# SECTION 13

## LOCOMOTIVES

**ROA MANUAL**

**SCHEDULE OF AMENDMENTS**

**SECTION 13**

| AMENDMENT NUMBER | PAGES AMENDED | AMENDMENT SUMMARY | DATE ISSUED |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Portions of this Section of the ROA Manual highlighted by red text are superseded by one of the following RISSB Australian Standards:

- AS 7505 Railway rolling stock - Signalling detection interface
- AS 7507 Railway rolling stock - Rolling stock outlines
- AS 7508 Railway rolling stock - Track forces and stresses
- AS 7509 Railway rolling stock - Dynamic behaviour
- AS 7514 Railway rolling stock - Wheels
- AS 7515 Railway rolling stock - Axles
- AS 7516 Railway rolling stock - Axle bearings
- AS 7517 Railway rolling stock - Wheelsets
- AS 7519 Railway rolling stock - Bogie structural requirements
- AS 7531 Railway rolling stock - Lighting and rolling stock visibility

The superseding Australian Standard is identified adjacent to the superseded portion.

## CONTENTS

**Sub Section**

# CONTENTS

## 13.1 SCOPE

13.1.1 This section specifies the minimum standards of construction and performance for diesel-electric locomotives of both standard (1435 mm) and broad (1600 mm) gauge for intersystem use on Australian rail systems.

13.1.2 These requirements are applicable to all new locomotives and to those existing units which are subject to major reconstruction and/or repowering where applicable. Mandatory requirements within sub-sections are indicated by bold Italic type. In addition to those shown in that format, sub-sections 13.2, 13.4, 13.5, 13.7, 13.8, 13.9, 13.10, 13.12 and 13.13 are mandatory in their entirety as noted at the beginning of each sub-section. In order not to restrict locomotive development, nothing in this Section precludes the use or introduction of methods, materials, components or technology which differ from those specified herein provided that the minimum standards of strength, safety, performance, facilities and compatibility are maintained or exceeded.

13.1.3 Compliance with these requirements ensures interchangeability and acceptability of locomotives for intersystem working. Some aspects of locomotive equipment, layout and construction shall be determined in conjunction with the Australian Federated Union of Locomotive Enginemen. Some essential driver related requirements specified by that organisation have been incorporated.

13.1.4 Systems shall base their specifications for new and rebuilt locomotives on this Section.

## 13.2 DESIGN PARAMETERS

**Compliance with these requirements is mandatory.**

### 13.2.1 CLIMATIC CONDITIONS

The locomotive shall be capable of operating without distress under all climatic conditions experienced on Australian railway systems.The following range of climatic conditions are given as a guide:

(a) Ambient (Shade) Temperatures
-10°C to 60°C (in the shade)

(b) Atmospheric Conditions
May be heavily laden with fine dust and/or sand
Relative humidity up to 100%

(c) Altitude
From sea level to 1370 m above sea level

### 13.2.2 LOCOMOTIVE DIMENSIONS (Co-Co)

Section 13.2.2 wheel diameter & width superseded by AS 7514.
Section 13.2.2 back-to-back superseded by AS 7517.

Maximum length over coupler pulling faces.....22,000 mm
Minimum locomotive wheel base.....13,200 mm
Minimum bogie wheel base .....3,800 mm
Minimum distance from leading wheel to coupler face.....2,000 mm
Nominal diameter of new wheel.....1,016 mm
Nominal width of wheel rim .....140 mm
Distance between backs of wheels.....s.g. 1357-1360 mm
..... b.g. 1522-1525 mm

### 13.2.3 MASSES

Section 13.2.3 superseded by AS 7508

Maximum total locomotive mass on rail.....132 tonnes
Maximum axle load. This is the absolute maximum with the locomotive in full working order with full supplies of fuel, sand, coolant, lubricants and safety equipment. .....22 tonnes

*A lower axle load is preferable providing that the locomotive performance as specified in 13.2.7 is achieved.*

Any variations in wheel load shall comply with IEC 490 for static weighings.

