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Railway applications — Concepts and basic requirements for the planning of railway operation in the event of earthquakes

Applications ferroviaires — Planification des concepts d'exploitation en cas de séisme

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Foreword

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This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 3, *Operations and services*.

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

Modern transportation systems, including the railway, are constructed with the prerequisite of maintaining the functions required for public service under the designed usage conditions and/or when faced with the expected external effects of natural phenomena that were taken into account at the time of their design. Such natural phenomena include earthquakes or extreme weather events. In case of events caused by natural phenomena, functional damage to transportation systems can occur, adversely affecting lives and societies.

There are no predictive signs for many natural phenomena events, especially earthquakes. Earthquakes tend to occur suddenly and without any prior warning which could enable the forecasting of the intensity of ground shaking and the size of the affected area using existing technology. Large earthquakes including aftershocks can affect society for an extended period of time where extensive damage to transportation systems occurs. Compared to other natural phenomena, earthquakes are infrequent. As such, it is difficult to obtain experience-based knowledge for improving information on construction countermeasures for resisting future events reliably.

Because of the nature of earthquakes, it is difficult to predict the scale and timing of damage to transportation systems. Therefore, due to potentially significant effects on society, the planning and implementation of countermeasures to restrict damage and to reduce the risk due to earthquakes is essential for transportation systems.

Railway operators aim to provide a safe and reliable transport service. In doing so, they need to take into account the reliability of the railway service for customers (passengers and consignors) and railway owners. This aim should be achieved as far as possible even under irregular railway operation conditions. One case in which irregular railway operation conditions are expected is that due to earthquake events. This is potentially the case not only for a specific area/country which has experienced a large earthquake event before, but also for other areas/countries without previous experience of significant earthquake events, but for which a risk of exposure to ground shaking exists. For these areas/countries, a significant seismic potential and a significant risk of exposure to ground shaking can be present. Therefore, in order to reduce a customer's risk in relation to earthquakes, the planning of any countermeasures for railway operation becomes an important issue for consideration.

Conversely, the solution to the above issue is hampered by the lack of standards, guidance, or other documentation available to the public. In order to help to reduce the potential risk due to earthquakes, and to thereby improve the reliability of a railway service and to protect the reputation of railway businesses, the establishment of an internationally accepted and publicly available document is essential.

Railway applications — Concepts and basic requirements for the planning of railway operation in the event of earthquakes

1 Scope

This document specifies the concepts and basic requirements for the planning of railway operation in order to reduce risk in the event of earthquakes. This excludes regions where the consequences of seismic hazard for railway operation are low or non-existent. The definition of such regions is out of the scope of this document.

NOTE The stages defined for consideration of the countermeasures necessary for the safe management of the seismic hazards can also be relevant for dealing with other natural phenomena.

This document includes only operational measures and excludes any infrastructure measures. Furthermore, this document does not include specific measures which ensure, without fail, passenger safety or which provide protection against railway-operational damage caused by earthquakes. Therefore, residual risk can remain.

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 terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
railway operation
control and management of the railway service

Note 1 to entry: In this context, railway operation includes responsibility for managing and maintaining railway infrastructure, traffic management and signalling, provision and maintenance of rolling stock, and services for the transport of goods and/or passengers by rail. In countries where these responsibilities are provided by different parties, the tasks defined in this document should be divided accordingly.

3.2
operator
party responsible for *railway operation* (3.1)

3.3
operational restriction
application of a speed restriction or an operation suspension to trains according to relevant operational procedures in order to improve the safety of the trains or to reduce the risk

3.4
operational condition
operational mode which depends on the permitted running velocity of a train on a particular section of the network

Note 1 to entry: Operational condition consists of two modes: regular and irregular conditions (3.5 and 3.6).

3.5
regular condition
condition in which trains can operate at the maximum permitted line speed

3.6
irregular condition
condition in which an *operational restriction* (3.3) is enforced due to an unusual situation

3.7
ground motion strength index
set of measures to represent ground motion strength utilized in decision-making

EXAMPLE Seismic peak ground acceleration.

3.8
threshold
pre-defined value for the strength of ground motion for deciding the *operational restriction* (3.3)

3.9
earthquake information
perception and/or physical information for earthquakes

EXAMPLE Perception of ground shaking, values of *ground motion strength indices* (3.7), earthquake source parameters such as origin time, hypocentre or epicentre location and magnitude.

4 Definition of stages for planning of railway operation

4.1 General

This clause defines the following five cyclic stages which are needed to consider the countermeasures necessary for railway operation during the time period of an earthquake (see Figure 1).

