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Automatic warning of track maintenance gangs

Système d'alerte automatique des brigades de la voie
Automatisches Warnsystem für im Gleis arbeitende Personen

UNION INTERNATIONALE DES CHEMINS DE FER
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Contents

Summary

The goal of the leaflet is to specify the requirements for an automatic warning system.

Such a system aims at:

- automatic warning of approaching rail vehicles in adequate time, with a high degree of safety, for staff working on or near tracks,

- reduction of the staff needed for track-gang warning.

The leaflet is based on Report, Part 1, of the ORE[1] A 124 Specialists Committee.

The system consists in an announcement part and a warning part, so designed that each part can operate separately.

The system is specified for operation till 200 km/h.

It is based on a radio transmission in the 160 MHz and 460 MHz frequency ranges.

A system based on the GSM-R frequency range is out of the scope of the present leaflet.

The leaflet is specified in a very detailed way. It includes:

- Operating conditions:
  for the complete warning system, detector, announcement transmitter, warning centre - including announcement receiver and warning transmitter, warning receiver, warning signal generator,

- Safety and reliability requirements,

- Technical requirements - including environment and design:
  for the complete warning system, detector, announcement transmitter, cables for the announcement transmission line and warning transmission line, centre - including announcement receiver and warning transmitter, warning receiver with acoustic warning signal, warning receiver with optical warning signals, acoustic warning signal generator, optical warning signal generator and continuous warning light.

- Concepts, definitions, block diagram and warning signal are given in Appendix A.

1. ORE became ERRI (European Rail Research Institute) in January 1992.

1 - Introduction

This Leaflet contains the requirements for automatic warning systems for persons working in the dangerous zone on or near tracks. It is based on the specifications relating to "Automatic track gang warning systems" laid down in Report 10, Part 1, of the ORE[1] A 124 Specialists Committee.

The aim of the system is to warn personnel working on or near tracks of approaching rail vehicles in adequate time.

The aim of the automatic warning is to ensure a high degree of safety for staff working on or near tracks and reduce the number of staff needed for track-gang warning.

The system should consist basically of an announcement section and a warning section (see Appendix A.3 - page 23), and be so designed that each of these sections can function separately.

The "announcement" section detects approaching rail vehicles and announces them. The rail vehicles are identified by means of a detector and reported by an announcement transmitter to an announcement receiver via an announcement transmission path which is either wireless or by cable. With cable transmission, some components may not be needed.

The "warning" section warns the endangered personnel after the announcement. A warning transmitter sends the warning signal to one or more warning receivers via a warning transmission path which is either wireless or by cable. The warning receiver(s) then actuate(s) the warning signal generators, which emit the warning signal. With cable transmission, some components may not be needed.

The most important concepts and definitions used in this Leaflet are listed in Appendix A - page 18.

1. ORE became ERRI (European Rail Research Institute) in January 1992.

2 - Operating conditions

2.1 - Operating conditions for the complete warning system

2.1.1 - It should be possible to use the warning system for all work in the track danger zone, on both stationary and moving work sites.

2.1.2 - It should be possible to use the automatic warning system on:

- single track lines with two-way traffic,
- double track lines on which each track can be worked in one or both directions,
- electrified lines operating on direct current from 600 V to 3 kV or on alternating current from 6 kV to 25 kV with 16 2/3 Hz and 50 Hz,
- lines running parallel to electric power supply lines,
- lines with diesel traction and electric train heating,
- lines worker at speeds from 3 to 200 km/h.

2.1.3 - The equipment should be designed on a modular principle so that systems can be provided for the different types of work site and operating conditions (e.g. for lines with one or more tracks, fast-moving, slow-moving and stationary work sites).

2.1.4 - The announcement device of the automatic warning system should be able to indicate approaching rail vehicles by track and direction of travel.

Rail vehicles travelling from a detection point towards the work site should be detected and announced.

Rail vehicles travelling from the work site towards a detection point should not actuate a warning signal.

2.1.5 - The automatic warning system should be capable of emitting automatically two different warning signals:

- warning signal 1 (Wa 1); meaning: withdraw to worked track (used when a rail vehicle is approaching on the track adjacent to the worked track under possession),
- warning signal 2 (Wa 2); meaning: withdraw from all tracks (used when a railway vehicle is approaching on the worked track not under possession and/or on the adjacent track).

In automatic operation, only one of these signals is used. The person responsible for work site safety switches on Wa 1 or Wa 2 depending on the type of work site.

2.1.6 - It should be possible to actuate manually from the centre warning signals Wa 1, Wa 2 or the acoustic danger signal Wa 3 as required (Wa 3 means: maximum danger ! clear all tracks immediately !).

2.1.7 - Warning Wa 3 has priority over Wa 2 and Wa 1.

2.1.8 - Together with the warning signals Wa 1 or Wa 2, a continuous optical warning should be given. The continuous optical warning will be switched off only when the last rail vehicle has left the system's zone of operation.

2.1.9 - The warning signal is given only when the first rail vehicle crosses one of the detection points. The work site remains on alert as long as the continuous optical warning is switched on. Between the arrival of the first rail vehicle at the detection point and the "all clear", it should be possible to store at least four vehicle entries per detection point. The failure warning signal should be actuated if the memory overloads.

It should be ensured that one train is not recorded by the recorder as being several trains and that several trains are not recorded as being one single train.

