Ultrasound Testing of Rail by Flaw Detection Vehicle

Specification

Rail Commissioner

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1. Introduction

As part of ensuring the safe operation of the Adelaide Metropolitan Rail Network (AMPRN), it is essential that the condition of the rails in the track can be monitored on a regular basis.

The rail, as part of the track structure, works in a harsh environment and has little redundancy, thus its failure may lead to catastrophic derailment of vehicles. Flaws or defects can arise in rail due to:

- small inclusions left within the rail during the manufacturing process
- rail damage or mishandling
- poorly executed aluminothermic or flash butt welds
- cracking initiating from a bolt hole

When subjected to train loadings the effects of fatigue and stresses induced in the rail can cause very small defects to propagate and ultimately cause the rail to break.

Ultrasound testing of rail provides a means of detecting these flaws and defects at an early stage before they have developed and enables them to be removed by cutting out the defective rail and replacing it with new. Ultrasound testing can be carried out using small handheld manual devices or on a larger scale using a purpose made rail mounted vehicle fitted with flaw detector equipment.

This document provides the requirements for ultrasound testing of rail by flaw detection vehicle on the AMPRN.

2. Purpose

This document specifies the frequency and technical requirements for the operation of rail mounted ultrasonic flaw detection vehicles on the AMPRN.

3. Scope.

This document applies to all rail mounted flaw detection operations on the AMPRN.

4. Related Documents

DOCUMENT NAME	DOCUMENT NUMBER
Rails & Rail joints - Train	CP-TS-961
Rails & Rail Joints - Tram	CP-TS-981

5. References

- *Rail Safety National Law (South Australia) Act 2012*
- AS7640 Rail Management
- AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing

6. Acronyms

ACRONYM	FULL NAME
AMPRN	Adelaide Metropolitan Passenger Rail Network

7. Definitions

TERM	DEFINITION
Ultrasound	Sound or other vibrations having an ultrasonic frequency,
Rail Mounted Vehicle	A vehicle that utilises rail wheels to travel along the track – includes road-rail vehicles.

8. General

Ultrasound rail flaw detection operates on the principal of introducing high frequency (ultrasonic) sound waves into the top or side of the rail and measuring the time period required for the sound wave to rebound from the bottom or opposite side of the rail. Any discontinuity within the rail will reflect the sound wave differently than would be expected in a normal rail since the wave did not travel through the full height or width of the rail.

The use of a continuous rail flaw detection vehicle allows the rail on the system to be fully tested on a regular basis.

9. Frequency of Testing

Rail within tracks on the AMPRN shall be tested by rail flaw detection vehicle in accordance with the frequencies shown in Table 1.

Rail Location	Frequency
Train Mainlines	6 monthly
Train Sidings	24 monthly
Tram Ballasted Sections	6 monthly
Tram In - Street Sections	Not applicable
Tram Ballasted Sidings	24 monthly
Tram Concreted Sidings	Not applicable

10. Rail Types and Sizes

The following rail types and sizes are found on the AMPRN:

Train Lines	47kg/m, 53kg/m, 50kg/m, 60kg/m, 80lb/yd.
Tram Lines	47kg/m/RI57a,82lb/yd, 50kg/m

Predominantly all tracks are continuously welded throughout, using both electric flash butt and thermite processes, although a number of tight radius curves have small sections of mechanical bolted joints.

All rail was purchased in either 12.2, 13.7 or 27.4 metre lengths.

The rail is primarily standard carbon steel with some segments of head hardened rail.

11. Service Requirements

The ultrasound rail flaw detection service shall provide the following:

1. Location of all defects, as specified, in the rail to the nearest 10 metres.

2. Provision of a report in electronic format showing locations and details of all suspect defects found in the testing.

3. Numbering and painting of the rail with oil based paint to show the limits or location of all defects. Where a defect has been identified it shall be marked with yellow paint for a length of not less than 200mm. The defect number shall also be marked.

4. Determination of the type, size and position of all defects in the rail.

5. Provision of daily reports, either by hardcopy, and/or computer disc showing locations and details of all defects found during testing.

12. Classification of Defects

12.1. Defect Classification by Type

Defect classification will be as described in CP-TS-961 *Rails & Rail joints – Train* and CP-TS-981 *Rails & Rail Joints - Tram*

12.2. Minimum Size Requirements

The minimum size for recording of defects shall be:
(a) Transverse Weld – 10mm
(b) Transverse Isolated Rail – 10mm
(c) Shatter Crack Rail – significant echo signals as compared to a 3.0mm side hole in the centre of the head as a reference test.
(d) Longitudinal – 25mm
(e) Vertical – 25mm
(f) Bolt Hole Crack – 5mm

All defects larger than the minimum shall be sized and recorded to the nearest multiple of 5mm.

13. Reports

The report provided to the Unit Manager Track & Civil Engineering or delegate shall detail all of the following:

- Defect Number
- Location (line, kilometrage)
- Rail Side
- Size of Rail
- Code of Practice defect classification
- Size of defect
- General comments if necessary

14. Unsafe Conditions

Some defects require immediate action on detection and it is essential that the Unit Manager Track & Civil Engineering or delegate are notified if this occurs.

15. Quality Assurance

15.1. Hand Sizing Competency

Prior to the commencement of each yearly test, all testing operators may be required to demonstrate hand-sizing competency by assessing flaw size, to the nearest 5mm.

Samples of rail and rail weld defects (flash butt, aluminothermic, arc and longitudinal defects) will be provided. Hand sizing will be by equipment calibrated in accordance with *AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing* and be determined using the intensity drop method.

