Centre d'Etudes des Tunnels
Tunnel Study Centre

Reference Points

Guide to Road Tunnel Safety Documentation

Booklet 2

Tunnels in Operation "from the existing condition to the reference condition"

June 2003

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
ministère de l'Équipement des Transports du Logement du Tourisme et de la Mer

For every tunnel in the national road network whose length is over 300 metres, safety documentation has to be compiled and submitted to the prefect, who refers it to the CESTR (Comité d'Evaluation de la Sécurité des Tunnels Routiers / road tunnel safety assessment committee) for its opinion.

All the persons and services involved in tunnel safety (the owner, the operator, the maintenance and repair and emergency services, the prefecture) must assist with the compilation of this dossier which in its final version will contain among other things the fundamental aspects of tunnel operation under any and all circumstances.

This **safety documentation guide**[1] is intended for the above services, the owner and the relevant engineering and design offices.

The introductory booklet, "Safety Documentation Objectives" was issued in March 2003; it should be read by all persons who need to understand the general intent of the recommended procedures and how the various documents contained in the safety documentation are organised.

The **safety documentation guide**, of which the above-mentioned introductory document may be regarded as "Booklet 0", comprises the following **five booklets**, either issued or due to be issued in 2003 and 2004:

Booklet 1: Practical method of compiling the safety documentation
Booklet 2: Tunnels in Operation: "From the Existing Condition to the Reference Condition" (June 2003)
Booklet 3: Comparative risk analyses
Booklet 4: Specific hazard investigations (September 2003)
Booklet 5: Emergency response plan

Statutory Background

- Interministerial circular 2000-63 of 25 August 2000 concerning the safety of tunnels in the national road network requires the owner (jointly with the operator in the case of tunnels in service) to compile safety documentation for all tunnels in the national road network of over 300 metres in length.

- Circular 2000-82 of 30 November 2000 supplements the above circular in regard to dangerous goods transport vehicles in road tunnels belonging to the national network.

- The implementing order for the Law of 3 January 2002 in respect of the safety of infrastructures and transport systems, which has yet to be finalised, is designed to confirm this statute and extend it to all local authority tunnels of over 300 metres in length.

[1] This guide enlarges on and replaces the document entitled *Specific hazard investigations of Tunnels in the Road Network, Guide to Methods, Provisional Version*, issued July 2001.

Booklet 2

Tunnels in Operation
"from the existing condition to the reference condition"

Introduction

In the case of a tunnel at the project stage, the safety documentation is based on the tunnel with the technical and organisational characteristics that it will have when opened to traffic.

With **tunnels in operation**, the safety documentation is based not on the existing condition (the tunnel as it is) but on **the reference condition**, the tunnel as it will be on completion of the **safety upgrade programme** decided on by the owner. Thus the reference condition has to be established by the owner before the safety documentation is compiled, though this may be an iterative process.

Booklet 2 deals with the analyses and surveys on which the reference condition and the safety upgrade programme are based. In this respect, the owner is advised not to have detailed surveys carried out until he has first completed a general analysis. **Booklet 2** provides guidance on the content and degree of accuracy required for the existing condition report. The appendix to this booklet gives the technical data required in order to draw up the specifications in the event of outsourcing.

1. Specific issues relating to tunnels in operation

Even if the safety documentation has not yet been completed for examination by the assessment committee, owners and operators should have already implemented the more obvious safety provisions

1.1 1999 Safety diagnostics for tunnels of over one kilometre

Immediately following the fire in the Mont-Blanc tunnel of 24 March 1999, tunnels of over one kilometre were examined by a committee set up by the ministers of the interior and civil engineering. The committee set out its recommendations on 2 July 1999. Recommendations specific to each structure were sent by the roads department to the owners and prefectures concerned; recommendations of a general nature were sent to all owners and prefects for application not only to the tunnels examined but also to all other road tunnels, including those of less than 1 kilometre.

1.2 Objectives of the Circular of 25 August 2000: Tunnels in operation

The revision of the Interministerial Circular of 29 December 1981 concerning road tunnel safety was embodied in Circular 2000-63 of 25 August 2000, applicable to tunnels in the national road network of a **length greater than 300 metres**. There are two appendixes to this circular:

- **Appendix 1** defining the procedures applicable to all tunnels, with particular mention of tunnels in operation;
- **Appendix 2** consisting of a technical instruction applicable to new tunnels.

With tunnels at the project stage the new safety requirements can be included right from design, the safety level of tunnels in operation varies considerably depending on how long ago they were built, how well they have been maintained and their operating facilities.

The purpose of the procedure provided for in Appendix 1 is to upgrade all tunnels in operation of a length greater than 300 metres.

The deadline specified by the circular is the beginning of 2005[2]; this will enable the safety documentation on each tunnel in the road network of over 300 metres to be submitted to the prefect for referral to the assessment committee for its opinion.

[2] From 25 August 2000, six months in which to draw up an introductory timetable and three years (recently extended to four years) in which to compile the dossier for examination by the assessment committee.

In its letter of 26 December 2000, the roads department reminded tunnel owners of their obligation to apply the more obvious safety provisions such as, for example, stop signals and barriers, as well as their obligation under the circular to compile safety documentation. It was pointed out that the safety documentation could well be incomplete since it would not include a specific hazard investigation[3].

1.3 Safety documentation submitted for examination

The safety documentation referred to here must be complete and, more especially, must include a specific hazard investigation (see **Booklet 4**).

The dossier presents and explains the **reference condition** of the tunnel, namely the condition of the tunnel on completion of the safety upgrade, i.e. after the renovation works have been carried out and the operating and maintenance provisions implemented.

The safety documentation must then be regularly updated throughout the life of the structure.

