terminations.

It must be clear from the splicing plan how individual fibres are spliced in the splicing unit and terminated in ODF.



Example, splicing plan

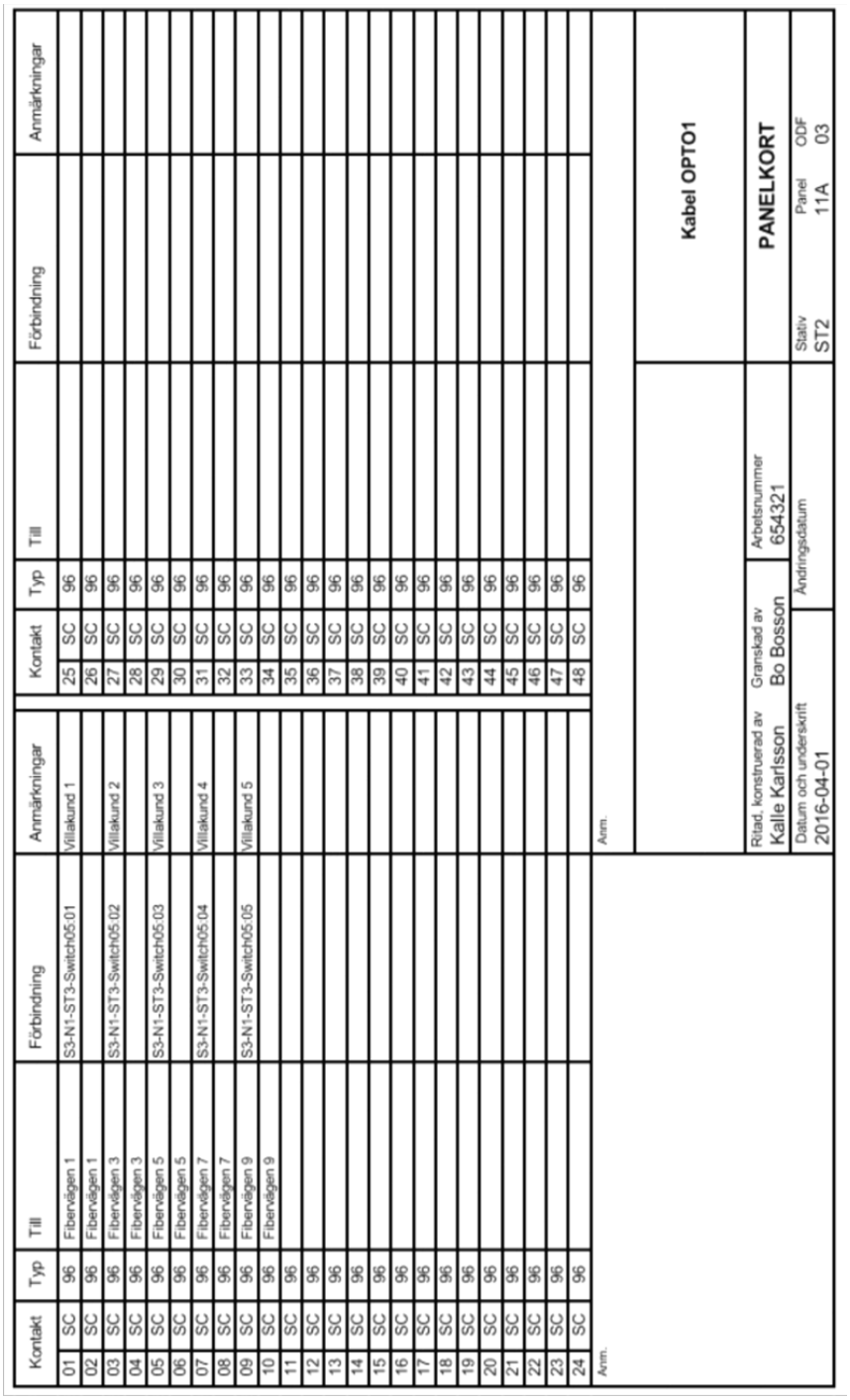
2.3.3.4 Panel card

MINIMUM REQUIREMENTS, PANEL CARD

- A panel card must be produced.

A panel card is a list of terminations in an ODF.

The panel card must contain information about the position of fibres in ODF rack and ODF panel, as well as information about where the other end of the fibre optic cable is terminated. It must also contain information about where a connection cable in a particular position is connected, as well as information about the connection.



Kontakt	Typ	Till	Förbindning	Anmärkningar
01	SC	96	Fibervägen 1	S3-N1-ST3-Switch05:01	Villakund 1
02	SC	96	Fibervägen 1		
03	SC	96	Fibervägen 3	S3-N1-ST3-Switch05:02	Villakund 2
04	SC	96	Fibervägen 3		
05	SC	96	Fibervägen 5	S3-N1-ST3-Switch05:03	Villakund 3
06	SC	96	Fibervägen 5		
07	SC	96	Fibervägen 7	S3-N1-ST3-Switch05:04	Villakund 4
08	SC	96	Fibervägen 7		
09	SC	96	Fibervägen 9	S3-N1-ST3-Switch05:05	Villakund 5
10	SC	96	Fibervägen 9		
11	SC	96			
12	SC	96			
13	SC	96			
14	SC	96			
15	SC	96			
16	SC	96			
17	SC	96			
18	SC	96			
19	SC	96			
20	SC	96			
21	SC	96			
22	SC	96			
23	SC	96			
24	SC	96			

Anm.

Kontakt	Typ	Till	Förbindning	Anmärkningar
25	SC	96		
26	SC	96		
27	SC	96		
28	SC	96		
29	SC	96		
30	SC	96		
31	SC	96		
32	SC	96		
33	SC	96		
34	SC	96		
35	SC	96		
36	SC	96		
37	SC	96		
38	SC	96		
39	SC	96		
40	SC	96		
41	SC	96		
42	SC	96		
43	SC	96		
44	SC	96		
45	SC	96		
46	SC	96		
47	SC	96		
48	SC	96		

Anm.

Ritad, konstruerad av: Kalle Karlsson
Granskad av: Bo Bosson
Arbetsnummer: 654321
Datum och underskrift: 2016-04-01
Ändringsdatum:

Kabel OPTO1

PANELKORT

Stativ: ST2
Panel: 11A
ODF: 03

Example, panel card

2.3.3.5 Measurement report

MINIMUM REQUIREMENTS, MEASUREMENT REPORT

- Measurement reports from delivery measurements in the form of OTDR measurements must be included in the documentation.
- Used measuring instruments must be specified in the measurement report. Software for reading the measurement results must be included in the documentation.

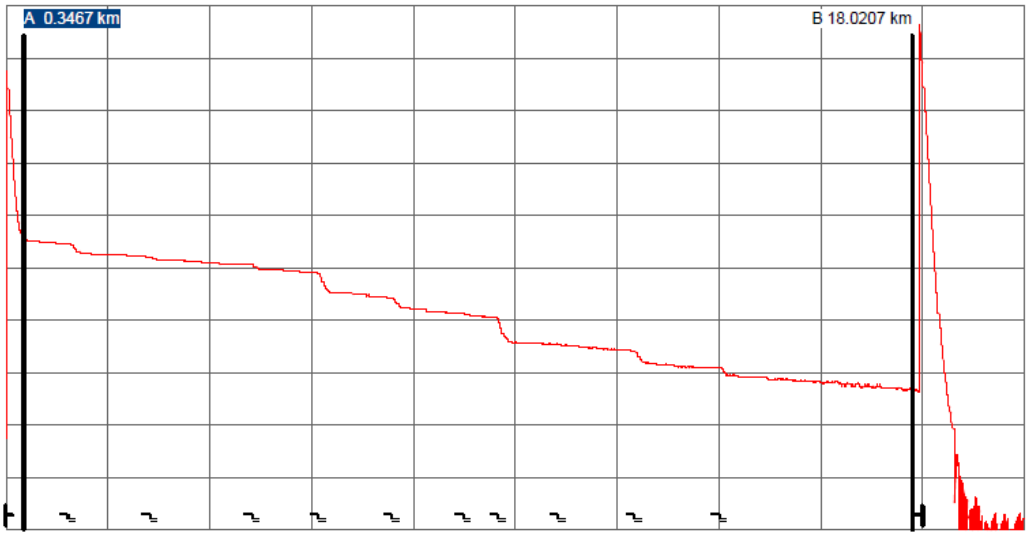
See Robust Fiber's instructions, appendix 2, points 2.5.11–13 for minimum requirements during measurement.

The measurement report is ideally attached to the cable specification. The format of the measurement record can be PDF.