New operators that arrive during a test may also be required to perform a hand sizing competency test to the satisfaction of the Unit Manager Track & Civil Engineering or delegate.

15.2. Quality Assurance of Track Test

The quality assurance of the test shall be assessed by the capability of the test car to detect previously marked significant defects left in the track, to the satisfaction of the Unit Manager Track & Civil Engineering or delegate. If at any stage the test is not to the satisfaction of the Unit Manager Track & Civil Engineering or delegate, the test shall stop. The test shall not resume until the detection capability of the test vehicle is to the satisfaction of the Unit Manager Track & Civil Engineering or delegate.

Any section of the track not tested to the satisfaction of the Unit Manager Track & Civil Engineering or delegate may be required to be retested (to a maximum of 5km for each specific retest).

15.3. Certification of Operators

At least one member of the team operating the Flaw Detection Vehicle shall possess tertiary qualifications in non-destructive testing. Evidence of certification shall be provided.

15.4. Vehicle Operating Detection Levels

At the start of each daily testing the vehicle's operating detection levels shall be recorded. Any variations to these levels are to be subsequently logged. The parameters to be recorded shall include:

- Pulse Count
- Sensitivity Levels
- Calibration Setting

16. Ultrasound Flaw Detection Vehicle Requirements

16.1. General

The test vehicle shall be self-propelled and have sufficient capacity to carry out all required functions.

16.2. Road–Rail Vehicle

Where the Ultrasound Flaw Detection vehicle is a road-rail vehicle it shall fully comply with *PTS-MS-10-RS-GUD-000000095 Requirements for Road Rail Vehicles Accessing and Operating on the AMPRN*

16.3. Track Machine

Where the Ultrasound Flaw Detection Vehicle is a rail mounted track machine it shall fully comply with *RS4-DOC-000885 Requirements for Track Machines Accessing and Operating on the AMPRN*

16.4. Health & Safety Regulations

The work environment of the Ultrasound Flaw Detection Vehicle must comply with all South Australian regulations relating to occupational health and safety.

16.5. Test Probe Carriage

The test carriage must be able to be manipulated to adapt to test on curve worn rail.

16.6. Water/Couplant

The Ultrasound Flaw Detection Vehicle shall carry enough water/couplant for at least eight hours on track testing.
Generally water is used during testing operations. If other couplants are used then the tenderers shall supply a Material Safety data Sheet with the tender.

16.7. Fuel

The Ultrasound Flaw Detection Vehicle shall carry enough fuel for a least one day's operation.

16.8. Seating

The Ultrasound Flaw Detection Vehicle shall have adequate cabin space for carrying one observer and one Protection Officer from DPTI in addition to the test operators.

When testing one seat must be provided for a DPTI Track & Civil Engineering representative in such a position that the representative has a clear view of the test operators instrumentation. If any audio detection system is used the representative shall be provided with identical equipment.

16.9. Location Measurement

The Ultrasound Flaw Detection Vehicle shall be equipped with an odometer that will indicate the location of detected defects to an accuracy of +/-5 meters per 1000 metres. The odometer shall have the capability of being updated every kilometre post by the driver of the vehicle.

17. Presentation

17.1. Hand Testing equipment

A scan presentation shall be used. The equipment shall be calibrated in accordance with *AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing*. Either analogue or digital equipment may be used.

17.2. Automated (vehicle) Equipment

A scan presentation shall be available for each flaw detector channel for calibration and routine operational checking. For the performance of test runs the automated system may be used individually, or in combination with the following:

- Digitised data processed into numerical size and location displays, printouts, etc.
- Digital data processed into visual (i.e. LED) and/or audible displays B Scan Charts.
- The only requirement is that the presentation shall be capable of indicating reflectors within the resolution of this specification.

17.3. Assessment of Horizontal and Vertical Linearity

Horizontal and vertical linearity shall be assessed for the test ranges used (with any distance amplitude correction switched off). Any deviation of horizontal linearity exceeding 2% over the full screen width or vertical linearity exceeding 2dB between 30% and 100% graticule height shall be known and recorded. Suppression shall not be used.

17.4. Gain Control

A gain control calibrated in steps not exceeding 2dB shall be used for measuring the ratios of ultrasonic amplitudes.

17.5. Frequency Range

The equipment shall be capable of testing at a frequency within the range of 1 MHz to 10MHz.

17.6. Probes

Either single or twin probes may be used. They should have a nominal frequency in the range 2MHz to 4MHz. The probes selected shall take into account the beam path, the rail attenuation and the beam profile. For automated testing, probes may be mounted as “skid” and/or “roller” units. Dominant frequency may be measured in accordance with *AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing*.

17.7. Overall System Gain

The overall system gain shall be assessed in accordance with *AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing* and shall be less than 20dB.

17.8. Resolution

The equipment should be capable of readily resolving adjacent reflectors with a separation along the beam axis of 2.5 wavelengths. The resolution requirements are:

NOMINAL WAVE FREQUENCY (MHZ) (MM)	COMPRESSION WAVE PROBES (MM)	SHEAR PROBES
2.0	7.4	4.1
2.5	5.9	3.3
4.0	3.7	2.0

17.9. Couplant

Generally water is used during testing operations. If other couplants are used then the Material Safety data Sheet shall be supplied prior to use.

A suitable permit to dump water/couplant at the end of a testing run is required if it is necessary to dump water/couplant prior to travelling on the road.

Water/couplant must not be dumped in the rail corridor.

17.10. Calibration Blocks

Calibration blocks as specified in *AS 2083 Calibration Blocks and their Methods of use in Ultrasound Testing* shall be used to calibrate (statically) the testing equipment.