### 13.2.4 FORCES

Section 13.2.4 superseded by AS 7508

Maximum vertical dynamic rail force "$P_2$" ..... 250 kN

Maximum theoretical flange force..... 84 kN

Absolute maximum Cooper' static bridge loading (preference will be given to lower static bridge loading).....M210

L/V Ratio .....maximum of 0.63

## 13.2.5 TRACK LIMITING DIMENSIONS

Section 13.2.5 superseded by AS 7509

Minimum track curvature radii

| | |
|---|---|
| Uncoupled locomotive | 70 m horizontal circular curve |
| Coupled locomotive | 80 m horizontal circular curve<br>120 m reverse curve<br>300 m vertical curves<br>(both concave and convex) |
| Maximum track gradient | 1 in 30 |

## 13.2.6 TRACK FORCE FORMULAE

Section 13.2.6 superseded by AS 7508

### 13.2.6.1 Dynamic Rail Force

Dynamic rail force, $P_2$ is to be calculated by:

$$P_2 = P_o + 2\alpha V \left[\frac{M_u}{M_u + M_t}\right]^{‰} \cdot \left[1 - \frac{C_t \pi}{4\left(K_t (M_u + M_t)\right)^{‰}}\right] \cdot \left[K_t M_u\right]^{‰}$$

The symbols are:

| Symbol | Description | Units |
|---|---|---|
| $P_2$ | Dynamic Rail Force | kN |
| $P_0$ | Vehicle Static Single Wheel Load | kN |
| $M_u$ | Vehicle Unsprung Mass Per Wheel | kg |
| $2\alpha$ | Total Joint Angle | rad |
| $V$ | Speed of Vehicle | m/s |
| $K_t$ | Equivalent Track Stiffness | MN/m |
| $C_t$ | Equivalent Track Damping | kNs/m |
| $M_t$ | Equivalent Track Mass | kg |

For nominal track, $2\alpha = 0.01$

and:

| Track Class | $K_t \times 10^6$ MN/m | $C_t$ kNs/m | $M_t$ kg |
|---|---|---|---|
| 1 | 109 | 52 | 133 |
| 2 | 99 | 48 | 116 |
| 3 | 92 | 44 | 103 |

13.2.6.2 The theoretical flanging force may be calculated from :

$$FlangeForce = \mu W\ [\ \frac{1}{\cos\Theta_1} + \frac{1}{\cos\Theta_2} + \frac{a}{2b}\ ] + \frac{3KW}{2} + \frac{M}{2b}$$

where:

$\mu$ = 0.25

W = axle load

$\Theta_1$ = angle of line drawn from instantaneous centre to front flange relative to longitudinal centre line of bogie

$\Theta_2$ = as for $\Theta_1$ but to middle wheel, instantaneous centre is assumed to be at rear axle on longitudinal centre line of bogie

2b = wheel base of bogie

a = half of track gauge

K = 0.053 ( superelevation compensation)

M = rotational resistance of the bogie relative to the vehicle body

For a floating centre axle flange force is reduced by removing 1 / 2cos$\Theta_2$ in the first stage of the formula and removing the mass of the middle wheel set from 3KW/2.

An alternative acceptance criteria is:

When negotiating a 200 m radius curve with a superelevation deficiency of 75 mm the ratio of the lateral horizontal force on the rail to the vertical force shall not exceed 0.63 (L/V < 0.63) for a distance of more than 2 m. The components of the lateral forces are the wheel/rail forces ( as calculated using the Heumann techniques) to overcome rotational resistance of the bogie and the gravitational forces due to the superelevation.

**13.2.7 TRACTION REQUIREMENTS**

The traction performance requirements for the locomotive shall be specified in the following manner:

*" The locomotive shall be capable of hauling a train of a load .....tonnes and a length of .....metres over the track section between ..... and ..... under all weather conditions. The locomotive shall be able to start the train and accelerate to balance speed on the ruling grade of 1 in ... without exceeding the short time rating of the traction equipment. The locomotive shall haul the specified load over the route between .....km and .....km in a minimum time of ..... minutes, and shall be capable of completing ..... duty cycles without requiring servicing ( replenishment of fuel, oil, water, sand, etc.)"*

## 13.3 CODES AND SPECIFICATIONS

### 13.3.1 GENERAL REQUIREMENTS

The materials and parts supplied shall, unless otherwise specified, comply with the undermentioned specifications, where such are applicable, or equivalent Internationally recognised specifications and standards approved by the rail System.