Chapters 2 and 3 in this booklet, supplemented by two appendixes, specify how the existing condition is to be surveyed in order to measure discrepancies between it and an ideal reference condition and assess what needs to be done to upgrade the tunnel as it exists to the reference condition.

Upgrading can be spread over a given period, in which case the safety documentation would have to be updated intermittently, with the tunnel continuing to be operated in a condition appreciably the same as it was in 1999 (subject to the provisions already implemented), with the work carried out in stages that will necessarily interfere with the use of the tunnel (closing one tube, etc.).

1.4 Tunnels longer than one kilometre

Tunnels of over one kilometre were inspected in 1999. However, since this was done somewhat hurriedly the definition of the safety upgrade programme was often imprecise. Of these tunnels, the assessment committee designated those subject to **centralised control**, i.e. those whose safety documentation had to be submitted to the committee with their composition as specified in the circular of 25 August 2000.

[3] For each tunnel in operation subject to the provisions of Circular 2000-63 of 25 August 2000, a safety documentation, even if incomplete, is required, and must include the following:

- a description of the tunnel and its access points together with the drawings required to explain its design and operating arrangements;
- an analysis of current traffic plus traffic projections, including the rules governing the transport of dangerous goods.
- a description of the organisation, the human and material resources and the instructions laid down by the owner to ensure effective tunnel operation and maintenance.

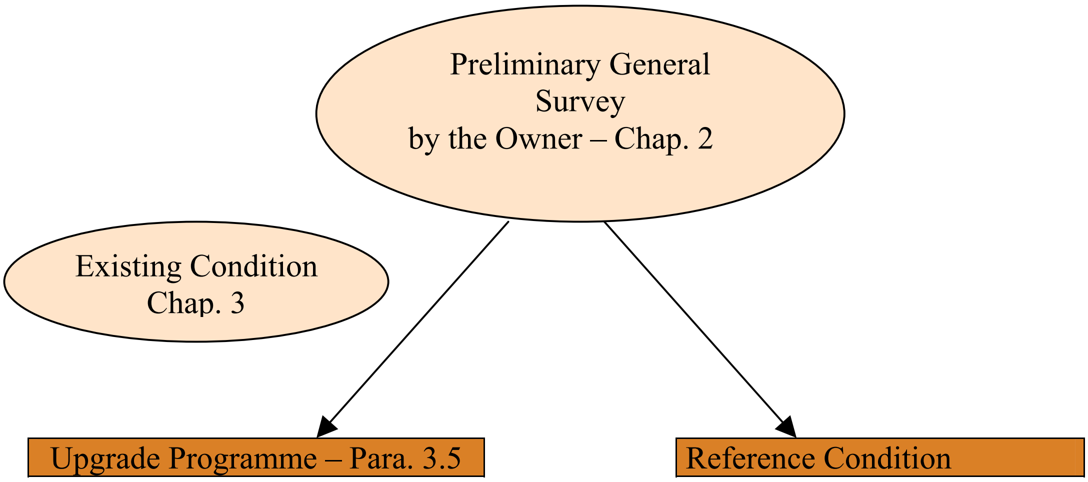
The owners concerned were informed of this in a letter dated 22 November 2000 from the chairman of the committee.

Safety documentation is required for tunnels of over one kilometre that are not subject to centralised monitoring, as they are for all other tunnels. Prior to any major modifications, the owner must draw up a descriptive document, accompanied by an expert's opinion, and send it to the prefect, who may refer it to the assessment committee[4].

