



**International
Standard**

ISO 37175

**Smart community infrastructures —
Operation and maintenance of
utility tunnels**

*Infrastructures urbaines intelligentes — Exploitation et
maintenance des tunnels techniques*

**First edition
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A utility tunnel is typically constructed underground to carry pipelines. A utility tunnel is also used to carry communications cables such as telecommunication cables, radio cables and television cables.

In a smart community, a utility tunnel is an important part of the infrastructure that accesses energy distribution, city information / data acquisition as well as transmission systems, while also being crucial for the redistribution of social resources. It is a valuable aspect of public infrastructure and a lifeline to ease the congestion of community traffic by fully utilizing the community underground space.

If the utility tunnel is well-planned, constructed and managed, it can have the following advantages:

- effectively conserves underground space;
- reduces the need for repetitive road / pavement excavations in contrast to traditional buried pipelines;
- eliminates the risk of overhead facility accidents caused by inclement weather, thereby enhancing the landscape and public safety of the community;
- reduces the operation and maintenance costs of pipelines and improves infrastructure management;
- increases community energy carrying capacity and promotes community efficiency and sustainable development.

This document provides a general overview and framework for the operation and maintenance of utility tunnels. It aims to provide requirements and recommendations for stakeholders of utility tunnels to improve safety, maintainability, cost-effectiveness, technology application, sustainability and management efficiency.

This document benefits the stakeholders of utility tunnels, including but not limited to, authorities, investors, developers, operation providers, maintenance providers, pipeline operators and citizens. It provides requirements and recommendations for cooperation between the public and private sectors and their regulators. Effective cooperation ensures the safe, orderly and intensive development and rational utilization of community underground space. The document also assists operation and maintenance providers in delivering safe and reliable energy supply services, improving the quality of community living for citizens.

This document contributes to the digitalization and smartness of the operation and maintenance of utility tunnels. Several global innovations have been made for the digitalization and smartness of the operation and maintenance of the utility tunnel, such as:

- National Underground Asset Register (NUAR)¹⁾ in the UK provides a digital map for stakeholders to access information about underground pipelines and cables, enabling stakeholders to obtain the data required for safe operation and maintenance based on their roles;
- The community underground pipeline network management platform in China are integrated platforms, for example, Beijing Government Services²⁾;
- Before You Dig Australia (BYDA)³⁾ in Australia is a national infrastructure information system platform that ensures the safety of construction workers and communities during excavation projects, promoting the vision of zero damage and zero harm.

This document encourages a platform-based approach for managing the operation and maintenance of the utility tunnels. It aims to strengthen information exchange and sharing, and ensure the safe and effective operation and maintenance of the utility tunnels.

1) <https://www.gov.uk/guidance/national-underground-asset-register-nuar>

2) <https://banshi.beijing.gov.cn/>

3) <https://www.byda.com.au/>

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Smart community infrastructures — Operation and maintenance of utility tunnels

1 Scope

This document specifies requirements and recommendations for the operation and maintenance of utility tunnels in terms of application, safety, energy conservation, advanced technology and economic rationality. This document aims to ensure the sustainable development as well as safe and stable operation and maintenance of utility tunnels.

This document is applicable to communities of any size that have utility tunnels.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 utility tunnel

enclosed structure and ancillary facility built under the city to access two or more pipelines, e.g. electricity cables and water supply pipes

Note 1 to entry: A utility tunnel is also used to carry communications cables such as telecommunication cables, radio cables and television cables.

Note 2 to entry: For the purposes of this document, "utility tunnel" is used, but other terms that can be used such as utility corridor, common services tunnel, common ditch or utilidor.

3.2 utility tunnel body

enclosed structure that can independently withstand the effects of external water and soil within the design service life, including the main body structure of the utility tunnel and the various entrances and exits, maintenance roadways, ventilation ducts and other structures

3.3 ancillary facility

supporting facility of the utility tunnel for the purpose of safe operation and maintenance

EXAMPLE Firefighting system, ventilation system, power supply system, illumination system, monitoring and alarm system, water supply system, drainage system and identification system.

3.4 pipeline

pipe or cable utility line that is installed inside the utility tunnel for carrying water, rainwater, sewage, reclaimed water, gas, heating water, cooling water, steam, electricity and communication data

3.5

operation and maintenance management platform

OMMP

integrated platform that meets the monitoring, management, processing, and decision-making needs of stakeholders of a utility tunnel based on the latest smart community infrastructure technologies, e.g. smart monitoring, Internet of Things (IoT), big data, building information modelling (BIM), geographic information system (GIS) and related smart equipment

Note 1 to entry: An OMMP should be reliable, safe, advanced, usable, maintainable, extensible and open.

Note 2 to entry: An OMMP should be able to be accessed to the development map of the utility operator and provider.