OTDR Report

File : trumma_4_ab_1550.sor	Test Date : 02-26-2016 15:55:43	Device : palmOTDR
Cable ID :	Orig.Location :	
Fiber ID :	Term.Location :	
Operator :	Fiber Type : Conventional Singlemode Fiber	
Range : 20.4 km	PulseWidth : 100 ns	Wavelength : 1550 nm
IOR : 1.4700	Scatter Coef. : -51.80 dB	Average Time : 00:01:00
End Threshold : 3.00 dB	NRefl.Threshold : 0.00 dB	Refl. Threshold : -52.00 dB

Trace 2.025 km/Div 2.903 dB/Div



Markers A/B	
A-B:	17.6740 km
2pt. Loss:	8.438 dB
2pt. Attenuation:	0.477 dB/km
LSA-Attenuation:	0.534 dB/km

Marker A	
Position:	0.347km
Ins. Loss at #1:	-.-- dB
Reflectance at #1:	44.490 dB
Cum.Loss to A:	-0.100 dB

Total Fiber Information

Total Length:18.166 km | Total Loss:8.361 dB | Total Attn.:0.460 dB/km

Event Table

No.	Type	Location[km]	Refl.[dB]	Ins.Loss[dB]	Attn.[dB/km]	Cum.Loss[dB]	Dist.Prev.[km]	Dist.End[km]	Loss Prev.[dB]	Comment
1	Start	0.0000	44.490	-.--	-.--	-.--	0.000	18.166	-.--	-.--
2	NonRefl.	1.2466	-.--	0.433	0.198	0.257	1.247	16.919	0.257 dB	-.--
3	NonRefl.	2.8705	-.--	0.103	0.183	0.990	1.624	15.296	0.300 dB	-.--
4	NonRefl.	4.9150	-.--	0.147	0.186	1.474	2.045	13.251	0.381 dB	-.--
5	NonRefl.	6.1998	-.--	1.068	0.186	1.861	1.285	11.966	0.240 dB	-.--

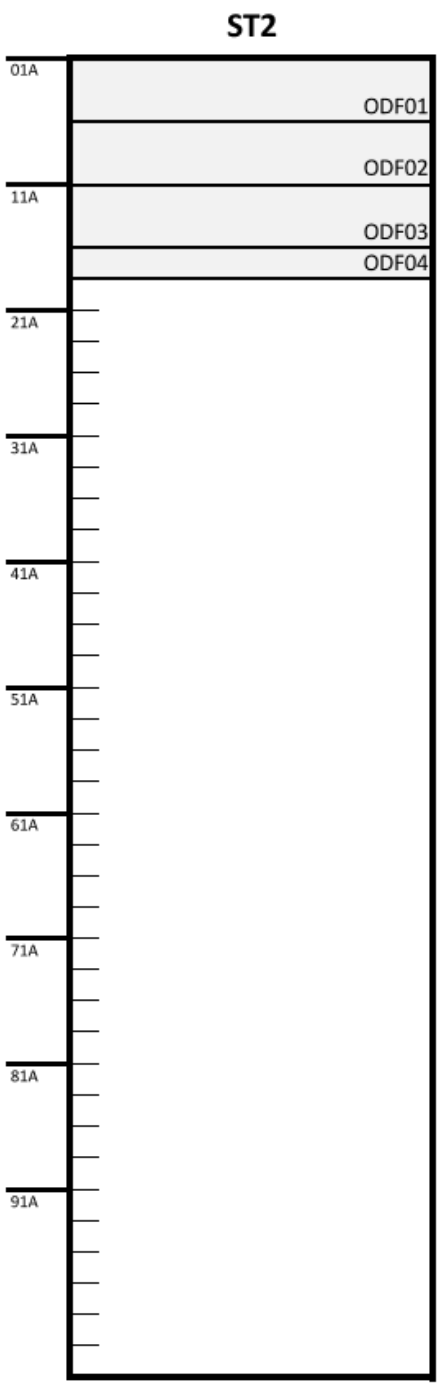
Example, measurement report, OTDR measurement

2.3.4 Sites and nodes

2.3.4.1 Rack layout drawing

MINIMUM REQUIREMENTS, RACK LAYOUT DRAWING

- There must be a rack layout drawing.



Position	Typ	Kabel
01A	ODF 96xSC	OPTO5
01C	ODF 96xSC	OPTO9
11A	ODF 96xSC	OPTO1
11C	ODF 48xSC	OPTO4

2.3.4.2 Access information

MINIMUM REQUIREMENTS FOR ACCESS INFORMATION

- Access information must be present.

The access information is a document that shows the route to a site or node (route description), where keys (pass cards, codes, gate locks) are located and which keys are required, as well as who is the responsible contact person for the site or node. Particularly important in the event of placement at another property owner.

Example, access information:

Access information

Network owner		
Site designation		
Node designation		
Street address		
Town		
Coordinates X and Y	X:	Y:
Created by		
Approved by		
Date		
Directions		
Key information		
Property manager		
Contact person property		
Electricity grid owner		
Contact, electricity grid		
Location of equipment		
Location of demarcation point		
Other information		
Space for image		

2.3.5 Land agreement

MINIMUM REQUIREMENTS, LAND AGREEMENT

- Required land agreements must be dawn up and stored together with the documentation.

Agreements regarding access to land are available in several different variants and with different purposes.
There must be a general land agreement as a basis, which has been entered into between the network owner and the local authority where the fibre installation is to be built. A general land agreement regulates the right to have cables in municipal land, regulations for restoration, any costs for future maintenance, etc.

Below are examples of various types of agreements:

Land lease agreement

- Agreement where the land owner grants e.g. the cable owner the right to use the land for laying cables. Binding for a maximum of 25 years (in planned ground) or 50 years (other ground). One agreement is entered into per property.

Utility easements

- The strongest form of agreement for cables. Regulates the right for legal entities to route cables through the property of other parties. A cadastral survey must be performed and utility easements apply until further notice and are presented on the property register map. Utility easements can relate to several properties.

Usufruct agreement

- Agreement that regulates the right to use something that is owned by another party. An example of this is the hiring of ducts.

Easement

- Can e.g. regulate the right to use another party's land for roads up to the site.

Other agreements and terms

- For example, agreements regarding terms and conditions for collocation, agreements regarding cable location with land owner.

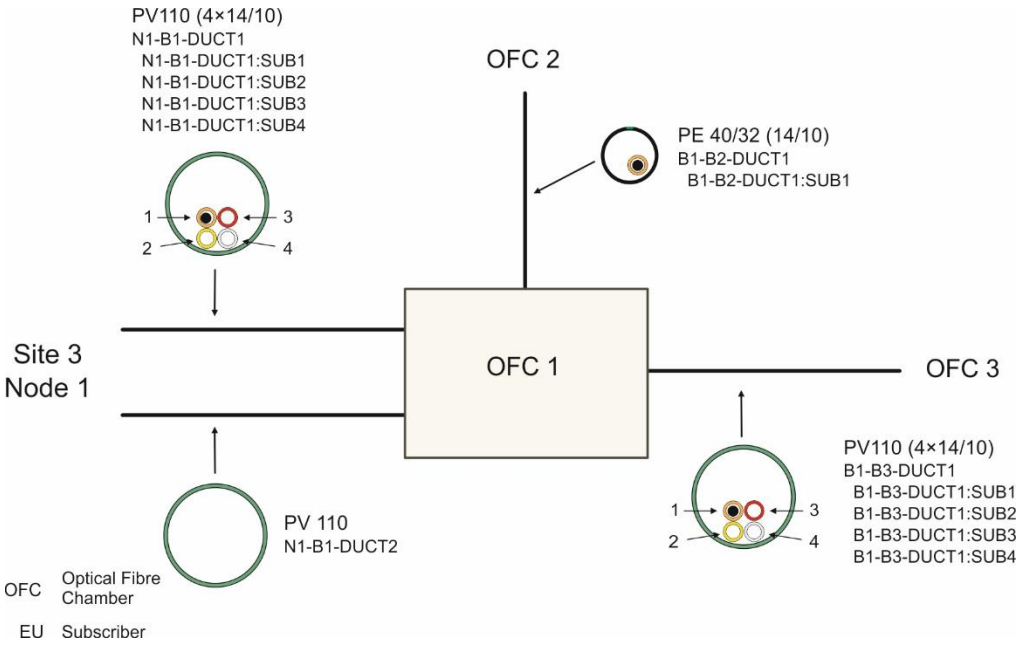
Agreement templates can be obtained from the Federation of Swedish Farmers, the Swedish Broadband Forum, Byanätsforum, etc.

2.4 Documents that should be included

The following documents are not mandatory but should be included. If the documents are included in the documentation, the minimum requirements must be met.

2.4.1 Distribution point drawing

When several ducts terminate in or pass a optical fibre chamber or a switch cabinet, the documentation should be supplemented with a distribution point drawing. This should give a schematic presentation of the distribution point with ducts.



Example of distribution point drawing

2.4.2 Distribution point card

A distribution point card is a specification showing information about the distribution point. Distribution point cards should be produced and can contain all the information or refer to other documents.