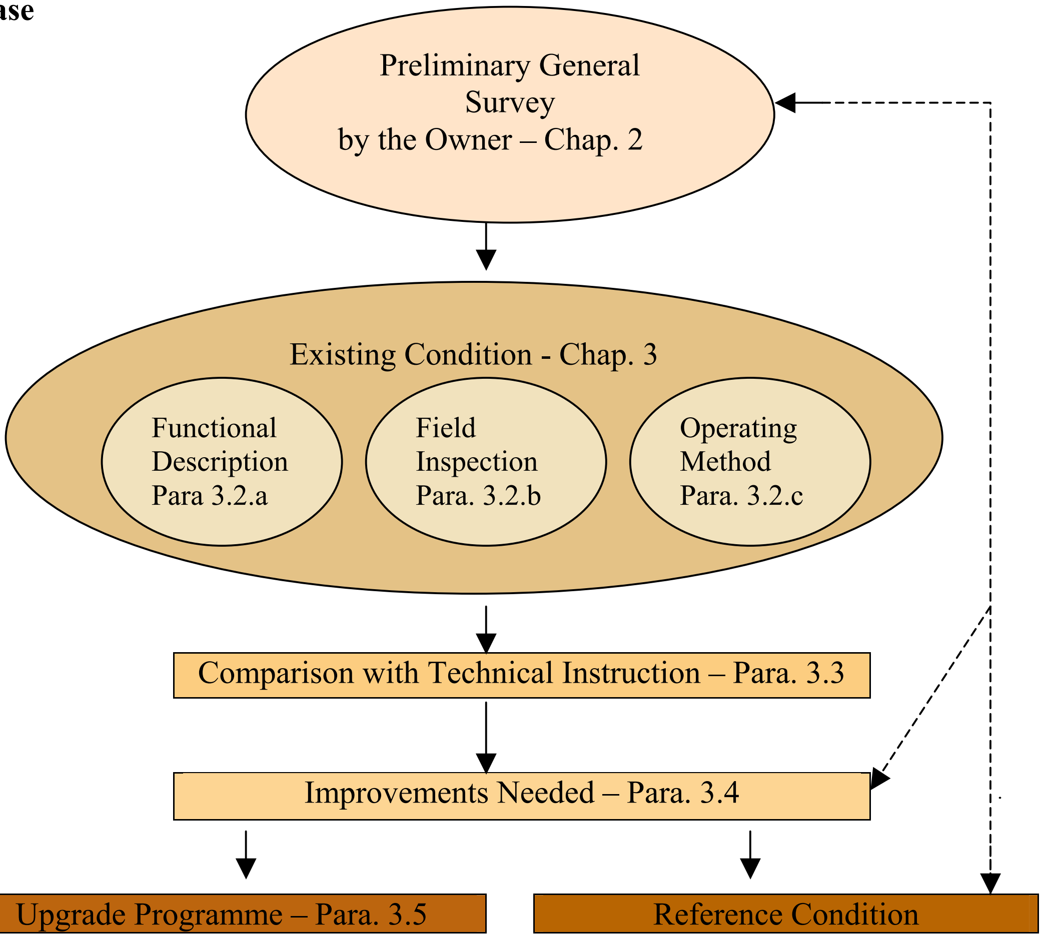
Notes

[4] This provision applies to all tunnels of over 300 metres in length (paragraph II of Appendix 1 of the circular of 25 August 2000).

Simple Case



Complex Case



2. Preliminary general analysis by the owner

The owner is required to conduct a general analysis of the tunnel, its environment and its potential development before embarking on detailed complementary surveys.

The procedure used to define the reference condition of the tunnel in relation to its existing condition is not a linear procedure: some of the measures envisaged for improving safety (putting in emergency exits, for example) may, depending on how difficult it is to do this, be either implemented or dropped in favour of other measures that are easier to apply but which ensure an equivalent overall safety level (e.g. reinforcing special surveillance or maintenance measures).

This procedure will be seen in a very different light according to the nature and extent of the problems encountered: a tunnel that has been in operation for just a few years will only require minimal inspection and its reference condition will be established fairly quickly when the upgrade consists simply of a few modifications or additional facilities. On the other hand, a more complex interactive procedure will be required in the case of an old tunnel having major safety deficiencies and whose development potential is limited by the existing engineering works.

Consequently, it is important that the **owner** himself should initially be able to identify the overall safety problems posed by the tunnel concerned and place its improvement potential in the general context of the structure as a whole. This procedure is designed to inventory the following points:

(a) Description of the existing tunnel

The following items are particularly important:

- the general features of the tunnel (siting in relation to the road, geometric characteristics, traffic data, etc.);
- the existing safety arrangements and their main functions (cross-passages between the traffic tubes or emergency exits, details of the ventilation system, general electric power supply system, etc.);
- state of repair of the various facilities;
- operational resources and organisation;
- conditions governing action by the police and emergency services.

Familiarity with the provisional safety documentation of the tunnel, consultation with the operating services and an on-site inspection are usually sufficient to inventory the above points.

However, at this stage special attention must be paid to the fire behaviour of the structures as this very largely dictates the scope of any diagnostic reports to be made later. To this end, particular requirements in respect of the fire behaviour of the structures must be identified: the presence of a suspended road surface, protected emergency or user evacuation access points, tunnel likely to be flooded in the event of damage, etc. If there are any such requirements, any weaknesses in the relevant parts of the tunnel must be detected.

(b) Renovation projects

These projects may involve civil engineering works or improvements to the surroundings; they may already be noted in the form of a completed dossier or only in the form of a description of requirements to be met. The last tunnel inspection report could be of particular help as a source of information in this respect[5].

(c) Possible developments in operating methods

These may include the creation of an engineering and traffic management centre responsible for the road or of a new operating structure, etc.

(d) Other items

A list should be drawn up of any factor likely to affect changes to the structure: the possibility of building an alternative route or extending covering as a result of environmental considerations (e.g. covered section in urban surroundings), etc.

On completion of the inventory, the owner can now make out an initial report on the condition of the tunnel, and if applicable of any major deficiencies, either observed or possible, compared with the broad lines of the technical instruction, and target the possibilities regarding the safety upgrade.

In extreme cases, the only realistic possibility may lie in the creation of a second tube or in a complete overhaul of the engineering works amounting in fact to a project comparable to the construction of a new tunnel.

However, in the majority of cases, the work will consist of modifications to the existing tunnel and/or to the way in which it is operated, and these will have been identified by the preliminary survey.

[5] Tunnels in the national road network are inspected in accordance with the technical instruction of 19 October 1979 (revised 26 December 1955) concerning the surveillance and maintenance of civil engineering works (ITSOA) and more especially with section 40, which is currently being revised.

3. Additional surveys

The preliminary general survey will have determined the level of investigation required and the points that the detailed surveys will need to focus on.

The detailed surveys following the general survey described in the previous chapter comprise the existing condition report, a comparison of this report with the provisions of the technical instruction and, lastly, organisation of the upgrade programme culminating in the reference condition.

An existing condition survey, albeit brief, is always required in order for the tunnel to continue to operate pending implementation of the upgrade programme. It is in fact difficult to see how the operator could fail to be familiar with the current condition of the tunnel and the performance of its various facilities.

3.1 Decisional criteria

The question is to decide whether there is any reason for further surveys, and in what form, in order to draw up the upgrade programme and establish the reference condition. This has to be looked at on a case-by-case basis, and should essentially take the following points into consideration:

- The reference condition, which represents the safety objectives set by the owner, can often be established even if the existing condition survey, and more especially the field inspection (see para. 3.2.b) provide only brief information. If the existing facilities and the safety improvement plans are sufficiently precise and reliable, and if their implementation poses no major problems of feasibility or funding, the owner can in fact establish the reference condition of the structure on the principle that he will procure the resources he needs to carry out the necessary modifications. For example, if the tunnel's safety recess lighting or signalling equipment is patently obsolete, the decision to upgrade it in accordance with the technical instruction can be taken immediately; and the same applies to building new safety recesses or installing a fire protection system.
- In more complex cases, the owner will only be able to draw up the works programme and so establish the tunnel's reference condition after making an exact comparison between the existing condition report and the technical instruction and then identifying and studying the improvements that need to be made.