### 13.3.2 FERROUS METALS

Automatic Couplers; Body and other parts ..... AAR M201-Grade E
Automatic Couplers; Knuckles and Locks ..... AAR M201-Grade E
Coupler Knuckle Pivot Pin ..... AS 1442-K1060B
Coupler Yoke ..... AAR M201-Grade E
Coupler Yoke Pin ..... AS 2506-4140T

Steel Structures ..... AS 4100
Cold-formed Steel, Structures Code ..... AS 1358
Steel Forgings ..... AS 1448
Steel Castings ..... AS 2074 Grade C4-1
SG Iron Castings ..... AS 1831
Case Hardening ..... AS 1982
Structural Steels
ordinary grades ..... AS 3678
weather resistant grades ..... AS 3679
Steel Sections - Dimensions ..... AS 1131
Steel Plate ..... AS 1227
Steel Plates, Flanging and Pressing Quality ..... AS 3678

Wheels ..... AAR M107 Class B
Axles ..... AAR M101-F
Axle Bearings ..... AAR Class GG
Wheel and Axle Assembly ..... AAR Sections G, GII

Springs ..... AS 2903

Spur and helical gears ..... AS B61
Bevel Gears ..... AS B26 Class A

Rivets ..... AS G5 and G6
High Strength Steel Bolts ..... AS 1252
The use of High Strength Bolts ..... AS 1551
Hexagonal Bolts ..... AS 1110 not less than Grade 8.8
Hexagonal Nuts ..... AS 1112
Spring Washers ..... AS 1968

Screw Threads ..... AS 1275

Pipe Threads ..... AS 1722
Pressure Pipes ..... AS 1835 and AS 1836
Steel Pipes for Threading ..... AS 1074

Stainless Steel ..... AS 1449/301

Note: All pipes and fittings shall be suitable for a working pressure of 1700 kPa.

Section 13.3.2 Wheels superseded by AS 7514.
Section 13.3.2 Axles superseded by AS 7515.
Section 13.3.2 Axle Bearings superseded by AS 7516.
Section 13.3.2 Wheel and Axle Assembly superseded bv AS 7517.

### 13.3.3 NON FERROUS METALS

SAA Aluminium Structures Code ..... AS 1664
Extruded Aluminium Sections ..... AS 1886
Aluminium Plate and Sheet ..... AS 1734
Copper Pipe ..... AS 1572 half hard (annealed
..... where bending is required)
Copper Pipe Fittings ..... BS 1306 Pt.2

### 13.3.4 WELDING

SAA Structural Steel Welding Code ..... AS 1554 Pt.1
SAA Aluminium Welding Code ..... AS 1665
Electrodes for Manual Arc Welding ..... AS 1553
Filler Rods for Welding ..... AS 1588
Spot Welding ..... BS 1440

### 13.3.5 SURFACE COATINGS

Code of Practice for Preparation and
Pretreatment of Metal Surfaces ..... AS 1627
Wood Primer ..... AS K109
Surface Undercoat ..... AS K127 type 1 (GPC-U-23)
Enamel Finishes ..... AS K126 type 1 (GPC-E-24)

### 13.3.6 GALVANISED MATERIALS

Shall be subject to the tests prescribed in AS 1650.

### 13.3.7 SEAT TRIMMING MATERIALS

AS 1440 (Transport Quality).

### 13.3.8 DRAWINGS STANDARDS (AS 1100)

Sheet size shall be in accordance with the ISO `A' Series of paper sizes as shown in AS 1100.3.