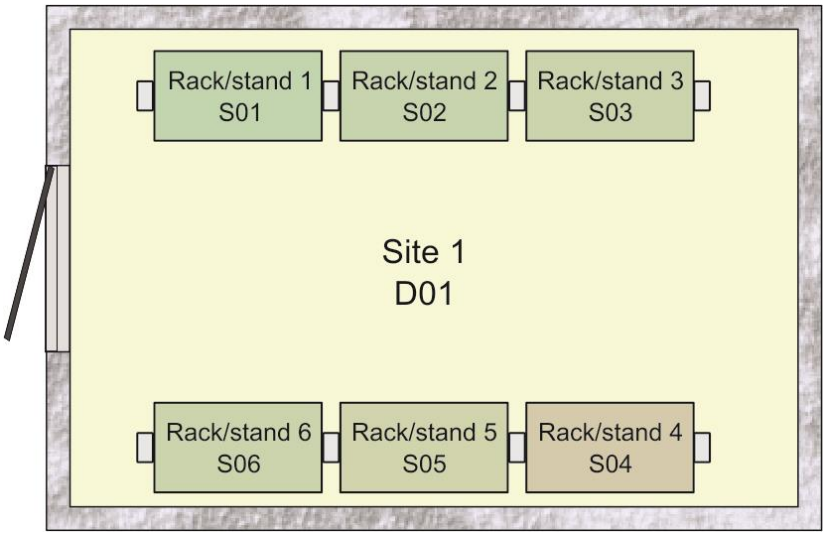
Examples:

Details	**Information**
Distribution point designation	Optical fibre chamber 1
Type of distribution	Optical fibre chamber level with the ground surface
Manufacturer's type designation	ABC-3456-78
Material	Concrete with cast iron cover
Interior dimensions in mm: width, depth and height	1200 x 800 x 600
Type of shell protection	Cast iron cover at ground level, inner hatch with lock
Layout drawing	Document ABC-12324–09
Accuracy class during survey	Accuracy class 2
Assignment agreement, rental agreement or similar	Land agreement ABD-12345

Example of distribution point card

2.4.3 Site drawing

The site drawing is a schematic drawing that should be produced and that presents the internal space in a site. The drawing must present designations and the nodes, racks and other units found in the site, as well as where they are located.

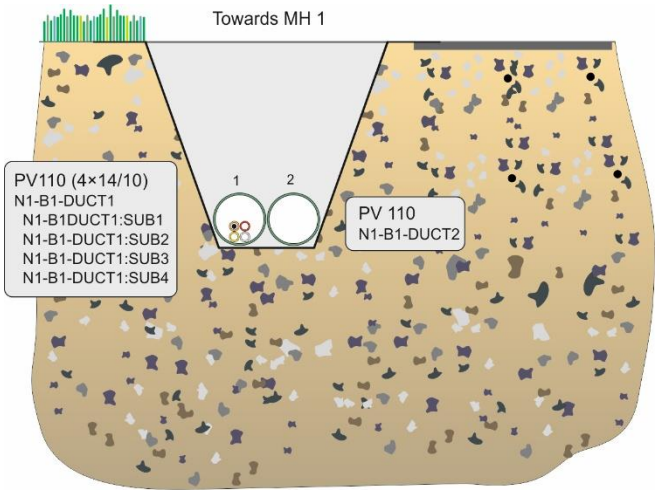


Example, site drawing

2.4.4 Cross-section drawing for trench

The drawing is a schematic drawing that shows a cross-section of buried ducts and their designation, including sub-ducts.

The drawing must set out relevant ducts, their designations and mutual location in the trench. The direction of the cross-section must also be specified.



Example, cross-section drawing for trench

2.5 Management of documentation

The documentation must be viewed and handled as sensitive information, as it describes the network's extent, structure and geographic location. The documentation may therefore only be passed to outside parties in accordance with settled regulations.

Minimum requirements for management:

- There must be an appointed function that continually updates the documentation in the event of changes in the fibre installation
- The electronic version of the documentation must be stored in such a way that the risk of it being lost is minimised. It is recommended to have backups in at least two different physical locations.
- The documentation must be stored in such a way that it is accessible in the event of actual or anticipated fault situations, so that faults can be rectified quickly.

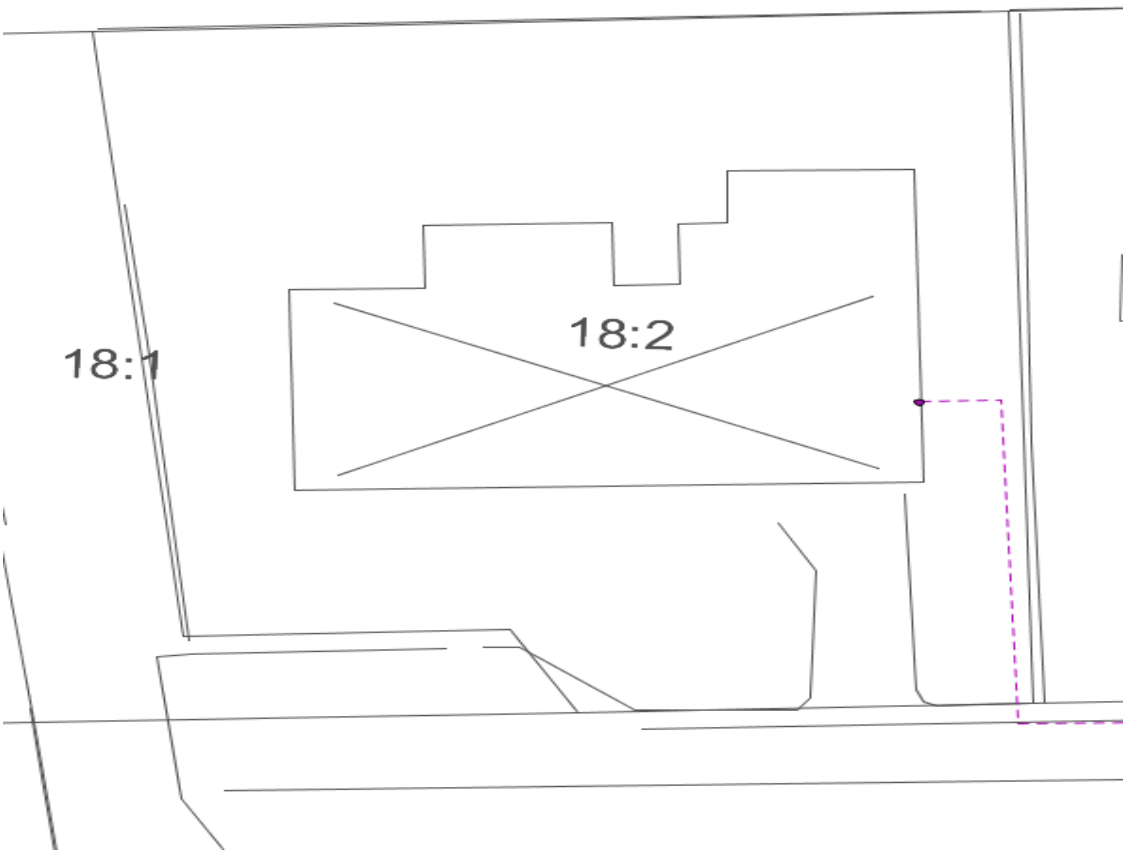
Location drawing with approval

Network owner		**Date**	
Area		**Company**	
Street address		**Town**	
Fixed designation		**Filled in by**	

Checklist	**OK**
Location of transfer point in relation to street agreed	
Marking for transfer point in relation to street located	
If the number of excavated metres exceeds that which is included, customer notified about additional costs	
Customer notified that only rough restoration is performed on building land	
Location of intake point in the property agreed	
Marking for intake point in the property located	
Customer notified that cable protection chute is placed on facade	
Customer notified that 5 metre internal installation is included	
Transfer route for internal installation agreed	
Location of installation of fibre termination agreed	
Location of placement of media converter agreed	
Other:	

Information	**Yes**	**No**
Is there existing ducting between plot boundary and property?		
Is there a cellar?		
Is there a crawl space? (leave note about access under “Other”)		
Does the customer approve work on the building plot being carried out when the customer is not at home?		

Other information



Plot sketch

Approval

Information provided in this form is hereby approved

Property owner 1

Property owner 2

Clarification

Clarification

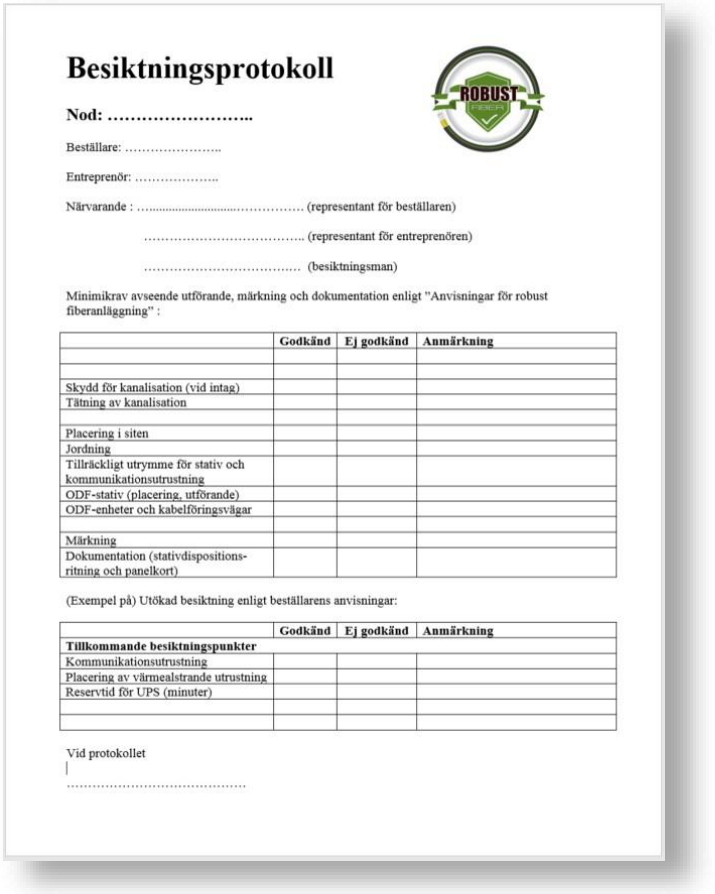
Planner

Clarification

Instructions for Robust Fiber

Appendix 6 Inspection

Ver 1.5



Besiktningsprotokoll

Nod: ……..