It is up to each owner, in consultation with the operator, to determine just how far he should go with the additional surveys described below.

3.2 Compilation of an existing condition report, scope and level of accuracy according to requirements

Using the information provided by the general survey, the owner draws up an existing condition report which is exhaustive or, alternatively, minus those areas in which an exact knowledge of the tunnel's current condition is not required. For example, whilst precise data on the fire behaviour of a particular component of the primary or secondary structure may be necessary according to the requirements identified in the general survey, there is no need for close examination of lighting or signalling equipment that is virtually obsolete and obviously needs to be replaced, or for a comprehensive existing condition report on buried networks when the tunnel's raft foundation is due for a major overhaul.

The existing condition report comprises several parts:

(a) Functional description of the structure and its facilities

This requires the owner to describe the tunnel and explain the functions of its components and facilities.

The difficulty here lies in the level of description of these functions, which has to go well beyond the general survey; however, it is neither necessary nor useful to describe the different functions down to the last detail, as this is usually done in the functional analysis of a centralised technical management system.

Taking electric power supply as an example, the description of the control units will include the principle of switching from one power source to another together with the load shedding possibly resulting from an uninterruptible power supply system, but without describing the opening and closing clearance of the different contactors. Likewise, the description of the ventilation equipment will include details relating to fire scenarios, such as the smoke evacuation sequences and the emergency airlock pressurisation sequences, or a list of the jet fan controls, but without giving details of the logical working of the different control mechanisms. More detailed examples will be found in **Appendix A.**

The inventory of functions is generally based on the design and completion documents (tunnel plan, contracts, compliance verification documents) as well as operating documents describing any functional modifications required when renovations are being carried out.

At this stage, the functions inventoried are assumed to have been installed; the field inspection report will show whether or not they are fully operational.

(b) Field inspection report

The field inspection is carried out as defined on completion of the general survey and if need be will take into account the above-mentioned functional description. This description may, if applicable, identify those parts of the structure not requiring field inspection since they quite obviously do not come under the functions that have to be maintained.

Appendix B gives details of the various points included in the inspection and which may serve as a basis for an outsourcing contract.

The field inspection includes the following:

- an assessment of the physical condition of the tunnel's components and facilities:
  - a check to make sure all the necessary equipment has been installed;
  - any disrepair or damage that might affect any of the functions (technical damage) or endanger the users (mechanical strength of hanging components);

- measurement of the performance of certain components: smoke evacuation air flow rate, illumination, etc.;

- functional checks to test:
  - the performance of the automatic controls operating the current slaving systems (ventilation slaved to tunnel pollution measurement) or used to self-correct certain technical damage (automatic start-up of a generating set in the event of a mains power failure or automatic reconfiguration of the remote transmission system if an optical fibre or an automatic controller is out of action);
  - alarm resets (excessive air pollution, emergency exit door open alarms) and the efficiency of the detection and surveillance equipment (reaction time of the fire detection system, performance of the televised surveillance and automatic incident detection equipment);
  - effective compliance with the commands from the remote controls operating certain components taken individually but mainly resulting from the activation of programmed sequences (signalling scenario for closing a traffic lane, fire protection scenario);

- the fire behaviour of the structures, components and facilities. As already mentioned, if fire behaviour requirements have been identified (see last line of para. 2a), this check is particularly important not only for reasons of safety but also because the inspections required are often lengthy and complex. These include checking the fire behaviour of the various facilities (fire-resistance rating of the emergency exit doors, rating of the safety circuit cables, mechanical strength of heavy equipment hanging over the roadway, etc.).

The two appendixes –

<u>Appendix A</u>, containing examples of the functional description of the tunnel and its facilities, and

<u>Appendix B</u>, containing specifications in regard to the field inspection report -

must be used judiciously as by its very nature each tunnel in operation is a case unto itself.

(c) Inspection of the tunnel as it operates in reality and of the different factors likely to affect its service life

The resources and instructions concerning the operation and maintenance of the tunnel are described in the safety documentation required for every tunnel in operation. The same applies to other aspects such as the emergency and safety plan, for example.

The existing condition report consists of a description of the above items as they actually exist. The guiding approach here should not be to prove that everything has been well thought out and organised, but to examine how the facilities currently in place might in reality differ for some reason from those required. It is also important to indicate the actual timescales for action by the console operator or the operations team in the event of an incident, and/or specify the number of persons actually available in one or another situation.

The extent to which the different operating documents should be analysed will vary from one tunnel to another. For example, if in the course of previous stages it was shown that an essential part of the installation and its various facilities was clearly inadequate, examination of the operating instructions will be of only limited relevance. However, in the operational phase prior to completion of the improvements, a check should be made to ensure that the instructions contain no anomalies[6]: "maximum ventilation towards the fire", for example. It will in fact be preferable to focus on the definition of the operating instructions and the suitability of the emergency and safety plan for the tunnel in its new configuration.

[6] This would be an abnormal situation, since the safety documentation of a tunnel in operation is supposed to have been completed so as to resolve any problems prior to its improvement.

3.3 Detailed comparison of the existing condition with the requirements of the technical instruction

This comparison is made for all three parts (a, b and c) of the existing condition report described above (para. 3.2).

This comparison with the reference technical instruction applicable to new structures is intended to provide an accurate picture of the safety level of the tunnel as it actually is and in particular to highlight any weak points. The owner and the operator will use the results of this comparative survey to examine what needs to be done to improve the safety of the tunnel concerned.

It will be remembered that the reference condition may well have been described as part of the preliminary general survey carried out by the owner. This applies when the possibilities for improvement have been examined and when their detailed definition does not run counter to that of the reference condition.