2.1.10 - In the case of a failure, the prearranged warning signal (Wa 1 or Wa 2) should be used. The optical warning signal should be switched on at the same time. In the event of a failure of one of the power supply sources or of the functional groups, as well as in case of component or transmission breakdown, the failure signal shall be emitted until the person responsible switches off the system manually, after safeguarding the work site by taking appropriate measures.

2.1.11 - The warning zone covered by an automatic warning system should be at least 300 m long.

2.2 - Operating conditions for the detector

2.2.1 - Detectors should reliably detect rail vehicles at speeds of between 3 and 200 km/h. It is also desirable for rail vehicles to be detected at speeds of less than 3 km/h.

2.2.2 - It should be possible to mount the detectors on various rail profiles (see point 4.2.2.6 - page 9).

2.3 - Operating conditions for the announcement transmitter

General conditions:

1. One announcement transmitter for each direction of travel should suffice to serve the number of detection points needed on one two-track line or two single-track lines.

2. The distance (Appendix A.3 - page 23) between detection point and warning centre should correspond to the minimum warning time. This distance may be up to 4 km long.

3. At the announcement transmitter level, it should be possible to relay information on an approaching rail vehicle not only via the detector but also, if necessary, by a manually-operated equipment or through signalling devices.

2.4 - Operating conditions for the warning centre (including announcement receiver and warning transmitter)

(See Appendix A.3 - page 23).

After analysing the information, the centre or announcement receiver should actuate the warning, either through directly-connected warning signal generators and/or controlling indirectly one or more warning receivers via a warning transmitter.

It should be possible to use the "warning" section of the warning system on its own. Point 2.1.6 - page 3 applies in this case.

The centre should meet the following conditions:

2.4.1 - The track and direction of approaching rail vehicles should be displayed clearly.

2.4.2 - Any failure in the system should lead to the failure signal being actuated and to optical and acoustic signals being issued to the centre. These signals are purely for the information of supervisory staff.

2.4.3 - Cancellation of a failure alarm should only be possible after elimination of the fault or shutdown of the system.

2.4.4 - It should be possible to record all warnings and faults together with the time they occurred.

2.5 - Operating conditions for the warning receiver

It should also be possible to actuate the warning signal generators manually from the warning signal receiver.

2.6 - Operating conditions for the warning signal generator

2.6.1 - It should be possible to issue different warning signals (see points 2.1.5 - page 3 and 2.1.6).

2.6.2 - It should be possible to use the warning signal generators freestanding or mounted on track machines.

2.6.3 - The optical warning signal may replace the acoustic one in the dark. Optical warning is given by reducing the work site light intensity.

2.6.4 - The continuous warning described in point 2.1.8 - page 4 is given by continuous warning lights (e.g. revolving lights) preceded by a short acoustic (see Appendix A.4 - page 24) or optical warning. The continuous warning lights should be available in addition to the warning signal generators.

3 - Safety and reliability requirements

3.1 - Safety

3.1.1 - The safety of the automatic warning systems should:

- comply fully with qualitative safety principles,
- and/or comply with quantitative safety principles, the "fail-safe rate" related to the number of train runs and installations may not exceed 10^{-8}.

3.1.2 - The proof of safety should describe in detail all the assumptions concerning the envisaged failures and rules, the fault display times and the safety principles adopted in the design of the automatic warning system (e.g. equipment and/or information redundancy, steady state current techniques, "handshake" system, etc.).

3.2 - Reliability

3.2.1 - The mean "fail-safe" rate related to train runs per system should not exceed 10^{-4}.

The "fail-safe" rate of the warning system should be related not to a time period but rather to the total number of train runs.

3.2.2 - The MTBF for the complete system should not be less than 5000 operating hours.

3.3 - Proof of safety and reliability

The manufacturer should provide proof of safety and reliability.

4 - Technical requirements

4.1 - Requirements for the complete warning system

4.1.1 - Staff protection

The automatic warning system should comply with international norms relating to protection in the event of direct or indirect contact, to maximum contact voltages and to the influence of strong currents.

4.1.2 - Power supply

4.1.2.1 - The power supply should guarantee uninterrupted operation for at least 10 hours.

The various sections of the warning system may be arranged in very different ways on the work site (e.g. detectors on the track, warning centre at a suitable point on the work site, warning signal generators on the track machinery). Given this situation, the type of power supply should be the most appropriate in terms of service and technique (battery, generator, mains power supply).

4.1.2.2 - If the supply voltage drops below a certain level, this should be appropriately indicated and the failure alarm should be actuated at the same time.

4.1.2.3 - The power supply for the failure alarm should be duplicated.

4.1.3 - Electrical environment

4.1.3.1 - The operation of the automatic warning system should not be adversely affected by:

- atmospheric discharges,
- traction and train heating currents,
- electromagnetic brakes,
- stray fields of transformers mounted low on motor engines,
- safety and telecommunications equipment (and vice versa),
- power supply system,
- high-frequency radiated interference.

4.1.3.2 - The equipment should function in ambient temperatures between -30°C and +70°C.

In the temperature range between -40°C and +80°C, the equipment should not suffer any irreversible change in its functioning. The changes in functioning likely to occur should not create dangerous situations for staff.

4.1.3.3 - The equipment should be designed for use in 100% relative humidity.

4.1.3.4 - The equipment should function perfectly up to altitudes of 2000 metres above sea level.