Beställare: ……..

Entreprenör: ……..

Närvarande : ……. (representant för beställaren)

…….. (representant för entreprenören)

…….. (besiktningsman)

Minimikrav avseende utförande, märkning och dokumentation enligt "Anvisningar för robust fiberanläggning" :

	Godkänd	Ej godkänd	Anmärkning
Skydd för kanalisation (vid intag)			
Tätning av kanalisation			
Placering i siten			
Jordning			
Tillräckligt utrymme för stativ och kommunikationsutrustning			
ODF-stativ (placering, utförande)			
ODF-enheter och kabelföringsvägar			
Märkning			
Dokumentation (stativdispositions-ritning och panelkort)			

(Exempel på) Utökad besiktning enligt beställarens anvisningar:

	Godkänd	Ej godkänd	Anmärkning
Tillkommande besiktningspunkter			
Kommunikationsutrustning			
Placering av värmealstrande utrustning			
Reservtid för UPS (minuter)			

Vid protokollet

……

CONTENTS

1. Introduction **4**

2. The inspection process **5**

3. Inspection **6**

3.1 Generally 6

3.2 Inspection of a facility that has received state support 6

3.3 Review with the client prior to implementation 7

3.4 Review with the contractor prior to implementation 7

3.5 Visual inspection with land owners prior to implementation 8

3.6 Ongoing inspection 8

3.7 Pre-inspection (Normative inspection) 8

3.8 Visual inspection after implementation 8

3.9 Final inspection 9

3.10 Inspection report 11

3.11 post-inspection 11

3.12 Warranty inspection 12

3.13 Special inspection 12

3.14 Other 12

1. INTRODUCTION

The document *"Instructions for Robust Fiber"* comprises one main document and a number of appendices.

This appendix, Inspection, contains a description of the various steps in the inspection process and the minimum requirements that are stipulated regarding e.g. final inspection.

The aim of the appendix is for it to be able to be used as supporting data when a client (network owner) wants to engage an inspector to inspect a fibre installation.

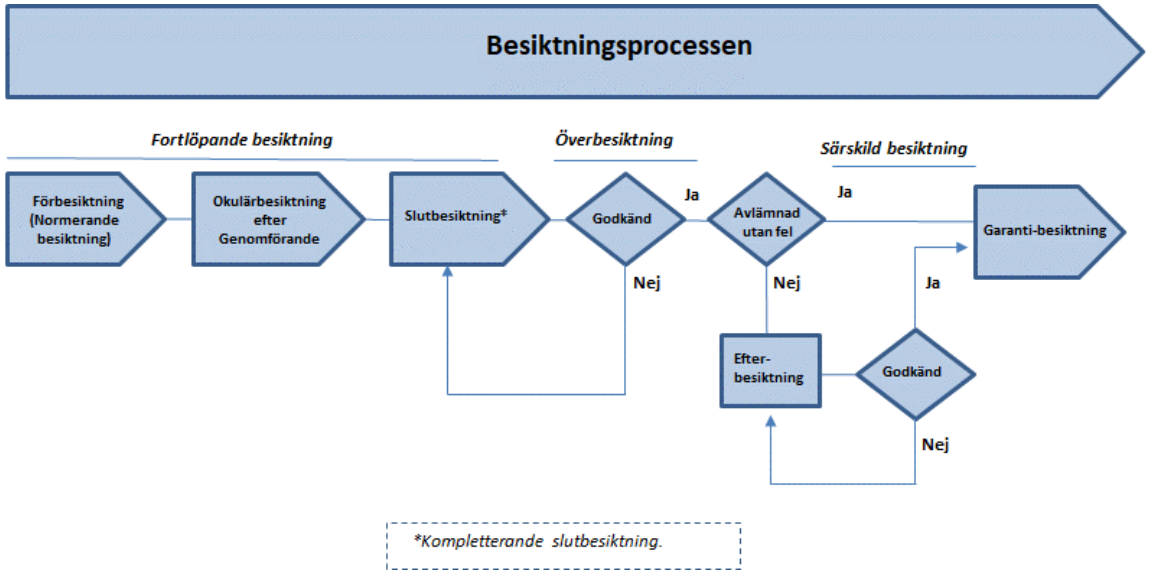
The inspection process is based on *AB 04 General conditions of contract for building and civil engineering works and building services* as well as *ABT 06 General conditions of contract for design and construct contracts for building, civil engineering and installation works.*

The contractor must carry out and document in-house checks, which are conducted and documented per section.

The scope of the inspector's work must at least conform to that set out in the minimum requirements below. The client normally has additional requirement/instructions that must also be included in the inspection.

2. THE INSPECTION PROCESS

The inspection process is illustrated by the following figure.



The inspection processes

Minimum requirements within the following areas are defined in the appendix:

- Review with the client prior to implementation
- Review with the contractor prior to implementation
- Visual inspection with landowners prior to implementation
- Pre-inspection (Normative inspection)
- Visual inspection after implementation
- Final inspection
- Inspection report
- Post-inspection
- Warranty inspection

In addition to the process steps specified above, there are further inspection measures that may be relevant for an inspector to implement:

- Ongoing inspection
- Reinspection
- Special inspection

The client should appoint a controller who then represents the client. A checklist must be drawn up regarding how the controller should continually check and document the installation work throughout the implementation period.

3. INSPECTION

3.1 Generally

An inspection of a fibre installation is carried out to verify that the installation has been executed in accordance with the contract documents and the client's instructions.

All the work and all documentation must be complete when final inspection is performed. The project is reported as complete to the client after approved final inspection.

The inspection work is a process involving three parties:

- the client
- the contractor
- the inspector.

Inspection of the fibre installation must be carried out by an impartial inspector with experience in this area. An inspector should be appointed relatively early in the project, before implementation commences, so that the conditions and contract documents can be reviewed. This makes things easier for the parties when the actual inspection work is to be carried out.

An inspector is appointed by the client. The inspector appointed by the client must be suitable for the assignment. The requirement of suitability includes, besides technical knowledge, the inspector's objectivity, since the assignment means that the inspection is carried out in an independent manner towards both the client and the contractor. Pre-inspection and final inspection are paid for by the client, while any post-inspection is paid for by the contractor.
The most common steps in the inspection process are presented below. Within each area, there are also minimum requirements in respect of the scope of an inspection. The client determines whether an extended inspection is to be carried out. Once each step has been implemented, this should be noted in the minutes from a Construction meeting (or equivalent).

For the implementation of the inspection, Appendix 6.1 Checklist final inspection is used. The checklist also includes the additional requirements, for the facility and the documentation, which must be verified if the facility has received broadband support in accordance with Chapter 3.2 Inspection of a facility that has received broadband support from the Swedish Post and Telecom Agency or from the Swedish Board of Agriculture.

3.2 Inspection of a facility that has received state support

If the facility has received broadband support from the Swedish Post and Telecom Agency or the Swedish Board of Agriculture, Appendix 6.1 Checklist final inspection is used. The checklist has been supplemented with the additional requirements, on the facility and the documentation, that the authority prescribes in the following documents:

- PTS. Requirements for robustness, reliability, security and overcapacity in accordance with PTS's conditions for investment support for broadband.

- SJV. The Swedish Board of Agriculture's regulations on business support, project support and environmental investments as well as support for locally led development (SJVFS 2016: 19).

- SJV. Regulations on amendments to the Swedish Board of Agriculture's regulations (SJVFS 2016: 19) on business support, project support and environmental investments as well as support for locally led development (SJVSF 2020: 33)

If the inspection refers to a facility that has received broadband support from the Swedish Board of Agriculture, the inspector must certify that the facility meets the Swedish Board of Agriculture's requirements for the facility and the documentation.

- LSB12_23

- LSB12_24

3.3 Review with the client prior to implementation

The client and the inspector should review the conditions prior to implementation as set out below:

If a review with the client is conducted prior to implementation, the minimum requirements are as follows:

- Checking of risk and vulnerability analysis (if one has been drawn up).
- Review of local conditions and instructions in respect of routing and restoration.
- Review of contract documents, e.g. contract agreement, equipment list and timetable, as well as requirements regarding labelling and documentation.
- During implementation it must be ensured that the selected equipment, as well as the labelling and documentation, satisfy the minimum requirements.
- Coordination with the controller and production of an overall inspection plan.

3.4 Review with the contractor prior to implementation

Before commencing implementation, the client, contractor and inspector should conduct a review as set out below:

If a review with the contractor is conducted prior to implementation, the minimum requirements are as follows:

- General review of detailed planning and dimensioning.
- Review of installation instructions
- Review of choice of equipment.
- General review of routing methods in different sections.
- Review of labelling and documentation prior to final inspection and any normative inspection.
- Review of the contractor's plan for in-house checks

3.5 Visual inspection with land owners prior to implementation

The client initiates visual inspection prior to implementation. The visual inspection is performed by a representative of the client (normally a controller) and a representative of the contractor. The inspection of the work area's surface layer is performed together with landowner and road operator along sections where earthworks are planned. A report is drawn up. It is an advantage if the report can be supplemented with pictures/film.