3.4 Identification and examination of desirable improvements

Some improvements can be decided on immediately, other than those where cost is a factor[7]; this usually applies to the facilities required at the access points (stop signals, barriers, etc.) or equipment suspended over the roadway.

Conversely, other measures may immediately be seen as unrealistic (e.g. building emergency exits in a tunnel running beneath a body of water or installing a smoke extraction system in a tunnel when there is patently no room available to run air ducts).

Yet other measures may be envisaged as the opportunity arises, in terms of both the infrastructure and the method of operation (for example, the introduction of a hazardous fluid runoff collection system or multitube ducting protected against heat in a tunnel whose road structure has to be rebuilt; or increasing the degree of tunnel surveillance when an operating centre is being set up, as planned in fact to meet other requirements).

In many instances, the most important improvements can only be envisaged on completion of the more detailed surveys designed to determine their feasibility, working requirements and cost, or compare a number of possible solutions (comparative study between extending the smoke evacuation system and, as a compensatory measure, putting in emergency exits; or, in connection with this last point, examining an alternative between putting in evacuation walkways linking the intermediate points in the tunnel with the outside and building a parallel gallery coming from one or both tunnel portals, for example).

[7] It may be assumed that these improvements have already been made and that the existing condition report takes this into account.

3.5 Tunnel upgrade programme

If the time required for the works is such that the reference condition can only be achieved in the long term (more than 5 years), an intermediate reference condition will be applied.

On completion of the previous stages, which may have been simplified[8], the owner will have all the information he needs to enable him to decide, following approval from the regulatory authority[9] (particularly as regards his financial commitment), on the scope of the technical and organisational modifications which he considers advisable and which when completed will achieve the tunnel's reference condition.

This reference condition, which at this stage is still provisional, will then be inspected under a specific hazard investigation (see Booklet 4), the results of which will either confirm the soundness of the decisions made or, conversely, oblige the owner to make the necessary alterations.

Depending on the scope of the safety upgrade programme and the timescale envisaged, the owner decides on the relevant phases of work and, if need be, adapts the emergency and safety plan accordingly.

[8] Even if the reference condition has been determined without any additional surveys, the existing condition must be known very exactly in order for the safety upgrade programme to be drawn up, together with its cost.
[9] For non-franchised tunnels in the national road network, refer to the roads department circular of 10 March 2003.

4. Contents of the safety documentation

As already mentioned, the safety documentation concerns the tunnel in its reference condition, and it is the reference condition that is described in the documents in this dossier, and in particular in the first two chapters of the specific hazard investigation (see Booklet 4).

The safety upgrade programme must be attached to the safety documentation.

The existing condition report is not, properly speaking, part of the safety documentation. However, the owner is required to explain the reasons for his decisions concerning the composition of the safety upgrade programme and his definition of the reference condition. If his reasons, based on the procedure described above (chapters 2 and 3) are not included in the safety upgrade programme, then they must be given in the "owner's report" or in a document accompanying it.

Notes

Appendixes

Appendix A ■ **Examples of the functional description of the tunnel and its facilities**
A.1 to A.5

Appendix B ■ **Field inspection specifications**
B.1 to B.10

Appendix A. Examples of the functional description of the tunnel and its facilities

This appendix takes a few examples illustrating the spirit in which the functional description of the tunnel should be approached, that is to say going beyond the general indications contained in the description of the safety documentation but without including an excessive amount of needlessly detailed information.

A.1 Functional Description of Safety Arrangements for User Protection

Each traffic tube includes four emergency exits positioned at intervals of approximately 210 metres, with the exception of the east tunnel portal exit located at 260 metres from the portal.

In the main part of the structure, which is a covered section, these exits each include stairs to the surface, the difference in level varying from 8 metres (west side) to 12 metres (east side). Each stairway has a usable width of 1.5 metres and includes two double doors not fitted with door closed contacts. The lower door opens on to the traffic area (slow lane side), the other to the outside. This means the stairs do not include a lobby in their lower part and the footway next to the access door is not designed for use by disabled persons. It should also be noted that all the stairs lead up to a pavement on the outside, except for stairway no. X (see drawing no. xxx) located in the middle and providing access to an area lying 50 metres from rue XXX (reached via a further area laid to turf).

In the eastern part of the tunnel, which is sunken, both traffic tubes include an intercommunicating passageway for pedestrians. This has a usable width of 2.10 metres and an effective height of 2.20 metres. At each end there is 0.90-metre wide two-hour fire-resisting door; the lobby here is not fitted with either a pressurising system or internal warning signs. The footways, like the above-mentioned stairways, include no special disabled facilities next to the passageway.

Lastly, there are no emergency exit signs in the tunnel apart from the small luminous sign panel.

A.2 Functional description of the ventilation and smoke evacuation systems

The tunnel is ventilated by a transverse-ventilation system consisting of the following:

- A fresh air supply system: the ducts are located in the bottom part of each sidewall in the part of the covered section and in the ceiling in the form of a single duct running on the left hand side in the same direction as the traffic in the sunken part. The continuous duct in the ceiling is connected with the continuous duct in the right hand sidewall of the covered section covered by a special linking structure. In the sunken part, the air is blown through small openings spaced at intervals of 10 metres and arranged laterally above the footway and connected either directly to the lateral duct (covered section) or via ducts recessed into the sidewall (sunken part).

- An extraction system for exhaust air or smoke from a fire: the extraction ducts, which are in the covered part, are located on either side above the fresh air ducts, with the openings in the upper part of the sidewall. In the sunken part, a single duct runs next to the fresh air duct, extending the extraction duct located on the right of the covered section; the exhaust openings here are then spaced at intervals in the ceiling along a distance taking up approximately one-third of the width of the tunnel. In both cases, these are small fixed-setting openings spaced, like the fresh air openings, at intervals of around ten metres.