### 13.3.9 ELECTRICAL

SAA Wiring Rules ..... AS 3000
Limits of Electro Magnetic Interference for
Electrical Appliances and Equipment ..... AS 1044
Rotating Electrical Machines for use on road .....
and rail vehicles ..... AS.C2 (BS 173)
DC Control Equipment for electric traction ..... BS 2618
Classification of degrees of protection provided
by enclosures for electrical equipment ..... AS 1939
Built-in thermal detectors and associated
control units ..... AS 1023.1
Bushings for alternating voltages above 1000 V ..... AS 1265
Insulating oil for transformers and switchgear ..... AS 1767
Enamelled round copper winding wires ..... AS 1194-1
Voltage Transformers for measurement and protection ..... AS 1243
7-bit coded character set for information processing
interchange ..... AS 1776
Code extension techniques for use with the
standard 7-bit coded character set ..... AS 1953
Information and processing 7-bit and 8-bit coded
character sets - Additional control functions for
character-imaging devices ..... AS 2761
Electrical insulating materials - evaluation and
classification based on thermal endurance ..... AS 2768
Information processing - character structure for start/
stop and synchronous character-oriented transmission ..... AS 2825
Protective isolating transformers ..... AS 3167

Approval and Test Specification - Plugs, socket-outlets
and couplers for general industrial application ..... AS 3123

**13.3.9.1 International Standards**

Semiconductor rectifier equipment ..... BS 4417
Resistors for traction purposes ..... BS 4417
General requirements for a system electronic
components of assessed quality..... BS 9000
Rules for electric traction equipment..... IEC 77
Semi conductor self-commutated converters ..... IEC 146-2
Rules for rotating electrical machines for road and rail vehicles ..... IEC 349

**13.3.10 PRESSURE VESSELS**

Unfired pressure vessels ..... AS 1210

**13.3.11 NOISE AND VIBRATION**

Sound level meters ..... AS 1259
Methods for the measurement of airborne
sound from railbound vehicles ..... AS 2377
Hearing conservation ..... AS 1269
Vibration and shock - Guide to the evaluation
of human exposure to whole body in vibration ..... AS 2670

**13.3.12 GLASS**

Safety Glazing Standards - Locomotives,..... FRA Standard 49 CFR
Passenger Cars and Cabooses..... Part 223
Safety glass for land vehicles ..... AS 2080

**13.3.13 QUALITY CONTROL**

Quality Systems Guide to Selection and Use..... AS 3900/ISO 9000
Quality Systems for design/development, production,
installation and servicing..... AS 3901/ISO 9001
Quality Systems for Production and Installation ..... AS 3902/ISO 9002
Quality Systems for Final Inspection and Test ..... AS 3903/ISO 9003
Quality Systems - Guide to Quality Management and
Quality System Elements..... AS 3904/ISO 9004
Guidelines for Auditing Quality Systems:
Part 1 - Auditing ..... AS 3911
Part 2 - Qualification Criteria for Auditors
Part 3 - Managing Audit Programmes
Guide to the Preparation of Quality Manuals..... AS QS 1
Comparison of Quality Systems Standards..... AS QS 2
Guide to the Assessment and Auditing of Quality
Management Systems ..... AS QS 5
Calibration System Requirements ..... AS 2415
Sampling Procedures and Tables for Inspection
by Attributes ..... AS 1199
Guide to AS 1199..... AS 1399
Sampling Procedures and Charts for Inspection
by Variables for Percent Defects ..... AS 2490
Software Quality Management System ..... AS 3563

**13.3.14 TESTING**

Methods for magnetic particle testing of
ferromagnetic products and components ..... AS 1171
Tests for early fire hazard properties of
materials..... AS 1530 Part 3

Methods for the ultrasonic testing of fusion welded joints in steels ..... AS 2207

An accelerated laboratory test method for assessment of the susceptibility of brass to dezincification..... AS 2345

Approval and test specification for elastomer insulated electric cables and flexible cables for working voltages up to and including 0.6/1 kV ..... AS 3147

Approval and test specification for electric flexible cords ..... AS 3191

Boilers and pressure vessels - In service inspection..... AS 3788

**13.3.4.1 International Standards**

Rules for testing of rail vehicle equipped with thermal engines and electric transmissions. After completion of construction and before entry into service IEC 490

**13.3.15 DESIGN LOADS AND STRESSES**

Steel, concrete and composite bridges..... BS 5400

**13.3.16 ERGONOMICS**

Ergonomics in factory and office work ..... AS 1837

**13.3.17 FUEL, LUBRICANTS, CORROSION INHIBITORS**

Automotive diesel fuel..... AS 3570

## 13.4 ENVIRONMENTAL AND PERFORMANCE REQUIREMENTS

**Compliance with these requirements is mandatory.**

### 13.4.1 NOISE

#### 13.4.1.1 Statutory Requirements

The locomotive shall satisfy all applicable State and Commonwealth Statutory Requirements in relation to noise levels.