MINIMUM REQUIREMENTS FOR INSPECTION PRIOR TO IMPLEMENTATION:

- A report must be drawn up setting out the inspected sections. Faults, deficiencies and agreements must be noted.
- Representatives of the client, the contractor and affected land owners/road operators must be set out in the report.

3.6 Ongoing inspection

If the parties agree on Ongoing inspection, this is carried out as a pre-inspection or final inspection.

3.7 Pre-inspection (Normative inspection)

Pre-inspection should be conducted when significant parts of the installation cannot be checked after completion. This is done to ensure that execution corresponds with the contract documents and in order to review in detail how labelling and documentation should be carried out. Representatives of the client and the contractor must be present during the inspection. When the aim of the inspection is to establish principles or quality requirements for a large amount of recurring work, this is known as a normative inspection.

If a pre-inspection is performed, the minimum requirements are as follows:

- Check that newly established sites and nodes satisfy minimum requirements.
- Check that the employed routing method corresponds with the requirements.
- Check that the indicated cable location has been used.
- Review that duct bedding, number of ducts, cable marking, backfilling and backfill height satisfy the requirements.
- Check that used equipment corresponds with the requirements.
- Check that seals satisfy the minimum requirements.
- Check that labelling has been carried out in accordance with the requirements.
- Review of agreed documentation for the section in question. Examples of agreed documents must be available, but do not need to be complete.

3.8 Visual inspection after implementation

When the fibre installation is completed and restoration of the work area has been conducted, a new visual inspection is normally conducted by representatives of the client and the contractor. The representative of the client should contact affected land owners/road operators before this takes place in order to obtain any opinions about how the contractor has conducted the implementation and restoration. Affected land owners/road operators can also participate in the visual inspection. The results are documented in a report, which should be supplemented with pictures/film of that which deviates from the work area's appearance prior to the implementation of the project.

If a visual inspection after implementation is carried out, the minimum requirements are as follows:

- A report must be drawn up setting out the inspected sections. Faults and deficiencies must be noted.
- Representatives of the client, the contractor and opinions from affected land owners/road operators must be set out in the report.

3.9 Final inspection

When the fibre installation is complete and (normally) visual inspection after implementation has been conducted, the final inspection is implemented. At this point, it is also a condition that all labelling, all documentation, all position measurement and all measurement reports are complete. The documentation must be available so that the inspector can examine it an agreed number of days prior to the final inspection.

The inspector calls the final inspection and draws up an inspection plan, which is followed unless something abnormal is discovered. It is normally the case that 10–15% of the fibre installation is checked during the final inspection. If deficiencies are discovered, the scope of the inspection work is expanded.

During the final inspection, checks are performed to ascertain that execution, labelling and documentation (including position measurement and measurement report) are carried out in accordance with the contract documents, the client's instructions and agreements during the normative inspection and at construction meetings.

MINIMUM REQUIREMENTS IN RESPECT OF FINAL INSPECTION:

Preparations prior to the final inspection:

- An agreed number of days prior to the final inspection, the inspector must review all documentation and check that no data is missing.
- The inspector must draw up an inspection plan. The inspection plan may be drawn up in consultation with the client.
- The inspection plan must not be communicated to the contractor prior to the final inspection.

Review with representatives of the client and the contractor:

- Check that selected installation instructions and routing methods correspond with the requirements.
- Check of the contractor's documentation of in-house inspections.
- Review of notes regarding deficiencies in respect of duct bedding, number of ducts, cable marking, backfilling and backfill height. The inspection plan is supplemented with a check of deficiencies that are to be rectified.
- Review of notes regarding deficiencies relating to normal restoration (e.g. deficiencies in respect of gravel, asphalt, slabs and grass). The inspection plan is supplemented with a check of faults and deficiencies that are to be rectified.
- Check that used equipment corresponds with the requirements.
- Check that labelling has been carried out in accordance with the requirements.

Inspection in the field (random check of 10–15% of the fibre installation):

- Check of newly established sites and nodes in respect of location, execution and labelling so that minimum requirements and additional requirements are satisfied (see checklists and instructions from the client).

- Check of newly established optical fibre chambers and outdoor splice cabinets in respect of location, positioning, fittings, ground insulation, sealing of ducts and locking.
- Check that the indicated cable location has been used.
- Check of UV protection and mechanical protection for visible ducts outdoors.
- Check that search string (if this is used) is accessible in distribution points.
- Check that there is protection for fibre optic cables indoors where there is a risk of vandalism or sabotage.
- Check of bushings entering properties in respect of incline, sealing and labelling.
- Check of terminations in properties in respect of execution and labelling.
- Check that labelling and documentation correspond.

If a pre-inspection and/or visual inspection before/after implementation have not been carried out, the following must be verified, as far as this is possible, during the inspection in the field:

- Check that selected installation instructions and routing methods have been used.
- Check that duct bedding, number of ducts, cable marking, backfilling and backfill height have been executed in accordance with the requirements.
- Check of faults and deficiencies from normal restoration (e.g. deficiencies in respect of gravel, asphalt, slabs and grass).
- Check that used equipment corresponds with the requirements.

When routing in lakes or large watercourses, the following are added:

- Check that the ducts/underwater cable satisfies the minimum requirements (must be checked by divers).

When routing on poles, the following are added:

- Check that the height above ground satisfies the requirements.

The final inspection is concluded with a final meeting, during which the inspector goes through the results of the final inspection and gives verbal approval/rejection of the fibre installation.

Comment:
If the contract at the final inspection is obviously not completed so that it can be approved, the Inspector may cancel the Inspection and prescribe a new final inspection. The inspector must state in his opinion the reasons for this.
The fact that a party fails to attend the inspection without acceptable reason does not impede the conduct of the inspection.
If the final inspection is not carried out within the prescribed time due to the failure of the client, the contractor is considered approved and delivered from the date when the inspection would have been properly carried out

3.10 Inspection report

When the final inspection is complete, the inspector prepared an inspection report (inspection statement), which is distributed to the parties.

MINIMUM REQUIREMENTS REGARDING WHAT IS TO BE SET OUT IN THE

INSPECTION REPORT:

Parties	client, contractor
Conditions	relevant contract documents
Participants	representatives for each party, other participants and the inspector
Scope	which elements are included in the final inspection
Notes	observations in conjunction with the final inspection
Comments	that which must be rectified by the contractor
Results	in respect of execution, labelling and documentation, as well as deadline for rectifying comments
Approval	adopting a stance in respect of approval/rejection from both parties with written signatures, digital signatures or e-mail acceptance.
Warranty period	the end date of the warranty period

3.11 post-inspection

If the final inspection has resulted in comments, these must be rectified by the contractor, after which a post-inspection of the comments is carried out and a new inspection report is prepared. The process is repeated if necessary, until all the comments have been rectified.

Restoration that has to be conducted long after the fibre installation has been reported as complete and taken into use, e.g. asphalting that cannot be conducted in the winter or grass that cannot be sowed in the autumn, will result in comments in the inspection report. The deadline for rectifying these must be set according to the prevailing conditions in the area. The post-inspection can be carried out by the client or the inspector.

3.12 Warranty inspection

Before the end of the warranty period that applies according to AB/ABT, a warranty inspection is performed of the fibre installation. The client initiates the warranty inspection, unless otherwise agreed.

3.13 Special inspection

After the expiry of the contract period, parties are entitled to request a Special inspection in respect of faults pointed out by the client that existed at the time of the final inspection, but that had not been dealt with at the time because they had not been noticed or had been ignored by the inspector. Applies both to faults that have been discovered during the warranty period and/or to faults that have emerged after the warranty period but within the 10-year responsibility period and for the status of the contract in a certain respect

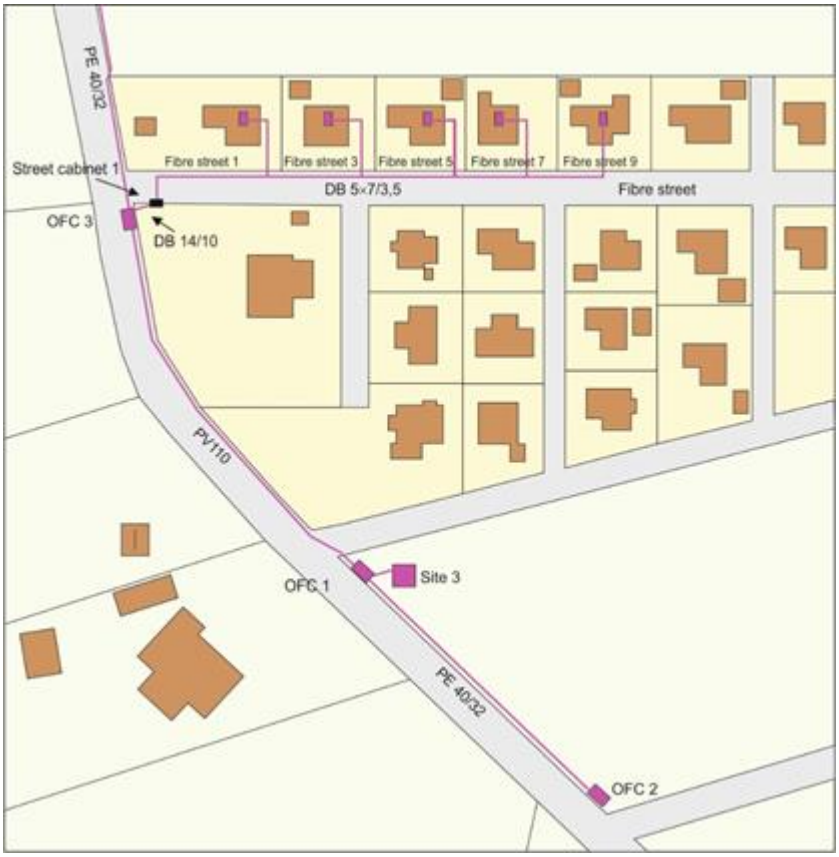
3.14 Other

It is up to the client to deal with warranty commitments in relation to other affected parties, such as landowners and road operators.