4.1.3.5 - Vibrations with a peak amplitude of A = 3 mm are to be allowed for in the 3 Hz to 40 Hz range, and of 0,1 mm in the 40 Hz to 100 Hz range.

When the automatic warning system is used on rail vehicles or track machinery, vibrations in the 100 to 800 Hz range are also to be allowed for.

4.1.3.6 - Allowance should be made for shocks with a mean acceleration of $\bar{a}$ = 5 g and a peak acceleration of $\hat{a}$ = 10 g. When sections of the automatic warning system are used on rail vehicles and track machinery, shocks with a mean acceleration of $\bar{a}$ = 50 g may occur with unsprung masses.

4.1.3.7 - The equipment should function even under the following conditions:

- dust, as defined in IEC Publ. 60529 (2001), Class 6 (see Bibliography - page 25),

- water, as defined in IEC Publ. 60529 (2001), Class 5,

- chemical effects, e.g. :

  - corrosive gases and vapours,
  - weedkillers,
  - salt and saline mist,
  - grease, oil and oil vapours

- direct solar radiation.

4.1.4 - Construction

4.1.4.1 - Each section of the automatic warning system should be so constructed that it can be transported or carried into position by at most two people.

4.1.4.2 - The maximum permissible weights for the different sections are:

- detector: 12 kg,

- centre: 20 kg,

- warning signal generator: 12 kg,

- unit of cable: 10 kg

It should be possible for a non-specialist to mount the automatic warning system.

4.1.4.3 - It should only be possible to switch the automatic warning system on or off by using a special key.

4.2 - Requirements for the detector

4.2.1 - Operating principles

The detector should be able to detect, with or without indication of direction, traffic with two or more axles and be capable of relaying notification of detection to the next section of the system (announcement transmitter or centre) in a usable form.

4.2.2 - General requirements

4.2.2.1 - The detector should be able to withstand 2000 V, 50 Hz, with respect to earth, for one minute.

4.2.2.2 - The detector should be monitored continuously as an integral part of the entire warning system. The "detector fault" condition should be indicated as a system fault.

4.2.2.3 - Core requirements for data transmission and supply voltage between the detector and the centre (long transmission path) may be no more than 4 cores.

4.2.2.4 - Core requirements for data transmission and supply voltage between the detector and the announcement transmitter (short transmission path) may be no more than 8 cores.

4.2.2.5 - It should be possible to attach the detector to various rail profiles without modifying the track equipment.

The Railway should specify the rail profiles to be taken into account.

4.2.2.6 - The efficiency and accuracy of the detector should be guaranteed for all the tracks in normal service, however much wear there is on the rails and wheel profiles.

4.2.2.7 - It should be possible to use the detector on tracks with an incline of 40‰, with a transverse incline corresponding to a slope of 150 mm (over a distance of 1435 mm) and on bends with internal and external radius reducing to 180 m.

4.2.2.8 - Traffic on adjacent track should not affect the detector.

4.2.2.9 - The detector should be designed to guarantee detection of axle loads between 1 and 25 Mp.

4.2.2.10 - The detector should be able to withstand shocks whose acceleration reaches a mean value of $\bar{a}$ = 50 g and a value of $\hat{a}$ = 150 g.

4.3 - Requirements for the announcement transmitter

4.3.1 - Principles of operation

The announcement transmitter is linked to the detectors (max. 2 detection points) and communicates by radio or cable with the centre or the latter's announcement receiver.

In addition, messages relating to approaching traffic, its own operational status (e.g. fault-free, faulty, insufficient voltage, etc.) and the detectors' operational status are notified to the centre.

4.3.2 - General requirements

4.3.2.1 - Information is transmitted to the centre by radio or by cable.

4.3.2.2 - In the case of transmission by cable, information (approaching traffic with track indication; fault-free; faulty; insufficient voltage) should be coded with a view to fail-safe transmission.

4.3.2.3 - In the case of transmission by cable, the announcement transmitter may be supplied with power by cable from the centre.

4.3.2.4 - In the case of radio transmission, the announcement transmitter should be supplied with power by a rechargeable accumulator with a nominal voltage of ≤ 24 V. This accumulator should also supply the detectors with power.

4.3.2.5 - The announcement transmitter for radio transmission should be so designed that transmission by cable is also possible via the same apparatus instead of radio transmission.

4.3.2.6 - In the case of radio transmission, the information is transformed into telegrams with address, useful information (approaching traffic with track indication; fault-free; faulty; insufficient voltage) and monitoring information.

4.3.2.7 - The time lapse between traffic detection and actuation of the warning signal should not be more than 3 s.

4.3.2.8 - The fault monitoring time (monitoring cycle) should be chosen in such a way that the notification period is no more than 3 s during which time a train announcement should not be rejected.

4.3.2.9 - In the case of digital transmission and assuming a bit error rate of 10^{-3}, the probability of invalid information (detected as erroneous) should be less than 10^{-4} after decoding.

4.3.2.10 - It should be possible to connect manual information input device at the position of the detector in order to make it possible to release information manually on the passing of a train. This manual information input device should be taken into account in the safety study.

4.3.3 - Technical requirements for the radio system

4.3.3.1 - Radio sets should have modulation inputs suitable for the transmission of digital and analog information.