3.5.1

building information modelling

BIM

use of a shared digital representation of an asset to facilitate design, construction and operation processes to form a reliable basis for decisions

[SOURCE: ISO 23386:2020, 3.6]

3.5.2

geographic information system

GIS

information system dealing with information concerning phenomena associated with location relative to the Earth

[SOURCE: ISO 19101-1:2014, 4.1.20]

3.6

stakeholder

organization or individual who obtains investment returns, supply quality, safety guarantees and city management benefits through the operation and maintenance of utility tunnels EXAMPLE Authority, investor, developer, operation provider, maintenance provider, pipeline operator, citizen.

3.6.1

authority

organization that develops, maintains, administers and / or enforces regulations to ensure safety, quality and performance as well as other important aspects of a utility tunnel

Note 1 to entry: The role of authority sometimes can be performed by the government or land owner.

EXAMPLE Community governmental agency.

3.6.2

investor

organization that invests in the development of a utility tunnel

Note 1 to entry: The financing institution can also be an investor when they provide funding for the development of a utility tunnel

EXAMPLE Development bank, commercial bank.

3.6.3

developer

organization that is responsible for the plan, design and construction of a utility tunnel and operation of a utility tunnel by organizing it in whole, or in part

Note 1 to entry: The developer can delegate utility tunnel operation and maintenance providers to operate and maintain the utility tunnel.

EXAMPLE Private developer, municipality.

3.6.4

operation provider

organization that is responsible for operating a utility tunnel

3.6.5

maintenance provider

organization that is responsible for maintaining a utility tunnel

3.6.6

pipeline operator

organization that is responsible for operating and maintaining a portion or the entirety of the pipelines

EXAMPLE ICT vendor, water supplier, electricity supplier, gas supplier.

3.6.7

citizen

member of a smart community who benefits from the development and operation of a utility tunnel

4 Benefits to stakeholders

4.1 General

The main relationship among stakeholders is shown in [Figure 1](#):

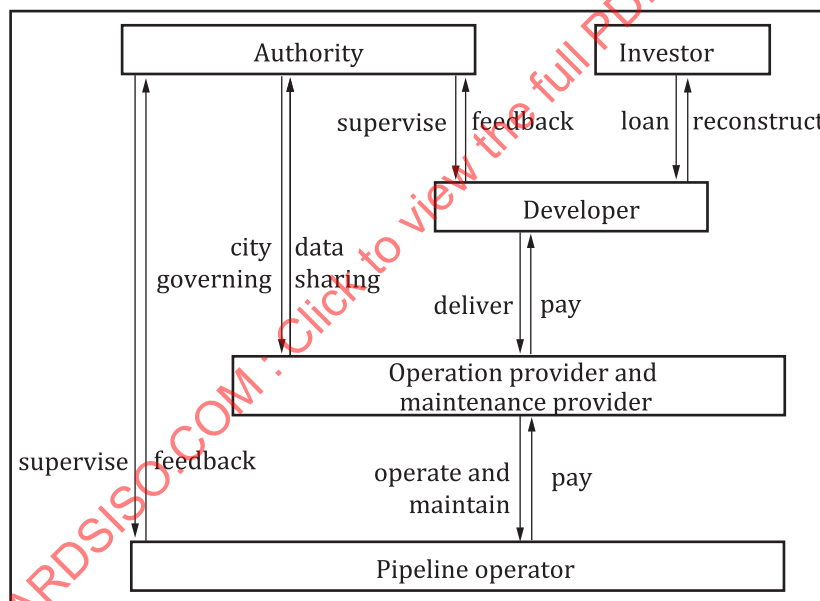


Figure 1 — Relationship among stakeholders

The operation and maintenance of a utility tunnel covers the stakeholders' benefits involved in the plan, design, construction, operation and maintenance of the utility tunnel throughout its life cycle. The main benefits that the stakeholder contributes to the process are as follows:

- improve the level of community governance and operation, to plan and use underground space efficiently, and to promote the sustainable development for the city authority;
- generate investment income for the investor;
- balance the sustainable development of community construction for the developer;
- realize the safe and efficient operation of the utility tunnel, as well as certain economic benefits for the operation provider;

- realize the normal operation of the utility tunnel and specific economic benefits for the maintenance provider;
- ensure the safety of pipelines and meet the energy supply needs for the sustainable development of smart cities for the pipeline operator;
- save costs for operation and maintenance of utility tunnels;
- ensure smart management in the operation and maintenance life cycle of the utility tunnel.

4.2 Authorities

The authority is responsible for the overall management of the operation and maintenance of the utility tunnel. Application of this document helps authorities to:

- coordinate the issues and activities in the entire life cycle of the utility tunnel including plan, design, construction, handover of the operation and maintenance services, smart operation and maintenance, to promote the formulation of requirements related to smart infrastructure, reduce operation and maintenance costs, and achieve cost efficiency;
- operate as a "system of systems" to improve efficiency of the smart utility tunnel as an integrated infrastructure;
- ensure the safe operation of the utility tunnel through efficient distribution and optimized management;
- achieve a better balance of benefits among all stakeholders.