Instructions for Robust Fiber

Appendix 7 Fibre installation projects

Ver 1.5



CONTENTS

1. DESCRIPTION OF FIBRE INSTALLATION PROJECT 5

1.1 Plan 5

1.1.1 Determine area 5

1.1.2 Check future plans 5

1.1.3 Investigate collocation 5

1.1.4 Prepare rough projection 5

1.1.5 Investigate ground conditions 6

1.1.6 Conduct risk analysis 6

1.1.7 Apply for permit 6

1.1.8 Enter into land agreement 6

1.1.9 Draw up work environment plan 6

1.1.9 Produce timetable 6

1.1.10 Perform cost calculation 6

1.1.11 Procure construction 6

1.2 Project 7

1.2.1 Conduct detailed projection 7

1.2.2 Enter into land agreement 7

1.2.3 Apply for permits 7

1.2.4 Select equipment 7

1.2.5 Select routing technique 7

1.3 Implement 7

1.3.1 Order equipment 7

1.3.2 Protect cables with *Ledningskollen* 7

1.3.3 Establish on site 7

1.3.4 Self monotoring 8

1.3.5 Excavate 8

1.3.6 Route ducting 8

1.3.7 Route main cable 8

1.3.8 Splice/terminate fibre optic cable 8

1.3.9 Install fibre optic cable to end customer 8

1.3.10 Measure fibres 8

1.3.11 Restore 8

1.3.12 Measure position 8

1.3.13 Conduct checks 8

1.3.14 Inspect 8

1.3.15 Report as complete 9

1.4 Document 9

1.4.1 Document 9

1.4.2 Update areas of interest in *Ledningskollen* 9

1.5 Operate 9

1.5.1 Transfer to operation 9

1.5.2 Operate and maintain 9

1.5.3 Conduct service 9

1.5.4 Handle planned measures 9
1.5.5 Handle supplementing 9
1.5.6 Manage documentation 9
1.5.7 Manage agreements 9
1.5.8 Update risk analysis 10
1.5.9 Ledningskollen 10

1. DESCRIPTION OF FIBRE INSTALLATION PROJECT

This appendix is a brief description of the elements included in a fibre installation project. The description does not follow a strict chronology, rather it should be viewed as a review of the various elements. The elements can be carried out wholly or partially by the client.

The planning work is normally carried out by the client (the prospective network owner) or a suitable planner appointed by the client. Planning, implementation and documentation are normally conducted by the selected contractor. The finished fibre installation is then transferred to an operating organisation which runs, maintains and manages the fibre installation.

In the event the installation is receiving public co-financing from the Swedish Agency for Economic and Regional Growth (xx) or the Swedish Board of Agriculture (SJV), consideration must be given to these authorities' requirements regarding the design of the passive infrastructure in accordance with:

The Swedish Agency for Economic and Regional Growth:
- Guidance for a successful broadband project
- Particular requirements for broadband expansion

The Swedish Board of Agriculture:
- Regulation SJVFS 2016:19, Chapter 6

1.1 Plan

1.1.1 Determine area

The network owner determines which area is to be planned. Choice of area is made on the basis of market, geographic and technical conditions.

Create a control area (Bevakningsområde) in the *Ledningskollen* service for the area you intend to plan for.

1.1.2 Check future plans

Coordination is conducted with affected land owners regarding future plans in the area in order to prevent collisions with other planned projects, e.g. house or road-building.

1.1.3 Investigate collocation

The potential for collocation with other pipe and cable owners (e.g. electricity, water and sewage, district heating) is investigated. This is done, for example, by creating a collaboration case (Samordningsärende) in the *Ledningskollen* service, or through routines for co-location at the local level

1.1.4 Prepare rough projection

A rough projection is produced including the number of potential customers, a proposed network structure to cover the area, suitable routing technique, excavation lengths and the material in which excavation is taking place. A sketch of the area (network overview) and a table containing estimated equipment amounts are attached to the rough projection. The rough projection is used e.g. as a basis for cost calculations. Create a project case

(Projekteringsärende) in the Ledningskollen service to get information about existing infrastructure on central parts of the network already. Information on existing infrastructure, for example, provides information for cost calculations, schedules and risk analysis

1.1.5 Investigate ground conditions

The ground conditions along planned excavation sections are investigated on site, in order to gain an understanding of the actual situation.

1.1.6 Conduct risk analysis

A risk analysis is conducted for constituent parts of the future fibre installation, in accordance with the PTSFS 2022:11 The Swedish Post and Telecom Agency's regulations and general advice on security in networks and services.

1.1.7 Apply for permit

Necessary permits **must** be obtained as soon as possible after the application is submitted and before commencing work on establishing the broadband installation.

1.1.8 Enter into land agreement

A land agreement is entered into with affected property owners in respect of the placement of nodes, optical fibre chambers and outdoor splice cabinets, as well as transfer routes for ducts.

1.1.9 Draw up work environment plan

A work environment plan is produced for the entire project. This must be carried out by the client or by the contractor that has assumed the client's responsibility.

1.1.9 Produce timetable

A rough timetable is produced in which main activities and the number of weeks for the project from start-up to finished network are specified.

1.1.10 Perform cost calculation

A cost calculation for the fibre installation is conducted, based on the results of the above stages.

1.1.11 Procure construction

A contractor is procured for the construction of the fibre installation. Detailed projection can be carried out by the client or be included in the contract. The choice of contract form is made (normally on the basis of one of the general conditions of contract drawn up by the Construction Contracts Committee, known as AB and ABT), which means:

- AB (General conditions of contract).
  The client is responsible for detailed projection and the contractor for execution, normally on a current account basis.
- ABT (General conditions of contract for design and construct contracts).
  The contractor is responsible for both detailed projection and execution, normally at a fixed price.

1.2 Project

1.2.1 Conduct detailed projection

The network owner or the selected contractor performs detailed projection on a location map, prepares an equipment list (volume calculation) and other work documents.
The installation **must** be projected and planned in detail per section.

1.2.2 Enter into land agreement

A land agreement is entered into with affected property owners in respect of the placement of nodes, optical fibre chambers and outdoor splice cabinets, as well as transfer routes for ducting pipes.

1.2.3 Apply for permits

Required permits are produced, including opening notification, start permit, TA plan (traffic arrangement plan) and permission from the Swedish Transport Administration regarding the placement of telecommunication lines. Necessary permits **must** be obtained as soon as possible after the application is submitted and before commencing work on establishing the broadband installation.

1.2.4 Select equipment

Equipment is selected for the project based on the volume calculation.

1.2.5 Select routing technique

Selection of the routing method(s) that is most suitable in the area.

1.3 Implement

1.3.1 Order equipment

Equipment for the project is ordered based on volume calculation and choice of equipment.

1.3.2 Protect cables with *Ledningskollen*

Although the Ledningskollen has been used in the planning and the design phase, cable indication case (ledningsanvisningsärende) must be created prior to each ground work as only the cable owner's response to the cable indication query is approved for ground work. No ground work can be commenced without a cable indication case being created, all answers and any conditions have been confirmed in the Ledningskollen and all answers (cable maps and physical marks (poles or color marking on ground) are at the workplace.
There may also be local procedures for cable indication queries in addition to Ledningskollen.

1.3.3 Establish on site

Permits applications are submitted to land owners regarding establishing e.g. workmen's shelters and equipment at indicated locations in the area.

1.3.4 Self monotoring

MINIMUM REQUIREMENTS:

- The installation of ducts is difficult to check why the contractor should carry out self-monitoring.

1.3.5 Excavate

The excavation work or equivalent is carried out according to the selected method.

1.3.6 Route ducting

Routing is performed for distribution points (nodes, optical fibre chambers and outdoor splice cabinets) and ducts.

1.3.7 Route main cable

Fibre optic cables are routed in ducting between nodes and optical fibre chambers, up to the outdoor splice cabinet or optical fibre chamber nearest the end customer.

1.3.8 Splice/terminate fibre optic cable

Fibre optic cables are spliced/branched in optical fibre chambers and outdoor splice cabinets. Fibre optic cables are terminated (made accessible via fibre connectors) in nodes.

1.3.9 Install fibre optic cable to end customer

A fibre optic cable is routed and spliced from the nearest distribution point for the final section in to the end customer. Connection points are installed, to which the end customer connects his equipment.

1.3.10 Measure fibres

Delivery measurement is performed on connected fibres.