4.3.3.2 - The transmitter and receiver should operate in the 160 MHz or 460 MHz frequency ranges; the 460 MHz frequency range is preferable because of the lower interference level. If other ranges are desirable, special mention should be made of this.

4.3.3.3 - Radio sets in each frequency band should comply with PTT regulations (spaces between HF channels). The radio sets should be production models.

4.3.3.4 - The HF output power of the transmitter should comply with the regulations laid down by the postal authorities on transmitting power (generally 6 W).

4.3.3.5 - The warning system should still function correctly with a high-frequency voltage ≤ 1 μV measured at the aerial input of the receiver.

4.3.3.6 - All the radio receivers of the warning system should be fitted with an indicator to show the intensity of the high-frequency signal received.

The transition zone between "good" and "inadequate" should cover a range of 10 dB.

4.3.3.7 - The aerial height should be adjustable between 1,5 and 5 m.

4.3.3.8 - At least three announcement installations should be able to operate in the immediate vicinity on a single radio channel.

4.3.4 - Technical requirements for the cable

In the case of cable transmission, the announcement transmission path consists of a sequence of cable units.

4.3.4.1 - The insulation control voltage between the conductors of a cable unit, including the connectors, should be at least 250 V, 50 Hz, for 2 minutes for service voltages rising to 24 V.

4.3.4.2 - The insulation control voltage between the conductors on the one hand and the sheath or lining of the cable on the other, should be at least 2 kV, 50 Hz, for 2 minutes for. one cable unit, including the connectors.

4.3.4.3 - The insulation resistance between the conductors and between the sheath and the conductors, should be higher than 10 Mohm/km for one cable unit fitted with its connectors.

4.3.4.4 - In order to reduce the effect of interference caused by the use of alternating current, the cable placed parallel to the overhead announcement line, together with the connectors and connection circuits, should be mounted symmetrically with respect to the earth. The attenuation of symmetry should be at least 60 dB. Protective measures should be taken against dangerous induced longitudinal voltages.

4.4 - Requirements for the cables of the announcement transmission line and the warning transmission line

4.4.1 - The cable link may consist of several cable units. One cable unit consists of a cable of fixed length, a carrier device and connectors at each end of the cable.

4.4.2 - The minimum permissible bending radius should be 50 mm or less.

4.4.3 - The cable should not be damaged by tensile loads of less than 500 N.

4.4.4 - It should be possible to bolt the connectors together. Each connector should be fitted with a built-in removable protective cap.

4.4.5 - The cable connectors should guarantee at least 5000 connection and disconnection operations.

4.5 - Requirements for the centre (including the announcement receiver and warning transmitter)

(See Appendix A.3 - page 23).

4.5.1 - Principles of operation

The centre communicates with the announcement transmitters and warning receivers by radio or by cable.

Moreover, the messages from the announcement transmitter relating to approaching traffic or operational status (e.g. faulty-free, faulty, insufficient voltage) are announced to the centre or announcement receiver.

The messages are analysed in the centre, acoustically signalled, optically displayed on the panel and transmitted to the warning transmitter.

The warning transmitter automatically transmits the warning and failure messages by radio or by cable to the warning receivers which actuate the warning signal using acoustic and/or optical devices.

It should also be possible to actuate the warning messages manually at the centre or warning transmitter.

4.5.2 - General requirements

4.5.2.1 - The control centre for radio transmission should be so designed that transmission by cable is also possible by means of the same apparatus instead of radio transmission.

4.5.2.2 - The warning messages Wa 1, Wa 2 and Wa 3, the fault message and, if necessary, the monitoring information should be transmitted (in analog or digital form) in the "forward" direction (from the warning transmitter to the warning receiver).

4.5.2.3 - If necessary, the monitoring information should be transmitted in the "return" direction (from the warning receiver to the warning transmitter).

4.5.2.4 - The control centre should be fitted with optical and acoustic signalling devices.

1. The following should be signalled optically:

   - the serviceability of the system,
   - the approach and direction of trains,
   - the track used (work-site track or adjacent track),
   - the battery charge level, and
   - faults.

   Optical signals should be clearly discernible, even in bright conditions (sunlight).

2. The following should be signalled acoustically:

   - the approach of trains,
   - faults, and
   - a fall in the battery voltage to below a preset level.

4.5.2.5 - The lookout should be provided with an acknowledgement device enabling him to acknowledge receipt of the announcements.

4.5.2.6 - There should be buttons for manual actuation of all the warning signals (see point 2.1.6 - page 3).

4.5.3 - Technical requirements for the radio

4.5.3.1 - Technical requirements of points 4.3.3.1 - page 10, 4.3.3.2 - page 10, 4.3.3.3 - page 10, 4.3.3.5 - page 10, 4.3.3.6 - page 10 and 4.3.3.8 - page 10 for the radio and those defined for the announcement transmitter also apply here. The HF output power of the warning transmitter should be 1 W at the maximum.

4.5.3.2 - In terms of the radio procedure for warning transmission, a unilateral warning transmission from the warning transmitter to the warning receivers should be given priority.

4.5.3.3 - Because of the limited number of radio frequencies, transmission of the announcement and of the warning should take place along the same channel and via the same aerial.

4.5.3.4. - At least three warning systems should be able to operate in the immediate vicinity on the same radio channel. In the case of high transmission density (more than 5 warning receivers with return signal), it should be possible to use a bypass channel for the warning transmission line.