4.3 Investors

The investor focuses on investment returns. Application of this document helps investors to:

- identify relevant risk during the operation and maintenance period by understanding the technical requirements during the operation period before investing;
- provide a basis for investors to formulate possible operational risk management strategies;
- understand the relevant technical requirements of operation and maintenance, and monitor investment or loan control more accurately;
- contribute to decision-making on collaborative investment or fund-raising.

4.4 Developers

Application of this document helps developers to:

- identify the relevant requirements during the plan, design and construction stages which can improve the efficiency and cost control during the operation stage, and increase the developer's income;
- contribute to the systematic development of a smart integrated utility tunnel operation and maintenance system;
- specify the requirements for the plan, design and construction, and operation and maintenance of the utility tunnel to the entrusted party.

4.5 Operation providers

Application of this document helps operation providers to:

- develop organizational policies, overall management plans and control requirements for the operations and maintenance of utility tunnels that suit operation providers' specific characteristics;
- identify safety management and emergency requirements to help operational safety and risk management;

- adopt new technology to improve the efficiency and profitability of operations;
- guide the evaluation and improvement of the operation level of the utility tunnel;
- ensure a consistent income to contribute to the daily operation and maintenance costs.

4.6 Maintenance providers

Application of this document helps maintenance providers to:

- identify the basic technical requirements and organizational requirements of operation and maintenance to develop daily maintenance measures;
- identify safety management and emergency requirements to help operational safety and risk management;
- adopt new technology to improve maintenance efficiency and cost control;
- understand the requirements of the maintenance of utility tunnels;
- promote the adoption and advancement of smart operations and maintenance.

4.7 Pipeline operators

Application of this document helps pipeline operators to:

- understand the safety and operation level of the utility tunnels;
- achieve a cost-effective utility tunnel that is financially acceptable to pipeline operators;
- reduce the scheduling waste of pipeline operators, and save resources through data sharing, data collection and data analysis.

4.8 Citizens

Application of this document improves the living environment for citizens by providing:

- more efficient and reliable infrastructure, resulting in a better quality of life;
- effective operation and maintenance of utility tunnels and the reduction of community carbon emissions.

5 Basic elements and overall requirements

5.1 General

The operation and maintenance of the utility tunnel body, the ancillary facilities, pipelines and the OMMP are the basic elements of the operation and maintenance of a utility tunnel.

Before the operation and maintenance of the utility tunnel begins, the authority or the developer should reach an agreement with the operation and maintenance provider. The authority or the developer shall issue an operation license to the operation and maintenance provider, which includes, but is not limited to, the operable and maintainable objects of the utility tunnel and the types of pipelines that can be accessed. The organization, personnel and rules of the operation and maintenance provider shall meet the operation and maintenance requirements. Relevant documents before the operation and maintenance stage, such as plan, design and construction stages, including BIM and GIS documents, should be submitted to the operation and maintenance provider.

5.2 Utility tunnel body

The utility tunnel body consists of ancillary facilities and pipelines, and the space where operation and maintenance activities take place. The following basic requirements shall be met:

- The design requirements for safety, functionality and durability of the utility tunnel body can be met by checking the construction acceptance documents of the utility tunnel body.
- The utility tunnel body shall take full advantage of the underground space considering the internal and external conditions;
- Functional parts of the utility tunnel such as entrances, vents and pipeline intersections, shall be constructed according to the design requirements and meet the operational and maintenance requirements. The internal space of the utility tunnel shall be comprehensively determined by details of pipelines, such as type specification, quantity, installation requirements;
- As a basic requirement of BIM, survey and mapping data of the utility tunnel body shall be obtained before construction is approved. A BIM+GIS model that meets the requirements of city information modelling (CIM) should be established. Individuals or organizations who survey and map the construction data should be trained and authorized to carry out the work;
- When a defect or damage occurs in the utility tunnel body due to material degradation or use of excessive loads during the service period, it should be recorded as defective and effectively disposed of according to the predetermined disposal measures.

5.3 Ancillary facilities

The ancillary facilities of the utility tunnel ensure the stable operation of the main body, the internal environment, pipelines and the safety of operations and maintenance personnel. The following basic requirements shall be met:

- Facilities for firefighting, ventilation, illumination, monitoring and alarms, drainage, etc. shall be capable of coordinated control;
- The lighting system shall meet requirements for operation, maintenance and emergency evacuation;
- The system composition, structure and configuration of the monitoring and alarm facilities should be determined according to the construction scale, the types of pipelines, and the operation, maintenance and management mode of the utility tunnel;
- Monitoring devices shall be installed for pipelines. For example, combustible gas detection and alarm devices shall be installed in the cabins containing gas pipelines. Thermal detectors shall be installed around the electricity cables for fire alarms.