1.3.11 Restore

Restoration is performed after earthworks, using e.g. gravel, grass or asphalt.

1.3.12 Measure position

Geographic position measurement is conducted for all newly established fibre installations. Survey files containing lists of items are presented on a location map.

1.3.13 Conduct checks

A controller appointed by the client performs ongoing checks of the installation work throughout the implementation period.

1.3.14 Inspect

Inspection of the fibre installation is performed to verify that the installation has been carried out in accordance with the contract documents, and to verify that all work and all documentation are complete.

1.3.15 Report as complete

The project is reported as complete to the client once final inspection is approved. The project is thereby transferred to the client.

1.4 Document

1.4.1 Document

Agreed documentation is produced and submitted to the client.

1.4.2 Update areas of interest in *Ledningskollen*

The information about the location of the fibre installation shall be converted into new or updated areas of interest in the *Ledningskollen*, so the cable owner will get cases in Ledningskollen regarding upcoming works near the new installation.

1.5 Operate

1.5.1 Transfer to operation

The finished fibre installation is transferred from the client to the selected operating organisation.

1.5.2 Operate and maintain

Following transfer, it is the responsibility of the operating organisation to operate and maintain the fibre installation.

1.5.3 Conduct service

Agreements regarding service measures within stipulated times are drawn up with the operating organisation and field personnel. Service must include the remedying of faults and the replacement of defective network components.

1.5.4 Handle planned measures

Ensure you have the resources and expertise to carry out planned replacement of network components as well as the connection/disconnection of end customers.

1.5.5 Handle supplementing

Supplementing of the fibre installation is handled in accordance with the applicable stages above.

1.5.6 Manage documentation

There must be an organisation for continually updating the documentation when changes are made.

1.5.7 Manage agreements

The network owner must ensure that agreements entered into are registered. This must be done in order to monitor agreement periods and warranty periods, as well as to initiate renewals and the signing of new agreements, if necessary.

1.5.8 Update risk analysis

The risk analysis must be updated annually or in the event of major changes in the installation.

1.5.9 Ledningskollen

The network owner must ensure that cases from the *Ledningskollen* are answered promptly and correctly and that information and settings are kept up to date.

Instructions for Robust Fiber

Appendix 8 Ledningskollen

(Swedish version)

Ver 1.5

INNEHÅLLSFÖRTECKNING

1. Inledning **4**

2. Ledningskollen, en översikt **5**

3. Gå med som Ledningsägare i Ledningskollen **6**

4. Ledningskollen i fiberutbyggnadsprocessen **7**

4.1 Planera 7

4.2 Projektera 7

4.3 Genomföra 8

4.4 Dokumentera 9

4.5 Driva 10

1. INLEDNING

Anvisningen för Ledningskollen utgör en bilaga som kompletterar anvisningarna för förläggning av robusta fibernät. Denna bilaga, bilaga 8 - Ledningskollen i robust fiber, beskriver mer i detalj när, hur och varför Ledningskollen ska användas vid planering, projektering, utbyggnad och förvaltning av fibernät.

Anvisningen består av två delar där den första beskriver krav på nätägaren som ledningsägare i Ledningskollen och vänder sig i första hand till nätägare som inte redan är med i Ledningskollen som ledningsägare.

Den andra delen beskriver om hur Ledningskollens i funktioner används som stöd under hela fiberanläggningsprocessen. Anvisningen kan läsas från början till slut för att få en helhetsbild över Ledningskollens roll genom hela fiberanläggningsprocessen men det går också att läsa ett enskilt avsnitt för att få instruktioner kopplade till en speciell del.

2. LEDNINGSKOLLEN, EN ÖVERSIKT

Ledningskollen är en webbtjänst som sedan 2009 både minskar antalet grävskador och underlättar samordning och planering av bygg- och anläggningsprojekt. Ledningskollen gör detta genom att förmedla information mellan de som behöver information om ledningar och annan infrastruktur och de som har information om ledningar och annan infrastruktur.

Den vanligaste användningen av Ledningskollen är inför ett markarbete då ett **ledningsanvisningsärende** görs för att få utsättning eller ledningskartor från berörda ledningsägare så att arbetet kan bedrivas utan att skada befintlig infrastruktur.

Ledningskollen drivs av Post- och Telestyrelsen, PTS och finansieras av PTS, Svenska kraftnät och Trafikverket.

I Ledningskollen skapar användare olika typer av ärenden, se bild nedan. Gemensamt för alla ärenden är att ett geografiskt område anges. Ledningskollen förmedlar ärenden till de ledningsägare som har ledningar eller andra intresse i just det område som ärendet avser. För att Ledningskollen ska veta till vilka ledningsägare ett ärende ska skickas har varje ledningsägare skapat **intresseområden** där de har ledningar och **bevakningsområden** där de är intresserad av framtida utbyggnad . **Ledningskollen har alltså inte information om var alla ledningsägare har sina ledningar,** det har bara den enskilda ledningsägaren och det är också ledningsägaren som skickar svaren till den som skapat ärendet.

För mer allmän information om Ledningskollen, besök gärna Ledningskollens hemsida, www.ledningskollen.se

Ledningskollens olika ärendetyper:

	Välj **Ledningsanvisning** för att få information om ledningars läge, så att du kan genomföra ditt markarbete utan att skada dessa. Ledningsanvisning är den vanligaste typen av ärende och kallas även **kabelanvisning**.
	Välj **Projektering** om du behöver information om befintlig infrastruktur men inte ska utföra något markarbete i närtid. Exempelvis för planering av ett framtida markarbete eller Projektering.
	Välj **Samordning** när du vill erbjuda andra aktörer grävsamordning i samband med era projekt eller om du vill undersöka möjlighet till framtida samordning
	Välj **Samhällsplanering** när du arbetar med en **detalj- eller översiktsplan** för en kommun eller myndighet och vill komma i kontakt med ledningsägare i aktuell kommun.
Ledningskollen och *lag (2016:534) om åtgärder för utbyggnad av bredbandsnät*	
	Om du som bredbandsutbyggare vill **undersöka möjligheter att nyttja annans infrastruktur** enligt lag om åtgärder för utbyggnad av bredbandsnät börjar du med att göra ett projekteringsärende
	Om du som nätinnehavare ska **publicera ett bygg- och anläggningsprojekt för att möjliggöra samordning** för bredbandsutbyggare enligt *lag om åtgärder för utbyggnad av bredbandsnät* ska du skapa ett samordningsärende.

3. GÅ MED SOM LEDNINGSÄGARE I LEDNINGSKOLLEN

Även om man är ny aktör och ännu inte har någon infrastruktur kan man vara med i Ledningskollen för att ta emot ärende bland annat för att identifiera samordningsmöjligheter. Det ger också möjlighet att skydda kanalisation mm under pågående utbyggnad.

Processen för att gå med i Ledningskollen kan beskrivas i följande steg:

1. Gå in på Ledningskollens hemsida https://www.ledningskollen.se/Ledningskollen-for-dig och ta del av den information som gäller din typ av verksamhet
2. Ta kontakt med Ledningskollens användarstöd och meddela att organisationen ska gå med i Ledningskollen, se sidan Gå med i Ledningskollen.
3. Användarstöd skickar ut en länk till ett formulär för att samla in information om er organisation. Exempelvis om ni är ledningsägare eller blivande ledningsägare. Användarstöd skickar också ut **Ledningskollens användarvillkor** som nätägaren ska godkänna innan organisationen kan aktiveras.
4. Ni fyller i formuläret och användarstöd skapar er organisation i Ledningskollen. Därefter skapar ni de användare som ska arbeta i Ledningskollen för er organisation.
5. I nästa steg skapar ni intresseområden och bevakningsområden för er organisation och anger vilken eller vilka typer av infrastruktur som organisationen har. Ni kan också skapa fler användare med olika roller (ledningsägare admin, svarare och frågare). När all information är inlagd kommer Ledningskollens användarstöd kontakta er för ett aktiveringssamtal. Vid aktiveringssamtalet kontrollerar användarstöd att informationen verkar korrekt och ger förklaringar till viktiga inställningar och val.
6. När aktiveringssamtalet är genomfört och ni har skickat in undertecknade användarvillkor aktiverar Användarstöd er organisation. Ni kommer nu att få ärenden som berör era intresse- eller bevakningsområden.

När man är med i Ledningskollen ska man följa Ledningskollens användarvillkor som bland annat inkluderar att:

- Tillse att intresseområden minst täcker ledningsnätet. Se avsnitt dokumentera och drifta nedan. Intresseområden kan skapas och ändras från Ledningskollen webb genom att rita i Ledningskollen, ladda upp GIS- eller CAD-filer, med hjälp av ledningsägarmodulen eller genom att använda Ledningskollens API.
- Hålla övriga inställningar uppdaterade och aktuella.
- Svara snabbt och korrekt på inkommande ärenden.

4. LEDNINGSKOLLEN I FIBERUTBYGGNADSPROCESSEN

I detta avsnitt av anvisningen beskrivs hur Ledningskollen ska användas i fiberutbyggnads-processens steg Planera, Projektera, Genomföra, Dokumentera och Driva.

Löpande i texten finns referenser och länkar till www.ledningskollen.se där det finns mer information som filmer, manualer och instruktioner.