4.5.4 - Requirements for the cables

The technical requirements for the cables defined in point 4.3 - page 9 for the announcement transmitter apply, with the exception of point 4.3.4.4 - page 11.

4.6 - Requirements for the warning receiver with acoustic warning signal

4.6.1 - Principles of operation

The warning messages are transmitted by the centre (warning transmitter), by radio or by cable, to one or more warning receivers.

The warning receivers automatically actuate the acoustic warning signal generators. Furthermore, the warning receivers automatically actuate the continuous warning lights and only switch them off when the dangerous situation ceases to exist.

4.6.2 - General requirements

4.6.2.1 - A warning transmitter should be able to command several warning receivers.

4.6.2.2 - In the case of digital transmission and assuming a bit error rate of 10^{-3}, the probability of invalid information (detected as erroneous) should be less than 10^{-4} after decoding.

4.6.3 - Technical requirements for the radio

4.6.3.1 - Technical requirements of points 4.3.3.1 - page 10, 4.3.3.2 - page 10, 4.3.3.3 - page 10, 4.3.3.5 - page 10 and 4.3.3.6 - page 10 for the radio defined in point 4.3 for the announcement transmitter are applicable. The maximum aerial height is 1,5 m. When mounted on track machinery, other aerial heights can be considered if necessary.

4.6.3.2 - In terms of the radio procedure for warning transmission, unilateral information transmission from the warning transmitter to the warning receivers should be given priority.

4.6.3.3 - In the case of a return signal, the transmitter contained in the warning receiver should have HF output power of maximum 1 W.

4.6.4 - Requirements for the cables

4.6.4.1 - The requirements defined in point 4.3 for the announcement transmitter apply to the cables, with the exception of point 4.3.4.4.

4.6.4.2 - The warning receivers should be linked to the centre (output of the warning transmitter) by a cable with maximum four conductors.

4.7 - Requirements for the warning receiver with optical warning signals

4.7.1 - Principles of operation

The warning announcements are transmitted from the centre (warning transmitter) via a cable link to one or more warning receivers. Radio transmission is not provided for.

The warning receivers control the light intensity on the work site, in line with warning messages.

The warning receivers operate the continuous warning lights in line with the warning messages and switch them off when the dangerous situation ceases to exist.

4.7.2 - General requirements

The general requirements defined in point 4.6 - page 13 for the warning receiver with acoustic warning signals are applicable.

4.7.3 - Requirements for cables

4.7.3.1 - The technical requirements for cables defined in point 4.3 - page 9 for the announcement transmitter are applicable, with the exception of point 4.3.4.4 - page 11.

4.7.3.2 - The warning receivers should be linked to the centre (output of the warning transmitter) by a cable with maximum four conductors.

4.8 - Requirements for the acoustic warning signal generator

4.8.1 - General requirements

4.8.1.1 - The warning messages Wa 1, Wa 2 and Wa 3 and monitored information should be transmitted (in analog or digital form) from the warning receiver or the centre to the warning signal generator ("forward" direction).

4.8.1.2 - If necessary, monitored information should be transmitted from the warning signal generator to the announcement receiver or the centre ("return" direction).

4.8.1.3 - The warning signals should be produced electronically (spectrum generator).

4.8.2 - Acoustic requirements

4.8.2.1 - Each warning signal Wa 1 , Wa 2 and Wa 3 should consist of two different spectra A and B emitted alternatively.

4.8.2.2 - The individual tones of the frequency, spectra A and B should have the following frequencies:

Frequency spectrum A

200, 210, 400, 420, 600, 630, 1000, 1050, 1600, 1680 Hz.

Frequency spectrum B

378, 397, 756, 793, 1134, 1191, 1890, 1984, 3024, 3175, 4158, 4366 Hz.

The underlined frequencies are the reference frequencies of the warning signal. The others serve to produce a dissonance. The frequency tolerance should be 3% and the dissonance ratio should be between 1,04 and 1,05.

4.8.2.3 - The amplitude of the various individual tones should be identical wherever possible.

4.8.2.4 - The level of the warning signal measured 2 m from the warning signal generator should be 100 dB (A).

This requirement is based on an assumed maximum sound level of 97 dB (A) (machine and ambient noise); the condition for a minimum difference of 3 dB (A) between the signal and the sound level is thus met.

If higher values have to be taken into account, the relevant Railway should specify them.

4.8.2.5 - Each of the spectra A and B should be emitted alternately for 0,25 sec. This operation should be repeated until the different signals have been established.

4.8.2.6 - The switching time between A and B should be no longer than 0,1 sec.

4.8.2.7 - Signals Wa 1, Wa 2 and Wa 3 should be emitted as shown in point A.4 - page 24.

4.8.2.8 - As a general rule, the warning signals should be emitted along the track. Against this, the directional characteristics of the warning signal generators mounted on track machinery should be adapted to meet special requirements.

4.9 - Requirements for the optical warning signal generator

The work-site lighting may serve as a system's optical warning signal generator if it meets the safety conditions.

4.9.1 - General requirements

4.9.1.1 - The warning signal generators (work-site lighting) should be connected to a warning receiver. It should be possible to connect a warning receiver to the centre or to another warning receiver connected to the centre.

4.9.1.2 - The need to supply all the warning receivers from the same source should be avoided.

4.9.1.3 - The electric power needed by a warning receiver should not exceed 5 kW.