— Stage 1: Detection of earthquake

— Stage 2: Decision for operational restriction

— Stage 3: Implementation of operational restriction

— Stage 4: Inspection

— Stage 5: Resumption of regular condition

In Figure 1, the small black circles indicate “stages”, while the broken line arrows represent operational “conditions”. The stages here refer to a series of actions implemented by operators for railway operation during and after an earthquake event. The condition switches at Stage 3 or 5 as shown in Figure 1.

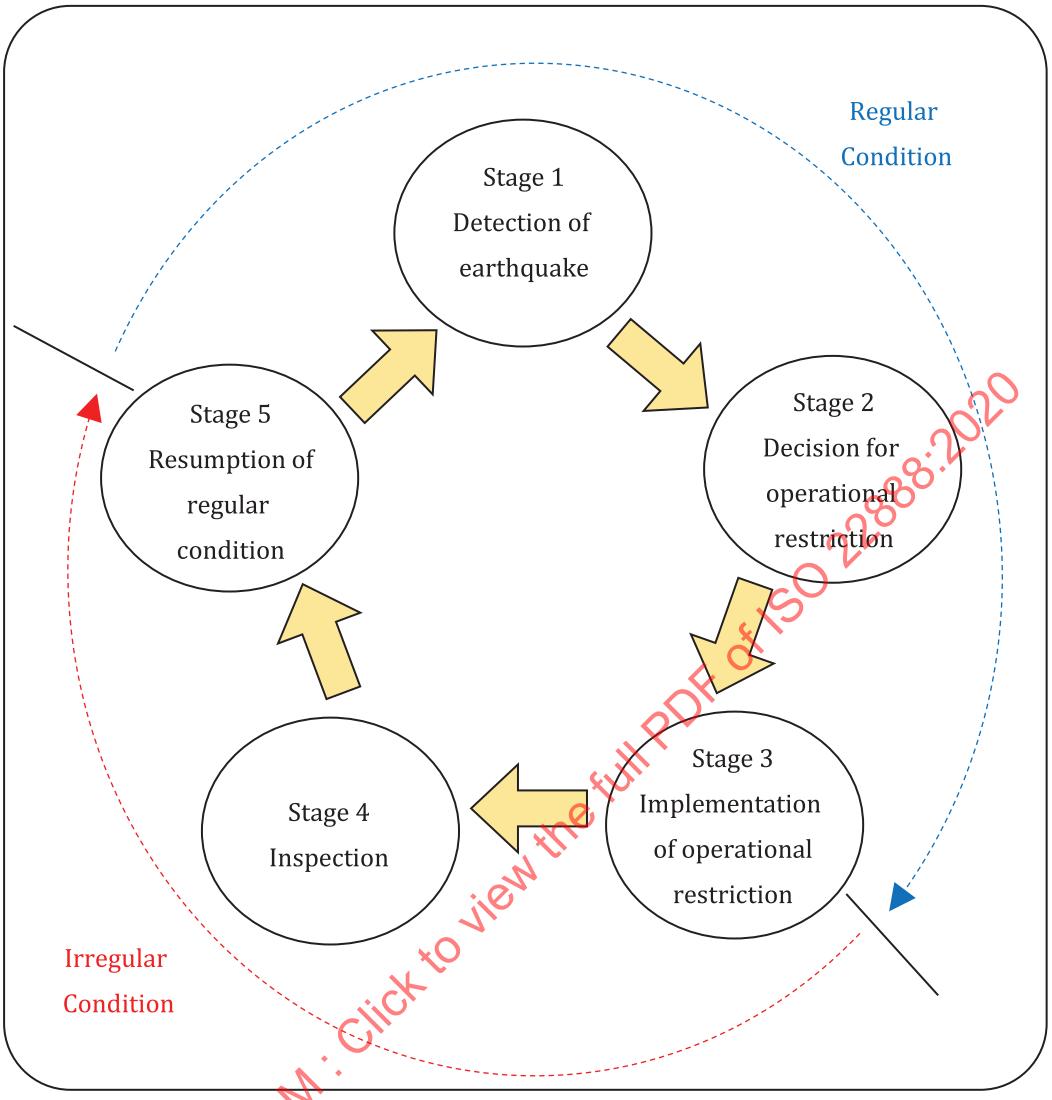

Figure 1 — Stages and conditions

4.2 Stage 1: Detection of earthquake

The purpose of Stage 1 is to detect an earthquake occurrence and to obtain event information.

4.3 Stage 2: Decision for operational restriction

The purpose of Stage 2 is to decide whether or not a safer operational condition is required and which mode of irregular condition shall be implemented (speed restriction or operation suspension) using the earthquake information obtained at Stage 1.

4.4 Stage 3: Implementation of operational restriction

The purpose of Stage 3 is to change to irregular condition (speed restriction or operation suspension) if it is decided as being necessary at Stage 2.