#### 13.4.1.2 Internal and External Noise Level Requirements

(a)Internal noise levels within the drivers' cabin shall be measured at the driver's ear level in accordance with AS 1269 Hearing Conservation Code. Internal noise levels shall not exceed the values shown in Table 13.2 under all operating conditions. Internal noise levels at infrasonic frequencies shall not exceed the 1/3 octave band limits shown in Table 13.1. Allowable levels in 1/3 octave bands between specified centre frequencies shall be determined by linear interpolation.

**TABLE 13.1**

**INFRASOUND LIMITS**

| 1/3 Octave Band Centre Frequencies | 1 Hz | 5 Hz | 10 Hz | 20 Hz |
|---|---|---|---|---|
| Sound Pressure Levels(re 2 x$10^{-5}$Pa) | 132 dB | 126 dB | 123 dB | 120 dB |

(b) External noise emanating from the locomotive shall be measured in accordance with AS 2377 Methods for the Measurement of Airborne Sound from Railborne Vehicles and shall not exceed the values shown in Table 13.2.

#### 13.4.1.3 Tonality

Both internal and external noise shall be non tonal. All measurements shall be assessed for tonality unless otherwise specified. Evaluation shall be on the basis of 1/3 octave analysis as follows:

(a) No third octave band below 160 Hz shall exceed 15 dB above either adjacent band.

(b) No third octave band in the range 160 Hz to 400 Hz shall exceed 8 dB above either adjacent band.

(c) No third octave band above 400 Hz shall exceed 5 dB above either adjacent band.

In addition, unless otherwise stated, the overall linear noise level shall not exceed the overall A - weighted noise level by more than 15 dB.

**TABLE 13.2**

**SPECIFIED NOISE LEVELS**

| Noise Levels in A-weighted Sound Pressure Levels re 2 x$10^{-5}$ Pa | | | | | |
|---|---|---|---|---|---|
| | **Operating Condition** | **Speed** | **External Location** | **External Noise Limit** | **Drivers Cab Internal Noise Limit** |
| 1 | Idle with compressor, radiator fans and air cond. operating at maximum load occurring at idle. | Stationary | 15m contour | 70 dB(A) max<br>82 dB lin.max | 70 dB(A) max |
| 2 | All other throttle settings under self load with compressor, radiator fans and air cond. operating | Stationary | 15m contour | 87 dB(A) max<br>95 dB lin.max | 75 dB(A) max |
| 3 | Brake equipment & annunciators | Stationary | - | - | 85 dB(A) max |
| 4 | Main Horn | Stationary | 200 m | 88 dB(A) min | 85 dB(A) max |
| 5 | Low Horn | Stationary | 100 m | 85 dB(A) min<br>90 dB(A) max | 85 dB(A) max |
| 6 | Idle | 0 - 50 km/h | 15 m from centreline | 80 dB(A) max | 75 dB(A) max |
| 7 | All service conditions | 0 - 80 km/h | 15 m from centreline | 85 dB(A) max | 75 dB(A) max (85 dB(A) under Cond. 4) |
| 8 | In service | N/A | N/A | N/A | 80 dB(A) Leq |

Notes: (a) All levels quoted in table 13.2 are with the doors and windows closed and air conditioning operating at full cooling load.

(b) Maximum allowable internal levels with windows open shall not exceed 5 dB(A) above the allowable levels with windows closed.

(c) 15 m contour is developed as per the 7.5 m contour in AS 2377 Appendix A.

(d) The external noise limits for Condition 2 assume a contribution of approximately 2 dB(A) from fans operating for self loading purposes.