5.4 Pipelines

The pipelines can obtain a stable environment through the operation and maintenance of utility tunnels. The following basic requirements shall be met:

- During the plan and design stage of utility tunnels, the developer should consider the requirements of the operation and maintenance of the pipelines.
- The pipeline operator should apply to the utility tunnel operator for access to the pipeline to the utility tunnel, and provide relevant documents such as the pipeline installation, operation and maintenance plan. The pipeline can be accessed to the utility tunnel with the permission of the utility tunnel operator. The pipeline owner shall submit the operation and maintenance schedule and emergency plan of the pipeline to the utility tunnel operator.
- After the installation of the pipelines into the utility tunnel, the operator shall ensure that the installation meets the requirements for the operation and maintenance of the utility tunnel.

- The number and type of pipelines entering the utility tunnel should be consistent with the plan and design specifications.

5.5 Operation and maintenance management platform (OMMP)

5.5.1 The OMMP is a comprehensive system. The system architecture and functions shall include at least, the following aspects to ensure effective operations:

- the requirements for developing a local smart community;
- the scale of the utility tunnels;
- the specifications for hosted pipelines;
- the mode for operation and maintenance management.

5.5.2 The basic architecture from layer 1 to layer 4 is shown in [Figure 2](#). The system shall include, at the least, the functions listed below:

- asset management;
- mechanical and electrical equipment monitoring management;
- environmental monitoring management;
- data management;
- inspection and maintenance management;
- a security alarm;
- emergency coordinated control.

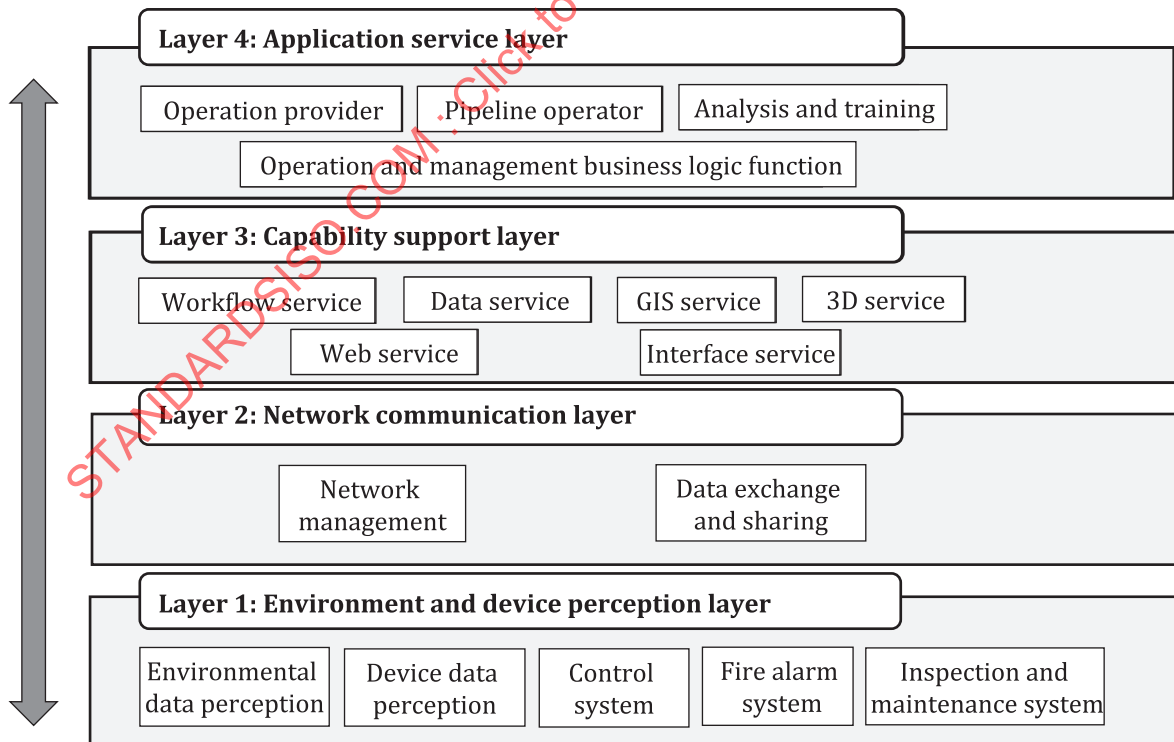


Figure 2 — Basic architecture of the OMMP

5.5.3 The platform should allow for safe information exchange among pipeline management units and relevant information platforms, or reserve a standard information exchange interface. The OMMP should reserve interfaces to ensure the platform connecting national infrastructure management and pipeline information networks.