4.5 Stage 4: Inspection

The purpose of Stage 4 is to inspect the condition of railway facilities in order to provide information on whether railway operation can be resumed under regular or irregular conditions.

4.6 Stage 5: Resumption of regular condition

The purpose of Stage 5 is to return to regular condition based on the information gathered in the previous stages.

5 Concepts for planning of railway operation

5.1 General

Operators should change to a safer operational condition without delay. Operators should make efforts to minimize the risk to safety and economic loss to customers and operators, and should revert to regular operation immediately after it is considered safe to do so.

5.2 Basic plan

Operators can develop a basic plan which includes consideration of the factors that are necessary to develop the procedures for the railway operation during an earthquake event. The basic plan may be updated depending on the situation.

The basic plan may include consideration, for example, of:

— traffic frequency;

— passenger density;

— infrastructure vulnerability;

— economic and social impact;

— earthquake information for past/predicted events;

— damage due to past/predicted earthquakes;

— line speed;

— cost effectiveness.

The basic plan is not mandatory.

5.3 Development of procedures for railway operation

5.3.1 General

Operators should establish the procedures of railway operation for each stage in advance of earthquakes. Implementation of the specific stages, operational procedures and basic requirements for railway operation in a particular area/country can take account of the organizational and responsibility chain practices in that area/country. See Annex A for additional information of the procedures implemented in some countries.

It is common for a number of operators to be involved in railway operation during an earthquake event. The developed procedures should thus be shared among the concerned operators who are responsible for each task. Operators can promote dissemination and training for the developed procedures to efficiently apply them in case of earthquake events.

5.3.2 Factors considered for all stages

Factors related to railway operation are shown below (see 5.3.3 to 5.3.7). Other factors that are relevant to the management of railway operation can be considered if necessary, including:

— corporate structure;

— resourcing and staffing requirements;

— tools, devices and equipment;

— operational procedures;

— emergency contact network among all concerned operators and relevant organizations;

— communication procedures;

— ground motion strength indices;

— thresholds for the decision;

— objectives and roles of the concerned parties.

5.3.3 Stage 1: Detection of earthquake

For the railway operation procedures, operators shall determine how to quickly obtain earthquake information, and should guarantee the means for reporting information accurately and as rapidly as possible to the parties responsible for the decision for operational restriction.

5.3.4 Stage 2: Decision for operational restriction

Operators shall consider how to determine the operational restriction. Operators should consider the information necessary to support their decisions, including the use of the ground motion strength indices when available. The thresholds for decisions shall be set suitably, considering the earthquake detection method, the impact on railway operation due to ground motion and the possibility of damage to the railway facilities.

5.3.5 Stage 3: Implementation of operational restriction

Operators shall define the procedure for changing the operational condition from regular to irregular as soon as possible, when operational restriction is decided to be necessary.

5.3.6 Stage 4: Inspection

Operators shall establish appropriate inspection procedures which take into account the corporate structure of an operator and the necessary resources needed to return the operational condition to regular as soon as possible, as well as the measured or estimated level of ground motion strength along the line (when this is available).

5.3.7 Stage 5: Resumption of regular condition

Operators shall develop a procedure for deciding that the resumption of regular condition is possible.

6 Basic requirements for planning of railway operation

6.1 General

This Clause describes the basic requirements for railway operation at each stage.

6.2 Stage 1: Detection of earthquake

Operators shall always be able to obtain information about the occurrence of an earthquake. In addition to the alarms issued by the staff with a direct perception of seismic shocks, earthquake detection may be obtained either by a specific system installed by the operators, or by exploiting sensors installed by other authorities, or by a combination of these options. When a specific system is installed by the operator, the operator shall make efforts to maintain the function of earthquake detection and the method of communication.

6.3 Stage 2: Decision for operational restriction

Operators shall make a decision regarding operational restriction as quickly as possible when an earthquake is detected. The decision can be automatically implemented. The decision shall be promptly transmitted to the concerned operators.

6.4 Stage 3: Implementation of operational restriction

Operators shall change the operational condition to irregular without undue delay as necessary, as a result of the decision for operational restriction. Operational restriction can be automatically implemented. The decision result should be communicated as early as possible to the operators concerned.

6.5 Stage 4: Inspection

After operational restriction is implemented, operators shall confirm whether or not there is earthquake-induced damage to the railway facilities and whether there are residual risks for railway operation. The inspection result and/or the decision made based on the inspection should be communicated to the concerned parties so that there is a shared understanding of the situation.