4.9.1.4 - Warnings Wa 1 and Wa 2 and monitored information should be transmitted from the centre to the warning receiver ("forward" direction). The lighting intensity of the warning signal generators should be controlled as a function of the warnings, by means of the power supply.

4.9.1.5 - If necessary, monitored information should be transmitted from the warning receiver to the centre ("return" direction).

4.9.2 - Requirements for brightness

4.9.2.1 - The work-site lighting may only be used to give an optical warning if the ambient light intensity does not exceed 10 Lux.

4.9.2.2 - The lighting should be as uniform as possible; alternating light and dark zones should be avoided.

4.9.2.3 - Signals Wa 1 and Wa 2 should be produced by a reduction in the light intensity of the work-site lighting. The reduction in intensity should be between 10 and 25% of the normal value.

4.9.2.4 - A reduction in the light intensity at a rhythm of 2 sec. signifies Wa 1 and Wa 2 at a rhythm of 0,5 sec. If different rhythms are to be used, this should be indicated by the Railways.

4.9.2.5 - After a certain period, to be specified by the Railway, the warning signal generator is switched off, while the continuous warning lights continue to provide a warning until the last rail vehicle has left the work site.

4.10 - Requirements for continuous warning lights (optical installations for continuous warning)

4.10.1 - General requirements

4.10.1.1 - The continuous warning lights should be connected to the control centre and/or the warning receivers.

4.10.1.2 - It should be possible to supply the continuous warning lights directly from the control centre or the warning receivers.

4.10.1.3 - Signals controlling the switching on and off and a monitoring signal should be transmitted from the warning receiver or the centre to the continuous warning lights ("forward" direction) or the supply voltage should be switched directly.

4.10.1.4 - If necessary, a monitoring signal should be transmitted from the continuous warning lights to the warning receiver or centre ("return" direction).

4.10.2 - Optical requirements

The light intensity and contrast should be sufficiently high for the continuous warning lights to be readily seen, even on the brightest day. It may be assumed that the lights are looked at deliberately and that they can be seen from those points of the work site where track workers are awaiting the "all clear".

5 - Documentation

In addition to the technical equipment, the manufacturer of an automatic warning system should provide the following documentation:

- operating instructions,
- technical documents: complete documentation on hardware and software for maintenance,
- proof of safety and reliability.

Appendix A - Concepts and definitions

A.1 - Concepts relating to the functions and components of the automatic track gang warning system

A.1.1 - Automatic track gang warning system

An automatic track gang warning system is intended to provide even without a lookout, a timely warning of the danger of approaching rail vehicles, which are either on the track where work is being carried out or on the adjacent track, to personnel working on or near the track.

A.1.2 - Announcement

The announcement is the identification and notification of the approach of rail vehicles.

A.1.3 - Warning

The warning is the indication of danger to a specific group of people.

Note on points 1 to 3:

Basically, every automatic track gang warning system contains an announcement section and a warning section (see point A.3 - page 23) where, depending on the embodiment (e.g. cable or radio links), certain elements may be dispensed with.

A.1.4 - Announcement installation

The announcement installation is that part of an automatic warning system dealing with all the announcement functions, i.e. from identification elements (detectors), via transmission paths (announcement transmission path, see point A.3) up to and including the identification logic (usually in the centre).

A.1.5 - Warning installation

The warning installation is that part of an automatic warning system dealing with all the warning functions after the announcement has been made; these functions go from the warning signal drive, via a transmission path (warning transmission path, see point A.3), up to and including the warning signal generator.

A.1.6 - Centre

The centre of an automatic warning system is situated at the interface between the announcement and warning sections and contains in particular train recognition, signal generation, monitoring logic, power supply and, depending on the embodiment, certain elements of the announcement and warning installations (e.g. announcement receiver and warning transmitter in the case of radio equipment). The centre should also have display facilities.

NB : The centre has variable boundaries, depending on what it contains. Usually, there is no hardware interface between the announcement and warning sections.

A.1.7 - Centre location

The centre location is the point where the centre is situated. This location is at the work site when there is no warning transmission path.

A.1.8 - Work site

The work site is any zone situated on or near the track on which endangered personnel, spread evenly or unevenly over the site, can be found.

The staff in this zone must be warned of an approaching rail vehicle.

A.1.9 - Detector (or train detector)

The detector is a device, either direction-sensitive or not, which can recognise the presence of moving rail vehicles.

A.1.10 - Detection point

The detection point is the location at which the vehicle must be detected approaching or leaving the site.

In order that staff on the work site should receive timely warning even for fast trains, the approach detector should be sufficiently far ahead of the work site. Conversely, the departure detector should be as close as possible to the work site so as not to prolong unnecessarily the warning period.

A.1.11 - Warning signal

The warning signal is a signal, noticeable to the personnel exposed to danger, emitted by a warning device (i.e. not only for the approach of a rail vehicle but also in application of the fail-safe technique in case of failures in the warning system).

A.1.12 - Failure signal

The failure signal is the warning signal, not automatically switched off , emitted in the event of failure of one of the sources of power supply, of functional groups, of components, or in the event of transmission faults as well as in particular operating conditions.

A.1.13 - Continuous warning

The continuous warning is an announcement to staff of continuing danger, i.e. when one or more rail vehicles approaching the work site are still within the operating zone of the automatic warning system.