5.5.4 The OMMP's security architecture shall be aware of local regulations regarding the protection of information. Measures should be taken to prevent the OMMP and data from attacks, intrusion, interference, damage, illegal use and accidents, in order to implement stable and reliable operation of the OMMP and data, and ensure the integrity, confidentiality and availability of the information.

NOTE Local security and confidentiality regulations can apply to the collection, storage, transmission and exchange of information.

5.5.5 The OMMP should meet the requirements for managing smart cities and integrate with the following smart technologies to effectively improve the capability, security, reliability, technology advancement of the system:

- IoT technology;
- big data, machine learning and artificial intelligence technology;
- cloud technology;
- BIM+GIS and visualization technology (see [Annex B](#));
- smart equipment, virtual reality and augmented reality technology.

6 Operations and maintenance

6.1 General

The operation and maintenance of the utility tunnel refers to a series of activities, including planning, organization, implementation and control, which are carried out during the life cycle of the utility tunnel body, ancillary facilities and pipelines. These activities can be divided into operations, maintenance and management. They ensure that the utility tunnel operates safely and provides services to stakeholders.

Operations and maintenance personnel shall have received pre-job training and a qualified certificate.

Personnel, equipment, instruments and operating procedures which are involved in the operations and maintenance in the flammable and explosive zone shall be aware of the explosion-proof safety requirements.

6.2 Operations

6.2.1 General

In general, operations should include at least, duty, detection, monitoring, routine inspection, safety operations and financial management.

6.2.2 Duty

Duty arrangements can be performed by the operation and maintenance provider and pipeline operator, and shall meet the following requirements:

- appropriate duty systems shall be established for operation and maintenance management according to operational requirements;
- the personnel involved in monitoring, firefighting, power supply and related professions shall be aware of the related local regulations;

- the utility tunnel body and its ancillary facilities shall be centrally monitored for operational and maintenance status;
- the image for key locations shall be monitored and recorded in real time, and should be analysed in real-time;
- any operation and maintenance anomaly shall be alerted to the operator, information about relevant facility anomalies shall be displayed and the anomaly should be disposed in a timely manner.

6.2.3 Detection and monitoring

Detection and monitoring of the utility tunnel body and ancillary facilities shall meet the following requirements:

- the utility tunnel body and ancillary facilities shall be detected on a regular frequency, and a related detection report shall be issued;
- the technical indexes of the utility tunnel body shall be detected onsite based on the indexes of technical information files;
- the detected anomalies of the utility tunnel body and ancillary facilities shall be recorded and analysed and a repair plan shall be prepared and implemented;
- the monitoring plan of the utility tunnel body shall be prepared according to the geological conditions, construction technology, structural form, external environmental conditions or safety assessment results of the utility tunnel;
- the monitoring of the utility tunnel body should be implemented when there are significant changes in hydrogeology, which can lead to cracks, leakage and other accidents affecting the stability of the structure;
- the accidents, defects or serious damage of utility tunnels shall be recorded and analysed and a maintenance plan shall be prepared and implemented;
- detection and monitoring of the utility tunnel body can be made by a third-party, detection and monitoring of its ancillary facilities can be made by the operation and maintenance provider.

6.2.4 Routine inspection

6.2.4.1 General requirements

The routine inspection shall meet the following requirements:

- The inspection shall be conducted on the utility tunnel body, ancillary facilities, pipelines, the internal environment and the external environment.
- The inspection personnel shall carry the necessary equipment and take appropriate protective measures.
- During the inspection, the operating status of facilities shall be checked, the inspection notes shall be recorded and anomalies shall be reported, analysed and handled in a timely manner. Effective measures shall be taken if an emergency occurs.
- Prohibited activities shall not be conducted within the safety protection zone and the safety control zone.
- The inspection shall adopt the use of manual or IT-based inspection or a combination of both.
- In high-risk zones (e.g. in the gas cabin), unmanned or remote inspection should be implemented to protect inspectors from potential harm in case of hazards.
- Each inspection should be controlled and an online report submitted, recorded and stored.

6.2.4.2 Routine inspection of utility tunnel body

The inspection of the utility tunnel body can be taken by the operation and maintenance provider, and shall meet the following requirements:

- The routine inspection shall be conducted on the utility tunnel body, personnel entrances and exits, material hoisting entrances, emergency exit, ventilator shaft, pipeline branch outlet, inspection channel, ventilation duct, supports and hangers of pipelines, drainage facilities, and other structures.
- The inspection plan, content and frequency shall be reasonably determined based on the operating conditions and external environment, and the operation status of the utility tunnel body should be checked accordingly.
- Inspection records of the utility tunnel body shall include, for example, inspection time, scope, personnel, defect type, defect degree and defect location.