- A ventilation unit, located above the eastern portal of the tunnel and consisting of the following:

  - two fans with a nominal unit output of 90 m^3/s; these are helical fans each of which is connected to an air supply shaft. A duct located on the outlet side of each fan connects the two shafts. In the event of a malfunction on either fan, a set of dampers is used to isolate it and connect both shafts to the undamaged fan, in which case the blown air output is then around 60% of the output achieved with both fans working.
  - two exhaust fans with a unit output of 70 m^3/s; these are helical fans designed to operate for two hours at 200ºC. As with the fresh air, in the event of damage to either fan a coupling system maintains an overall extraction rate of around 60% in each shaft.
  - A set of electrical cabinets for fan control: each fan has its own electrical cabinet used to command working speeds: full speed and half speed. However, it should be noted that for each pair of fans (supply air and exhaust air respectively) a single electrical cabinet is used to control both units and the associated dampers.

Sanitary ventilation controls

There are three types of control:

- Manual control using the electrical cabinets (reserved for maintenance).
- Remote manual control from the control/command station: this either covers the entire structure (normal operations) or is designed for individual unit control (special operations). It should be noted that this also controls both the normal operating mode (sanitary ventilation) and smoke evacuation (see below).
- Automatic control: this is the current operating mode in which all the supply blowers are slaved to the data provided by the pollution sensors located at different points along the tunnel: three CO analysers and three opacimeters per tube, located approximately 100 metres from each portal and in the middle of the tunnel. The control system relies on thresholds; an alarm signal is activated if the maximum threshold is exceeded (200 ppm of CO with K equal to 9×10^{-3} m^{-1} for air opacity).

Smoke extraction control

Smoke evacuation is activated by the roadway control console operator. At present there is just a single system for the entire tunnel which activates extraction at full speed and air supply at half speed. If requested by the fire brigade, the console operator can switch the fans to manual mode and adjust their speed. It should be noted that the documents inspected do not specify whether or not certain design limits affecting the units in normal operating mode have been removed from the smoke evacuation control system: minimum working time of 10 minutes to limit overheating on start-up or machine arrest on activation of a vibration limit threshold alarm, for example (point to be checked on site).

A.3 Functional description of power supply

Electrical energy

This is supplied exclusively by EDF (Electricité de France).

The tunnel has a single supply substation located in the west technical room, connected to two separate EDF power supply sources.

The power is supplied at 20 kV on the principle of double derivation using two cables: one cable is connected to source point X, the other to source point Y; in the event of no voltage on a lead-in, power is automatically switched to the other lead-in.

An East transformer station feeds the equipment in the associated plant room. This station is fed from the West station via a private network by two standard feeders, each in one of the traffic tubes. The power is supplied on a loop-in connection; in the event of a malfunction in one of the feeders, power can be restored when the operator switches supply manually over to the other feeder.

Conversion/supply

The main West station includes four transformers coupled in pairs. Each transformer in the same pair feeds a half-busbar; in the event of loss of power to one transformer, the two half-busbars are automatically coupled and the working transformer supplies all of the equipment served, if necessary after some of the load has been shed.

Two of the 20 kV/400V 315 kVA transformers are used for the ventilation system. Should either of them malfunction, the power available is sufficient to enable both exhaust fans to work at full speed and one of the supply blowers to work at half speed.

The other two 20 kV/400V 250 kVA transformers are used for the lighting and safety equipment, in particular the charger-battery-inverter assembly on a standby busbar. Should either of the transformers malfunction, there is sufficient power to operate:

- the lighting of the continuous section on full power;
- the reinforced entry lighting on half power;
- the dewatering pumps;
- two socket outlets per tube in the safety recesses;
- the charger-battery-inverter assembly;
- the ancillary equipment in the plant rooms (heating, normal lighting, etc.) on half power.

The charger-battery-inverter assembly can feed all the essential safety facilities independently for 30 minutes; these facilities include:

- the emergency lighting in each tube;
- the traffic control systems: televised surveillance, the fixed and variable signalling equipment;
- the tunnel management system equipment: automatic controls, supervisors, etc.

However, it should be noted that the prolonged mechanical ventilation units (PMVs) on the incoming side of the West portal are not fed by the inverter.

A manual switch is used to shunt the inverter for maintenance purposes. No information is sent to the control/command station, however, to inform it of this particular operating mode.

The East secondary power source has only two transformers, used for the lighting and safety equipment. The layout is the same as for the West unit.

Power supply to the equipment

The lighting for each tube consists of several circuits; more particularly, the safety lighting includes two separate circuits, one per sidewall.

The socket outlets in the safety recesses are fed by special cables laid in ducts under the footways.

All the other facilities in the tunnel are fed by splitter boxes housed in the safety recesses. In each tube, coming from each tunnel portal, a single circuit run in ducts under the footway feeds all the splitter boxes; the branch connection next to each recess goes via a box located under the grating in the recess.

Notes

Notes

Appendix B. Field Inspection Specifications

The structural work may have much to do with the safety of the persons using the tunnel. The relevant reports are those of the routine inspections laid down by the technical instruction governing the surveillance and maintenance of structures of 19 October 1979, Section 40, Tunnels, Covered Sections and Protected Footways. Therefore it is important to consult the tunnel dossier containing these findings.

Consequently, aspects of the structural works are not listed in this appendix, which enumerates the observations likely to be made concerning a tunnel in operation. This list, which should be as exhaustive as possible, covers only to the tunnel's facilities. Needles to say, it should be used with discrimination and take into account the age and sate of repair of the tunnel and its facilities.