A.1.14 - Warning signal generator

The warning signal generator is the device which produces the warning signal. It converts the warning information, e.g. into acoustic or optical signals.

A.1.15 - Continuous warning light (optical equipment for continuous warning)

The continuous warning light (e.g. revolving light) acts as optical warning signal during the whole of the continuous warning period.

A.1.16 - Warning signal point

The warning signal point is the location at which the warning signal generator is installed.

On long work sites, several such points are required.

A.1.17 - Warning zone

The warning zone is the zone within which the warning signal should be clearly perceptible. Its length is dependent on the intensity and nature of the warning signal, as well as on the topography and structure of the work site. Several warning zones are needed on long work sites.

A.1.18 - Announcement transmission path

The announcement transmission path covers the distance between the detection point and the centre location, and the equipment required for transmission of the announcement (announcement transmitter and receiver, cable or radio link).

A.1.19 - Announcement transmitter

The announcement transmitter is connected to the detectors and communicates by cable or radio with the announcement receiver or even directly with the centre. In the case of cable installations, it contains mainly matching and logical functions.

A.1.20 - Announcement receiver

The announcement receiver is situated at the centre location and communicates with the announcement transmitters. In the case of cable installations, the announcement receiver is integrated in the centre if the announcement and identification logic is concentrated there.

A.1.21 - Warning transmission path

The warning transmission path covers the distance between the centre location and the warning signal generator, and the equipment required for transmission of the warning (warning transmitter and receiver, cable or radio link).

A.1.22 - Warning transmitter

The warning transmitter is situated at the centre location. It transmits by cable or by radio the verified and processed information (announcement or fault) as warning information to the warning receivers located away from the centre.

A.1.23 - Warning receiver

The warning receiver is connected to the warning signal generator and actuates the latter after reception and analysis of the warning information.

A.2 - Concepts related to the safety and reliability of the automatic warning systems

A.2.1 - Safety of the system

A.2.1.1 - General (qualitative)

The safety of the system lies in its ability - even in the event of failures in service of the system or of its components, and on the basis of likely failures and defined rules - to emit a warning signal which, with a predetermined degree of probability, will eliminate any danger to personnel in the warning zone.

The occurrence of unforeseen failures and rules is the remaining uncertainty. This is systematically excluded.

A.2.1.2 - Statistical (quantitative)

The safety of the system is the probability that within a given period in operation under given conditions of use, no inadequate warning is given to personnel as a result of failures in service of the system or its parts. (The warning is "inadequate" if it does not materialise or if it is unclear or too late.)

The safety of the system can be indicated by a mean safety failure rate, i.e. by the ratio of the number of inadequate warnings given by an installation when a train is approaching to the total number of trains in circulation. This ratio should be calculated over a sufficiently long period of operation of the automatic warning system.

A.2.2 - Reliability of the system

A.2.2.1 - General

The reliability of the system is its ability - over a given period in operation under given conditions of use - to emit a warning signal when, and only when, a train is approaching.

A.2.2.2 - Statistical

The reliability of the system is the probability that - over a given period in operation under given conditions of use - it will emit a warning signal when, and only when, a train is approaching. Ways of statistically denoting reliability may include:

A.2.2.2.1 - *mean reliability failure rate*; this is the ratio of the number of inadequate warning signals (absent, unclear or late when a train is approaching), false alarms and fault alarms following a failure, to the total number of train runs within a sufficiently long period in operation.

A.2.2.2.2 - *mean time between failures (MTBF)*; this is the mean value obtained for the period between successive equipment, malfunctions under given conditions of operation.

A.2.3 - Proof of safety

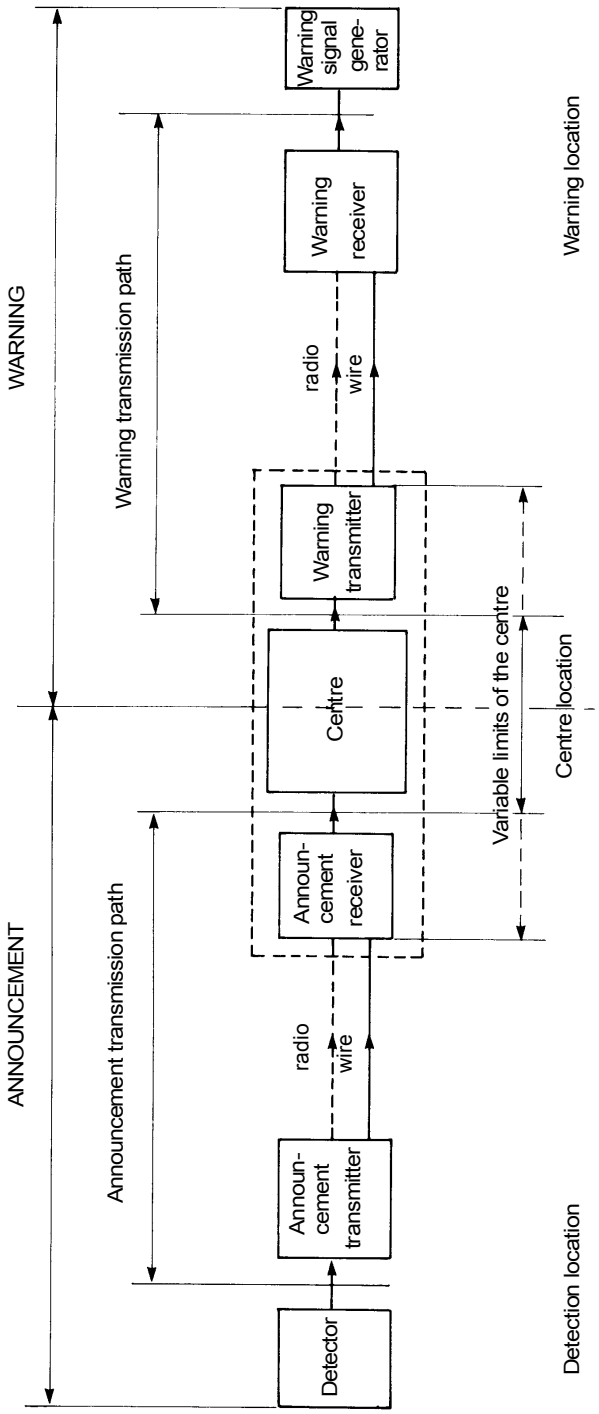
Proof of safety is a document in which the manufacturer demonstrates in a verifiable way that the technical safety requirements have been met so that the warning system can be accepted.