6.2.4.3 Routine inspection of ancillary facilities

The inspection of ancillary facilities can be taken by the operation and maintenance provider, and shall meet the following requirements:

- The routine inspection shall be conducted on, for example, firefighting systems, ventilation systems, power supply systems, illumination systems, monitoring and alarm systems, water supply and drainage systems and identification systems.
- The inspection plan, content and frequency shall be reasonably determined based on the operating conditions and external environment, and the operation status of the ancillary facilities should be checked accordingly.
- Inspection records of the affiliated facilities shall include, for example, inspection time, scope, personnel, defect type, defect degree and defect location.

6.2.4.4 Support of pipeline routine inspection

The inspection of pipelines in utility tunnels shall meet the following requirements:

- The routine inspection shall be conducted on, for example, pipelines, pipe fitting, supports and hangers which accompany pipeline construction, and detection and monitoring devices in utility tunnel.
- The inspection and maintenance plan of the pipelines in a utility tunnel shall be developed. The pipelines in utility tunnels should be inspected regularly and repaired, reconstructed or updated in time. Necessary measures shall be taken for pipelines that have stopped operating and have been sealed up or scrapped.
- The operation provider should be responsible for the daily inspection of the pipeline in utility tunnels, and should support each pipeline operator to carry out the professional inspection.
- The operation and maintenance provider shall provide a safe internal environment of the utility tunnel for the daily inspection of pipelines which are taken by the pipeline operator.

6.2.5 Safety operations

6.2.5.1 General

Safety operations can be taken by the operation and maintenance provider and the pipeline operator, and shall meet the following requirements:

- the internal environment of the utility tunnel shall meet the requirements of ventilation and lighting for operation, and the environment shall be kept safe;
- the operation site shall be supervised by specialists, warning signs shall be set up, and the contact with the monitoring centre should be maintained unimpeded;

- protective measures shall be taken in accordance with requirements for special operations;
- the safety protection zone should be set up within the specific area surrounding the utility tunnel body in order to protect the safety of the community utility tunnel body. it is prohibited to implement activities such as stacking, unloading, construction, and pouring of corrosive liquids in the safety protection zone;
- the safety control zone should be set up within the specific area which is in the surrounding of the utility tunnel body in order to protect the safety of the community utility tunnel body. any construction activities in the safety control zone shall take into consideration the relevant approval procedures.

6.2.5.2 Personnel security

Personnel entering or exiting the utility tunnel shall be aware of the following provisions:

- All work in the utility tunnel shall be detailed and approved.
- Personnel shall take safety training before being qualified for working in the utility tunnel.
- Entering the utility tunnel alone is forbidden.
- Personnel should check the environment and ventilate the tunnel, and confirm that the environmental indexes meet the safety requirements before entering the tunnel.
- The personnel entering the utility tunnel shall be equipped with necessary protective equipment, detection instruments and emergency equipment.
- Except for authorized work with flames or flammable equipment, personnel are not allowed to carry any flammable and explosive equipment during routine inspection in the gas cabin, and the equipment carried by personnel shall meet the corresponding explosion-proof requirements.
- Personnel, equipment, instruments and operating procedures that perform inspection and maintenance work in the zone where the utility tunnel has explosion-proof requirements shall meet the corresponding explosion-proof safety requirements.
- Smoking in the utility tunnel is forbidden.
- Emergency measures shall be formulated for personnel access, and emergency equipment shall be provided on site.

6.2.6 Financial management

The operation of the utility tunnel should include financial management of revenue and expenditures and shall meet the following requirements:

- there should be sufficient funds to ensure the safe and normal operation of the utility tunnel;
- the pipelines accessing the utility tunnel should pay a certain fee, and the pricing standard should be clear and easy to operate;
- if there is a charging mechanism of the utility tunnel operation and maintenance, effective measures should be taken to implement it;
- the income from the operation and maintenance of the utility tunnel can be afforded to offset part of the expenses of the stakeholders, such as the related expenses of the maintenance providers;
- continuous research and innovation of financial management methods in the operation and maintenance of utility tunnels should be promoted, e.g. investment, financing and charging.

6.3 Maintenance

6.3.1 General

The maintenance of the utility tunnel shall include the following:

- maintenance of periodic lubrication, anti-corrosion, fastening, dredging and replacement of consumable parts and others;
- cleaning, dusting and other sanitation tasks of the internal and external environments, facilities and equipment;
- taking test or verification measures regularly on the main performance of the facility;
- repair of all types of defects in the utility tunnel;
- repair of defective facilities, and repair or replacement of substandard equipment and components.

The maintenance of utility tunnel body and ancillary facilities can be taken by the operation and maintenance provider, and the maintenance of pipelines can be taken by the pipeline operator;

Requirements and procedures of maintenance shall be established and result in an online report, which is transmitted to relevant personnel and authorities.