B.1 Ventilation

B.1.1 Inspection of materials and equipment

Jet fans and fans

- Frame corrosion.
- Electric power supply (in particular cable insulation and switch cabinets).
- Safety equipment (isothermal equilibrium and vibration) and any feedback on it.
- Fire behaviour of the jet fans, extractor fans, wiring layouts, feeder cables and their housing.
- Condition of the air ducts, shafts, access panels and related equipment (dampers, valves, sound attenuators, etc.).

Atmosphere control

Inspection of the equipment and where required their protective enclosures for corrosion and dirt.

B.1.2 Atmosphere control

- Measurement of the air speed in the tunnel (mainly longitudinal system).
- If applicable, measurement of the effective reversibility times for the fans and jet fans.

- Measurement and calculation of the blower and extractor fan outputs in the ducts and, if applicable, the ventilation shafts: special attention should be paid to the performance obtained in smoke evacuation mode. Checks should also be carried out in degraded mode.
- Measurement of the flow rates and pressures at the fresh air openings and smoke venting dampers.

B.1.3 Functional Tests

- Calibration of the different pollution sensors and the anemometers.
- Remote control commands from the local electrical cabinets and the different supervisors.
- Slaving of ventilation speed to the data supplied by the pollution sensors.
- Generation and effectiveness of the pollution alarms in the event of an overshoot of the thresholds set for the different contaminants and opacity.
- Automatic fire detection system, inspected by simulating a fire at different points in the tunnel.
- Activation of the smoke evacuation devices concerned when actuated by the control/command station identifying a fire situation.
- Execution of remote control commands from the firemen's control switch boxes (if installed) to the jet fans/fans.
- Performance of the facilities in degraded mode.
- Performance and control of the smoke venting dampers.

B.2 Overpressure venting of shelters, emergency exits, passageways between tubes and safety galleries

B.2.1 Inspection of materials and equipment

- Fans, frames, fire dampers, air ducts and sound attenuators, for corrosion.
- Electric power supply (in particular, cable insulation and switch boxes).
- Fire behaviour of the equipment and feeder cables, including their routing.

B.2.2 Performances

- Measurement of the blown air outputs (shelters).
- Measurement of the effective overpressure with doors closed.
- Measurement of the air flow through an open (shelter) door or two open doors (lobbies).

B.2.3 Functional tests

- The equipment in standard operating mode (sanitary ventilation for the shelters and safety galleries) and activation of the overpressure venting in a fire situation or local controls.
- Performance of the equipment in degraded mode.

B.3 Metalwork

B.3.1 Inspection of materials and equipment

Inspection of the doors in safety areas (recesses, shelters, galleries, etc.), plant rooms and access panels, for:

- corrosion;
- fire behaviour.

B.3.2 Functional tests

- The door and access panel seals;
- The control, closing, return movement and locking systems.

B.4 Lighting

B.4.1 Inspection of materials and equipment

Lights

- If possible, inspection of the frames for corrosion, depending on their position in the tunnel.

Metalwork

- Inspection of the following items for corrosion and residual strength according to their position in the tunnel:

  - cable trays and laid (i.e. not drawn) cables;
  - light fittings;
  - junction box fastenings, (a) normal boxes and (b) fire-resisting boxes.

Wiring

- Partial or total inspection of the insulation of the following items:

  - wiring of the cable tray circuits;
  - normal and fire-resisting junction boxes.

B.4.2 Performances

- Under the different operating conditions, measurement of the luminance or illumination obtained on the roadway or at the bottom of the sidewalls with the different levels of reinforcement using a standard section; determination of the different lighting quality criteria (evenness, glare, etc.). Inspections can very often be limited to measuring the average and minimum levels of illumination afforded by the safety lighting over the roadway and the footways and in the different safety areas (shelters, inter-tube passageways, etc.).

B.4.3 Functional tests

- The remote control commands from the local consoles and different supervisors.
- Slaving of the reinforced lighting and standard section lighting to the data provided by the sensors.

B.5 Fire-fighting equipment

B.5.1 Inspection of materials and equipment

- Condition of the supply pipe (watertightness in particular).
- Condition of the hydrants (corrosion, watertightness).
- Condition of the control valves and equipment.
- Condition of the extinguishers.
- Condition of the booster pumps.
- Condition of the storage tanks.
- Condition of the pressure control systems.
- Condition of the layout of the piping and installations.
- Condition of the supply pipe lagging.

B.5.2 Performances

- Measurement of the pressure and output obtained at the hydrants at different points along the supply pipe, in both normal and degraded modes.

B.5.3 Functional tests

- The control valves and equipment.
- If applicable, the system's looping equipment in degraded mode.
- The pressurisation, filling and looping equipment.

B.6 Fire detection

B.6.1 Plant rooms

Check that the statutory inspections applicable to industrial and commercial establishments have been carried out by an approved body.

B.6.2 Below ground

Inspection of materials and equipment

Functional tests

Where applicable, perform a fire simulation test at relevant points in the tunnel.

B.7 Electric power supply

Check that the statutory inspections applicable to industrial and commercial establishments have been carried out by an approved body.

B.7.1 Inspection of materials and equipment

Electrical room

- Condition of the HTA cells.
- Condition of the transformers.
- Condition of the LV board equipment (circuit breakers, contactors, etc.)
- Cable routing (safety and fire protection factors).
- Earthing of the various items of equipment.
- Condition of the electronic cards of the inverters.

Below ground

- Inspection of the power supply (including any defective insulation) to the following items:

  - jet fan supply circuits;
  - normal and fire-resisting circuits of the different lighting modes;
  - camera and traffic signal supply circuits;
  - firemen's control switch boxes (if installed).

B.7.2 Performances

- Residual autonomy of the batteries.
- Residual autonomy of the inverters (if possible).
- Autonomy of the generator(s) and switchover time.

B.7.3 Functional tests

- Performance of the switchover equipment in the event of a fault in:
  - an EDF lead-in;
  - any of the transformers.