4.1 Planera

I planeringsfasen ska följande funktioner i Ledningskollen användas:

- Skapa ett **samordningsärende** i Ledningskollen för att informera ledningsägare som är intresserad av utbyggnad i aktuellt område om era planer. (Ref 1.1.2 och 1.1.3 i bilaga 7). Ärendet bör helst skapas av en användare (med rollen frågare) i nätägarens organisation men kan också utföras av konsult/entreprenör på uppdrag av nätägaren. På Ledningskollens hemsida finns en snabbmanual för hur man för samordningsärende. [1]Lägg till **bevakningsområde** i nätägarens organisation i Ledningskollen för det område som projektet avser. Då kommer ni att få ärenden i Ledningskollen som berör ert område. Detta måste göras av en användare med rollen Ledningsägare admin (Ref 1.12 och 1.1.3 i bilaga 7). På Ledningskollens hemsida finns instruktioner för hur man skapar bevakningsområden

4.2 Projektera

Senast när arbetet med att projektera fiberprojektet påbörjas ska ett eller flera **projekteringsärenden** göras i Ledningskollen. Projekteringsärendet ger svar om befintlig infrastruktur i området som det egna fiberprojektet behöver ta hänsyn till i sin projektering vad gäller ledningsläge, tidplaner, riskanalys och kostnadskalkyler. För de ledningsägare som har ledningar i området ger projekteringsärende också viktig information om era tidplaner så att de kan planera in resurser för att svara på de ledningsanvisningsärenden som kommer i genomförandefasen.

För att göra projekteringsärende behöver man ha information om när man planerar att utföra sina markarbeten, vilka sträckningar eller områden som projektet omfattar och på vilket format och i vilket koordinatsystem ni vill ha på GIS-filerna som ledningsägarna svarar med. Informationen skrivs in i ärendet i Ledningskollen och skickas automatiskt via Ledningskollen till de ledningsägare som har infrastruktur i de områden som fiberprojektet omfattar. Ledningsägarna som verkligen har ledningar i omedelbar närhet av fiberprojektets tänkta sträckning svarar med GIS-filer efter några dagar.

Att kunna visa på hur fiberprojektets önskade/tänkta ledningsläge förhåller sig till befintlig infrastruktur är viktig information i andra beslutsprocesser och vid tecknande av entreprenadkontrakt för genomförande av fiberprojektet.

Tänk på att om fiberprojektet sträcker sig över lång tid eller stora områden och kommer utföras i etapper så kan det vara bra att göra flera ärenden i Ledningskollen.

På Ledningskollens hemsida finns instruktioner för hur man skapar projekteringsärende.

Om man i planeringsfasen gör en grovprojektering kan man skapa ett projekteringsärende redan i planeringsfasen.

[1] Utbyggnadslagen: Notera att nätägare som omfattas av definitionen "Nätinnehavare" enligt Utbyggnadslagen är skyldiga att informera om bygg- och anläggningsprojekt. Genom att använda Ledningskollens samordningsärende uppfylls detta lagkrav. Läs mer på Ledningskollen.se om Utbyggnadslagen.

4.3 Genomföra

I genomförandefasen av fiberprojektet ska Ledningskollens funktion för **Ledningsanvisningsärenden** användas. Det är viktigt att ärenden skapas, att svaren från ledningsägarna bekräftas i Ledningskollen och lämnas till de som ska utföra markarbete.

Tänk på att långa projekt innebär att man behöver göra flera ledningsanvisningsärenden!

Det är viktigt att man i projekteringsfasen eller tidigt i genomförandefasen gör upp en plan för:

- Vem eller vilka som ansvarar för att skapa ärenden.
- När ärenden ska skapas så att ledningsägare hinner svara innan markarbete påbörjas och så att arbetet kan slutföras inom de 30 dagar som ledningsägarnas svar är giltiga
- Vem som ansvarar för att svar i form av ledningskartor och information om genomförda utsättningar finns hos de som ska utföra markarbete innan markarbete påbörjas.

När man skapar ärende är det viktigt att tänka på:

- Svaren på ledningsanvisningsärenden är giltiga i 30 dagar: Större arbeten måste etappindelas baserat på tidplanen. Ärenden skapas ca en vecka före planerad grävstart för varje etapp/del.
- Ledningsanvisningsärenden skapas minst en vecka före planerad start för markarbetet.
- Större projekt behöver etappindelas och flera ärenden skapas. De ska också skaps längre i förväg för att ledningsägare ska hinna genomföra eventuella utsättningar.
- Ange information så noga det går, gäller speciellt var markarbete ska utföras. Tänk på att det går att ladda upp GIS- och CAD-filer för att skapa ärende. Det ger oftast bättre noggrannhet än att rita i Ledningskollens karta.
- Vara tillgänglig via mejl och telefon om ledningsägare behöver ställa kompletterande frågor.
- Om någon annan ska vara kontaktperson för utsättning eller mottagare av ledningskartor: Glöm inte att meddela dessa personer det så fort ärendet är skapat.
- Varje ledningsägare som har ledningar inom aktuellt område avgör hur man vill skydda sina ledningar, oftast genom att svara med en utsättning eller genom att skicka ledningskarta.
- Den som skapat ärendet ansvarar för att bekräfta att man tagit emot och förstått svaren och att svaren förmedlas till arbetsplatsen och de som utför markarbetet.
- I Ledningskollen anger ledningsägaren vilken åtgärd som gjorts, den som skapat ärendet ska bekräfta att man fått sitt svar och att man förstått innebörden i svaret. Först när man bekräftat svaret och de eventuella villkor som ledningsägaren angett för informationsspridningen eller markarbetet är svaret giltigt. Svar från alla ledningsägare ska vara bekräftade innan markarbetet påbörjas.
- Det finns ledningsägare som inte är med i Ledningskollen och dessa måste kontaktas individuellt för att kontrollera om de har ledningar där markarbete ska utföras.
- Både utsättningar och kartor ska finnas på arbetsplatsen under hela markarbetet.
- När markarbeten är slutförda ska den som skapat ärendet stänga det i Ledningskollen.

På Ledningskollens hemsida finns snabbmanualer och filmer som beskriver hur man gör Ledningsanvisningsärenden.

4.4 Dokumentera

I steget dokumentera ska nätägaren skapa/uppdatera/kontrollera intresseområden i Ledningskollen så att den nya anläggningen täcks in. Inmätningsfiler eller annan detaljerad information kan användas.

Det är bara användare med rollen **Ledningsägare admin** som kan uppdatera intresseområden och nedan följer några tips/förslag på åtgärder.

- Som inloggad i rollen Ledningsägare admin klickar man menyn "Områden", där kan man se, redigera, lägga till och ta bort organisationens intresse- och bevakningsområden. Här kopplar man också organisationens svarsställen med intresse- eller bevakningsområden.
- Om du vill lägga till ett nytt intresseområde klickar du på knappen "Lägg till intresseområde" som även den finns under rubriken "Områden". Efter att ha gett området ett namn, tex A-stad, område Höjden kan man välja på att skapa områden genom att:
    - Rita område eller sträckning direkt i kartan
    - Ladda upp CAD/GIS-filer
    - Välja en hel kommun
    - Importera ett bevakningsområde.
- När det nya området är skapat väljer man också vilket eller vilka svarsställen som ska hantera ärenden som berör det nya intresseområdet.

Om man använder Ledningsägarmodulen eller Ledningskollens API kan man göra automatiserade uppdateringen av intresseområden i Ledningskollen baserat på data från egna dokumentationssystem.

Mer information om processen för att uppdatera intresseområden kan du läsa i manualen för Ledningsägare admin som finns bland manualerna på Ledningskollens hemsida.

Tänk på att redan när kanalisationen är på plats finns infrastruktur som kan skadas vid markarbete. Det finns stora fördelar med att redan då uppdatera sina intresseområden. Om inmätning inte sker förrän fibern är på plats kan man använda laddningsläget från projekteringen för att skapa intresseområden.

4.5 Driva

I steget driva handlar det om att besvara ärenden som skapas i Ledningskollen samt att hålla inställningar i Ledningskollen uppdaterade i enlighet med Ledningskollens användarvillkor. Det förutsätter att nätägaren bland annat:

- Har en organisation (egna resurser eller genom underleverantörer) som besvarar ärenden genom att skicka ledningskartor och utföra utsättningar.
- Uppdaterar intresseområden och andra inställningar löpande.
- Skapar användare i olika roller.

Integration och Ledningsägarmodulen kan förenkla för nätägare

Om man har ett system för sin nätinformation och vill förenkla hantering av inkommande ärende kan man undersöka möjligheterna att använda Ledningskollens API. Läs mer om Ledningskollens API på Ledningskollens hemsida

För att minska det manuella arbetet med att hantera inkommande ärenden i Ledningskollen kan man också använda Ledningsägarmodulen. Det är en serverprogramvara som kan laddas ner från Ledningskollens hemsida och installeras i nätägarens egen servermiljö.

Ledningsägarmodulen har två huvudsakliga funktioner:

- att automatiskt filtrera bort ointressanta ärenden för ledningsägaren och
- att uppdatera intresseområden i Ledningskollen när det egna ledningsnätet förändras.

Det går att integrera Ledningsägarmodulen med ledningsägarens eget ledningssystem. Läs mer om Ledningsägarmodulen på Ledningskollens hemsida.