6.3.2 Requirements

The operation and maintenance of the utility tunnel can be taken by the operation and maintenance provider, and shall meet the following requirements:

- The maintenance plan shall be developed for the utility tunnel, and the whole maintenance process shall be tracked and managed, e.g. the time and cause of task initiation, operation service process and quality acceptance standard.
- The maintenance of the ancillary facilities shall be carried out in accordance with the requirements of the product specifications, system maintenance manual and related technical specifications.
- The maintenance of ancillary facilities should be carried out separately for each ancillary facility system.
- A maintenance manual shall be developed as a reference for the operation and management, including guidance on the daily operation and maintenance of the main structure and facilities of the utility tunnel and on-site accident handling.

6.4 Management

6.4.1 Emergency management

Emergency management can be taken by the operation and maintenance provider and the pipeline operator, and shall meet the following requirements:

- Risk identification and assessment shall be carried out for hazard sources that can affect operational safety according to, for example, the location to which the utility tunnel belongs, type of construction, status of pipelines, influence of internal and external engineering construction.
- The utility tunnel operation and maintenance provider and pipeline operator shall formulate special emergency plans according to the types of potential accidents.
- The emergency management of utility tunnels should establish an intelligent emergency management system based on information technology and artificial intelligence, e.g. plan management, alerting and response.

- Regular training and drills of emergency plans shall be organized with a minimum frequency of at least once a year. The emergency plan shall be revised and improved no less than once a year according to the situation of pipelines and the changes of the utility tunnel body.

6.4.2 Data management

6.4.2.1 Data shall be collected through the whole life cycle of the construction, management and operation of the utility tunnel, including the historical data of the construction and the real-time data of the operation and maintenance.

6.4.2.2 The data management shall be conducted into the design of the operational and maintenance platform, and be classified in different precision levels, according to the functional and security requirements.

6.4.2.3 The historical data shall include the plan, designing and the construction of both the utility tunnel and the hosted pipelines. In addition, the historical data should include at least the following requirements:

- The data shall be integrated into a 3D model of BIM+GIS, if the OMMP has a BIM+GIS system. All components in the utility tunnel can be identified and geo-located.
- The data framework shall be standardized including at least name, type, format and identification.
- A standard data import interface shall be established, and the data collection, classification and storage shall be aware of the specific standard interface.

6.4.2.4 The real-time data shall include the following:

- the utility tunnel inspection and maintenance data, asset data and revenue data;
- monitoring data, security data, alarm data, communication data and emergency management data and smart decision-making data if the OMMP has a BIM+GIS system and can provide smart services.

6.4.2.5 Data management should establish an operational database which should have the functions of expansion and compatibility of various types of data. The database should be complete, accurate and standardized.

6.4.2.6 Data management shall construct an effective data backup and recovery mechanism.

6.4.3 Space management

The space management, including the management of pipeline location allocation and the stable and safety utility tunnel body, can be taken by the operation and maintenance provider and the pipeline operator, and shall meet the following requirements:

- The utility tunnel operation and maintenance provider shall effectively manage the internal space inside the tunnel.
- All types of pipelines and ancillary facilities shall be installed according to the planning and design requirements.
- When a utility tunnel is shared by multiple pipeline operators, the space inside the tunnel shall be allocated on a fair and rational basis by the utility tunnel operation and maintenance provider.
- The installation of pipelines and pipeline piers (supports / hangers) shall follow the instructions in the design requirements. Tunnel escape channels, inspection and maintenance channels shall not be obstructed, nor shall they occupy the spaces for pipelines inside the tunnel.
- The distance from the outer boundary line of the safety protection zones and control zones of utility tunnels to the outer boundary line of the utility tunnel body should be defined.

6.4.4 Energy savings and emissions reduction

Energy savings and emissions reduction shall meet the following requirements:

- In order to meet operational service requirements and improve the energy saving and emissions reduction capability, energy shall be used rationally, such as reducing the use of fossil energy or using renewable energy as a substitute.
- The environmental data analysis of the utility tunnel shall be combined with the real-time data analysis of equipment, conduct online monitoring of the energy consumption data, the energy consumption level and energy efficiency shall be available in real time, and the management of the energy consumption data of the utility tunnel shall be realized.
- On the basis of energy consumption data collection, the acquired data shall be classified, sorted and calculated, energy consumption benchmarks shall be established, and energy consumption analysis and energy conservation assessment shall be carried out.
- The actual energy consumption situation and consumption trend shall be observed. Through comparing the actual energy consumption with the benchmark energy consumption, the operation indexes shall be optimized, the excess benchmark conditions shall be monitored and give an energy saving alarm.
- An environmental protection plan shall be made and implemented during the operations management.