A.2.4 - Proof of reliability

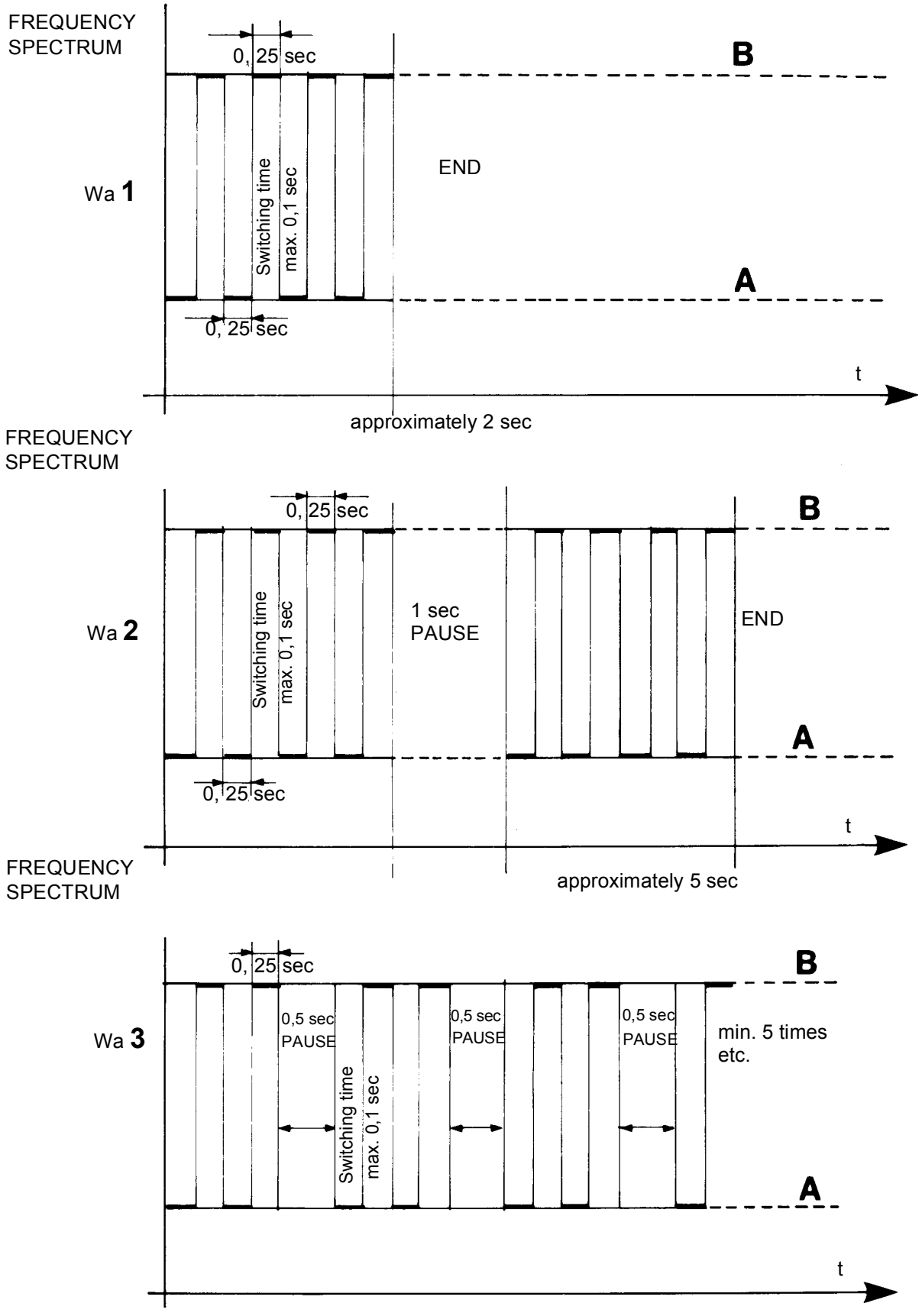
Proof of reliability is a document in which the manufacturer demonstrates in a verifiable way that the technical reliability requirements have been met so that the system can be accepted.

A.3 - Automatic track gang warning system - Block diagram

Basic system: some component parts may not be present or may be combined



A.4 - Graphical representation of the warning signal



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