6.6 Stage 5: Resumption of regular condition

Operators may change the operational condition from irregular to regular if the inspection confirms that there is either no damage or an acceptable level of damage to railway facilities and that the risks to safety are acceptable for regular operation. The information should be communicated with the concerned operators as soon as the decision to change the operational condition is made.

Annex A
(informative)

Examples of actions implemented for the five stages

A.1 China

An example of actions implemented for the five stages in China is shown in Table A.1.

Table A.1 — Example — China

	Example of a railway line without seismometers	Example of a railway line with the 1st generation system (earthquake monitoring system)	Example of a railway line with the 2nd generation system (earthquake early warning system)
Stage 1 Detection of earthquake	Any member of the railway operator's on-site staff reports the earthquake event, or the operator receives information from the China Earthquake Administration.	The earthquake is detected by the earthquake monitoring system.	The earthquake is detected by China's railway earthquake early warning system or through the systems from the China Earthquake Administration.
Stage 2 Decision for operational restriction	After receiving the earthquake information, the concerned staff of the railway operator make the decision for operational restriction based on the predefined rules.	Decision for operational restriction is made automatically by the earthquake monitoring system according to the predefined rules.	Decision for operational restriction is made automatically by the system according to the earthquake information. Decision for operational restriction is also automatically sent to the railway dispatcher, related departments and other related systems.
Stage 3 Implementation of operational restriction	The train operation command is sent to the train driver to control the train running.	The earthquake monitoring system automatically sends the stop command to the train through the CCS (control command and signalling) system and shuts down the power supply. The executive command is also sent to the railway dispatcher.	Operational restriction is implemented based on the following thresholds: — Speed restriction: The train driver operates the train with the restricted speed. — Stop of train: The train is automatically stopped. — Power shut down: The power supply is automatically shut down.
Stage 4 Inspection	Railway engineers from the concerned departments inspect the rolling stock and infrastructure and report the inspection results to the railway dispatcher.	Railway engineers from the concerned departments inspect the rolling stock and infrastructure and report the inspection results to the railway dispatcher.	Speed restriction: railway engineers from the concerned departments undertake the on-board inspection of the rolling stock and infrastructure. The inspection results are reported to the railway dispatcher. Stop of train: railway engineers from the concerned departments inspect the rolling stock and infrastructure and report the inspection results to the railway dispatcher.
Stage 5 Resumption of regular condition	If there is no damage to the rolling stocks and the infrastructure, or the infrastructure damage has been completely repaired, the regular operation is resumed step by step.	If there is no damage to the rolling stocks and the infrastructure, or the infrastructure damage has been completely repaired, the regular operation is resumed step by step.	If there is no damage to the rolling stocks and the infrastructure, or the infrastructure damage has been completely repaired, the regular operation is resumed step by step.

A.2 France

An example of actions implemented for the five stages in France is shown in Table A.2.

Table A.2 — Example — France

	Example of a railway line in France
Stage 1 Detection of earthquake	The detection of an earthquake can be achieved with the following methods: — by the permanent detection of ground motion with the seismic detecting system (DSI) distributed along the high-speed line; — by the national authority[a] whose role is to confirm that the event has been detected by DSI by means of their instrumented networks for detecting and obtaining earthquake information. Some high-speed lines are not equipped with DSI; in such cases, the national authority[a] delivers the information directly to the traffic manager.
Stage 2 Decision for operational restriction	The decision for operational restriction can be reached with the following methods: — the interlocking connected to the DSI either slows down the trains (minor ground motion strength) or stops the trains (major ground motion strength) within the perimeter of the concerned zone; — the information transmitted by national authorities[a] to the traffic manager is elaborated by the person in charge to assess the level of the ground motion strength and where operational restrictions are necessary.
Stage 3 Implementation of operational restriction	The implementation of operational restriction can be achieved as follows. The traffic manager suspends the circulation of trains within the concerned zone until authorization for the resumption of traffic is obtained: — directly from the national authority[a], when the decision confirms that the traffic can move again if the alarm is not confirmed (example: defect of the DSI); or — from the person in charge of maintenance after an exhaustive check following confirmation by the national authority[a] of detection.
Stage 4 Inspection	The traffic manager, after organizing medical support for passengers and staff, requests from the infrastructure manager the inspection of the infrastructure by each expert with the relevant speciality (major civil, earthworks, geometry of the way, telecommunications, electric traction, signage devices…).
Stage 5 Resumption of regular condition	The resumption of the traffic is authorized by the person in charge of maintenance: — after an exhaustive check of the infrastructure; and — when the conditions for continued operation are confirmed by each speciality expert.
[a] The DASE (Department of the environmental analysis and monitoring of CEA), CEA (Commissariat of atomic energy).	

A.3 Italy

An example of actions implemented for the five stages in Italy is shown in Table A.3.