7 Evaluation and continuous improvement

7.1 General

An evaluation system for a utility tunnel shall be established based on the life cycle of the utility tunnels. The evaluation should be related to the specific benefits realized by the stakeholders of the utility tunnels. The performance results can be used as an important basis for the purchaser (owner or user) to pay for the operation and maintenance service. The evaluation elements are as follows:

- In order to get the operation and maintenance service of the utility tunnels in the best state and promote the sustainable development of the city, all stakeholders involved in the operation and maintenance shall reach an agreed overall goal, and clarify and conduct the responsibilities and obligations.
- Flexible adjustment of the operation and maintenance charging mechanism of the utility tunnels should be conducted in order to:
 - obtain reasonable and available revenue of the utility tunnels' operation and maintenance;
 - reduce the risk of cost overruns of the utility tunnels' operation and maintenance;
 - promote the sustainable development of the utility tunnels' economy. The operation and maintenance charging mechanism should be in accordance with community development in the period of the operation and maintenance.
- Continuously improving technologies and equipment shall be adopted for the sake of reliable and efficient operation and maintenance services, and the promotion of the sustainable development of the operation and maintenance of the utility tunnels.
- Energy utilization and the reduction of energy consumption shall be continuously optimized throughout the operation and maintenance of utility tunnels. The optimization aims to operate the utility tunnels with low-carbon emissions and improve the sustainable development of the environment.

7.2 Sustainability evaluation

7.2.1 Evaluation principles

The principle for the evaluation of the utility tunnel operation and maintenance is sustainable development and the guiding concept is intelligence.

The operation and maintenance evaluation objects of the utility tunnel include the efficiency, the safety and the intelligent level of operation and maintenance, the potential impact and the degree level of the impact on the safe operation and ecological environment of the community. The evaluation shall meet the following requirements:

- Qualitative and quantifiable evaluation elements can be set according to the requirements of the region, for which the historical data and real-time data related to the elements are easy to collect.
- Evaluation elements shall reflect the relevance of the utility tunnel, e.g. utility tunnel characteristics, geographical environment conditions, the level of city management, life span.
- The evaluation indicators should be composed of multiple elements which should systematically and completely reflect the level and effectiveness of operation and maintenance of the utility tunnel, and each element should be independent of each other.
- All stakeholders should participate and interact with the evaluation. Evaluation by a third-party is recommended.
- The design of evaluation elements shall highlight the essence and characteristics of smart operation and maintenance management of a utility tunnel, focusing on the safety, quality and efficiency of operation and maintenance, which can fully guide the smart operation and maintenance management of the utility tunnel.

7.2.2 Evaluation elements

The maintenance, operation, management and continuous improvement of the utility tunnel are evaluated based on safety, efficiency and energy savings. The evaluation elements of the intelligent operation and maintenance management of the utility tunnels should be scientifically determined. The basic elements are as follows:

- maintenance: functional maintenance and safety maintenance;
- operation: operation and revenue;
- management: emergency response, energy savings and emissions reduction, liability accident and safety production;
- sustainability: technical improvement, management improvement and user satisfaction.

The elements are provided in [Annex A](#) of this document.

7.3 Continuous improvement

7.3.1 General

The operation and maintenance provider of the utility tunnel should make continuous improvements based on the assessed safety and risk results to ensure the safe operation and maintenance of the utility tunnel system. This clause introduces the process of continuously improving the operation and maintenance of a utility tunnel from both management and technical aspects and provides requirements and recommendations for the positive effects of their interaction.

7.3.2 Technology improvement

Based on the continuous upgrade of the operation demands for the utility tunnel, the operation and maintenance provider shall:

- use engineering technology, intelligence technology, new equipment and new materials to continuously improve the safety levels of the utility tunnel;
- provide training to improve the professional knowledge and skills of the operation and maintenance provider;
- establish a scientific and efficient OMMP;
- monitor the operation of the main body, pipelines and ancillary facilities of utility tunnels;
- improve the ability to anticipate accidents in utility tunnels to provide a decision-making reference for the safety of the utility tunnel operation and maintenance, and realize the smartness gradually.

The available technical strategies are as follows:

- In order to improve the efficiency of operation and maintenance management and community governance level, intelligent technology can be used.
- In order to improve the essential safety level of pipelines, new materials and technologies can be used.
- In order to improve the safety and operation and maintenance capabilities of personnel, new technology such as smart wearable devices can be used.
- In order to enhance the safety of the utility tunnel body and protect the ecological environment, the engineering techniques can be used.

7.3.3 Management improvement

The operation and maintenance management of the utility tunnel shall be improved by adapting to the changes caused by community development, such as the community safety and community scale. Operation and maintenance providers shall collaborate with stakeholders to achieve efficient and sustainable management improvements.

The management improvement shall meet the following requirements:

- setting the improvement goals cooperatively among the stakeholders;
- developing a complete and detailed plan;
- establishing mechanisms for appropriate implementation and equitable evaluation;
- optimizing management organization structure.

7.3.4 Improvement methods

The operation and maintenance provider shall use the plan-do-check-act (PDCA) cycle method for improvement periodically and to meet the following requirements:

- setting the target level based on the improvement demand;
- analysing and determining the gaps between the target level and current situation;
- developing plans and taking measurements to fill the gaps to achieve improvement goals.