- If applicable, the generating set start-up and resumption.
- Check that the inverter ensures an uninterrupted power supply to the safety circuits in the event of a power failure.
- The performance of each component included in the power supply wiring diagram.

The load shedding / reloading of the power installations should also be tested.

B.8 Radio communication

- Inspection of the aerial fixings and mountings.
- Inspection of the radiating cable attachments (corrosion, residual strength, etc.) in relation to their position in the tunnel.
- Inspection of the radiating cable performance along the tunnel (possible detection of dead zones in the radio coverage, frequency by frequency.
- Inspection of the associated active components (transmitters, receivers, amplifiers, relays, etc.) and their future in the market.

B.9 Emergency call system

B.9.1 Inspection of materials and equipment

- **Corrosion in general.**
- **Emergency call point accessibility**
- **Emergency call point signs**

B.9.2 Functional tests

- Performance of the different emergency call posts and audibility of the links.
- Call identification and handling, and the handling of queued calls at the central control station.

B.10 Remote surveillance

B.10.1 Inspection of materials and equipment

- Inspection of the cameras and brackets for corrosion.
- Inspection of the camera fixing devices and the mobile camera mounting plates.
- Inspection of all connections, particularly at the video rack.

B.10.2 Performances

- Monitor picture quality.
- Picture transmission time in response to a camera selection command.

B.10.3 Functional Tests

- The remote camera selection control.
- Camera identification: on site / by monitor.
- Monitor display cycles.
- Data storage on video tape or other medium.

B.11 Automatic incident detection

- Inspection of materials and equipment.
- Performances: to be inspected according to the characteristics of the installation: alarm detection time, for example.

- Functional tests:

  - Direct on-site inspection of the system used to locate a vehicle that has stopped or slowed down.
  - The actions triggered by a fire detection alarm: picture on the monitor, audible alarm, etc.

B.12 Sundry equipment

B.12.1 Service telephones

Inspection of materials and equipment

Functional tests

B.12.2 Traffic management

- Metering loops.
- Speed detectors.

Inspection of materials and equipment

Functional tests

B.13 Tunnel management system

B.13.1 Inspection of materials and equipment

- Condition of the system of supervision, performances, durability, etc.
- Condition of the robot cards.
- Inter-robot / supervisor links.
- Remote control / command equipment components

B.13.2 Performances

- Execution time of commands sent by the operator to the different safety functions and the corresponding feedback time.

B.13.2 Functional tests

- Execution of the principal remote commands.
- Information grouping on the video display consoles.

Special safety sequences: (as a guidelines, safety facility door opening, road incident and tunnel closure sequences, etc.).

The following are the only two sequences included here:

- **Safety recess door opening sequence or extinguisher release (automatic sequence). Check the following:**

  - alarm signal reception;
  - monitor display of the corresponding televised picture;
  - activation of the dynamic signalling;
  - full-power switch-on of the standard cross-section lighting.

- **Fire control sequence (following activation by the operator). Check the following:**

  - execution of the tube closure sequence;
  - activation of the smoke evacuation sequence;
  - pressure ventilation of the safety facilities concerned;
  - transfer to the control / command screen of the diagrams indicating the status of the equipment.

- **Operator Assistance**

For the above sequences, check the control / command screen to verify that it displays the appropriate instruction sheets.

B.14 Signs

This refers to all the variable signs (lane indicators, variable message panels, multiple-panel safety exit signs), fixed signs (police, safety areas) and, should the need arise, tunnel closure signs (road blocks, barriers).

B.14.1 Inspection of materials and equipment

- General inspection of the equipment: corrosion on the power supply and control boxes, panel visibility and legibility, condition of light sources, etc.

B.14.2 Functional tests

- Performance of the items below following a command from the control / command station:

  - lane indicators;
  - variable message panels;
  - user information signs;
  - closure signs.

B.15 Drainage

- Drainage equipment.
- Roadway drainage facilities.

B.15.1 Inspection of materials and equipment

- Inspect the pipework and pipe supports, drains, gutters, drainage tanks, pumps including lifting pumps, valves, etc.

B.15.2 Functional tests

- Inspection of the routing, storage, pumping, lifting and detection systems (levels, presence of hydrocarbons, pressures, etc.).

Notes

Contents

At the request of the CESTR, the CETU set up a working party to put together a guide intended for all persons to whom road tunnel safety documentation applies.

The working party was made up of representatives from the CETU, the land transport department's dangerous goods transport unit (DTT-MTMD), the national industrial environment and hazards institute (INERIS), of owners and operators, some members also belonging to the CESTR. The scientific management centre of the École des Mines in Paris provided methodological and operational assistance to the working party.

The working party's activities were based chiefly on a detailed analysis, conducted by the Docalogic Inflow engineering and design office, of the methods of organising and the content of specific hazard investigations carried out on a number of typical road tunnels in France.

A list of those attending the working party meetings is given below.

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Guide to road tunnel safety documentation:

Booklet 0: **Safety documentation objectives**
Booklet 1: Practical method of compiling the safety documentation
➤ **Booklet 2: Tunnels in operation: "From the existing condition to the reference condition"**
Booklet 3: Comparative risk analyses
Booklet 4: Specific hazard surveys)
Booklet 5: Emergency response plans

With **tunnels in operation**, the safety documentation is based not on the existing condition (the tunnel as it is) but on **the reference condition**, the tunnel as it will be on completion of the **safety upgrade programme** decided on by the owner.

Booklet 2 deals with the analyses and surveys on which the reference condition and the safety upgrade programme are based.

The CETU (Centre d'Etudes des Tunnels / tunnel study centre) set up the working party which compiled this booklet in response to the express request of the CESTR (Comité d'Evaluation de la Sécurité des Tunnels Routiers / road tunnel safety assessment committee).

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