**13.4.1.4 Noise Test Procedure**

**13.4.1.4.1 General Conditions**

External and internal noise from the locomotive shall be measured with equipment and environmental conditions as defined in AS 2377 Methods of Measurement of Airborne Sound from Railbound Vehicles for both stationary and pass by tests.

For Leq measurements a personal noise dosimeter to AS 2399 or equivalent integrating sound level meter shall be used.

**13.4.1.4.2 External Noise Measurements**

(a) Stationary measurements shall be carried out according to AS 2377 Appendix A to determine the location of the most significant noise sources on the locomotive. These measurements shall be conducted under Operating Conditions 1, 2 and 3 detailed in Table 13.2. It is sufficient to report these results in dB(A) without tonal assessment or 1/3 octave spectra provided dB (lin.) levels are also reported.

(b) Measurements shall be made on 15 m contours developed as per the 7.5 m contours of AS 2377 with microphone height of 1.5 m above rail level. The measurement points shall be perpendicular to the centre of the locomotive on both sides and at any other points on the 15 m contour corresponding to the maximum linear or A - weighted level in (a) above.

These measurements shall be conducted under Operating Conditions 1, 2, and 3 as detailed in Table 13.2. These results shall be reported in full including 1/3 octave spectra and tonal assessment.

(c) The warning horns shall be measured with the locomotive stationary in an unobstructed area with no significant reflecting objects within 50 m of the line of sight between the microphone and the locomotive. Wind speed shall not exceed 10 m/s during testing.

The horns shall maintain the levels stipulated in Table 13.2 for a 30 second continuous blast. Tonal assessment shall not be applied to horn assessments.

(d) Pass by noise shall be measured in accordance with AS 2377 Paragraph 9 with the microphone positioned 15 m from the track centreline and 1.5 m above rail level on both sides of the track. These measurements shall be made under the following conditions:

Idle at approximately 40 km/h.
Idle at approximately 80 km/h.
Full power at approximately 40 km/h.
Full dynamic brake at the speed where maximum dynamic braking is developed.
Full power at approximately 80 km/h.
Minimum reduction brake application from 30 km/h with the microphone position at approximately the mid point of the stopping distance.
Full service brake application from 30 km/h with the microphone position at approximately the mid point of the stopping distance.
The brake application tests above shall be conducted using an automatic brake application.

**13.4.1.4.3 Internal Noise Measurements**

Internal Noise measurements shall be made in accordance with AS 1269 Section 2.6.4.1 with the air conditioning operating at full cooling capacity and all doors and windows closed.

With the locomotive stationary noise and infrasound measurements shall be made under Operating Conditions 1, 2, 3, 4, and 5 as described in Table 13.2. These measurements shall include all throttle settings and representative brake equipment operations including a full service application. The horns shall be tested with the main reservoir fully charged.

The Leq measurement, Operating Condition 8, shall be based on a minimum 4 hour sample with stationary time not exceeding 20%.

**13.4.2 RIDE QUALITY**

**13.4.2.1 Ride Index Limits**

The locomotive shall be provided with a suspension system such that no dynamic instability of the locomotive body or bogies occurs at any running speed. The ride quality shall be maintained with the running gear in any

service condition.

The ride index shall not exceed the limits specified in Table 13.4.

**TABLE 13.3**

**RIDE INDEX LIMITS**

| Track Class (Note 1) | Speed (km/h) | Ride Index (Note 2) | |
|---|---|---|---|
| | | Vertical | Lateral (Note 3) |
| FRA Class 4 | 115 | 2.5 | 2.5 |
| | 130 | 2.8 | 2.8 |

Note 1: Track parameter data shall be supplied representing typical sections of track to allow consistent and repeatable modelling of locomotive ride performance.

Note 2: For transient conditions which occur during acceleration, deceleration, shunting or at crossovers vertical or lateral acceleration shall not exceed 0.3 g (2.94 m/s) in the 0 - 20 Hz band.

Note 3: Hunting tendencies are to be avoided where hunting is defined as greater than 0.5 Hz sinusoidal lateral oscillations of the wheelset resulting in lateral headstock accelerations of greater than 0.15 g sustained for longer than 2.5 seconds.

The ride index shall be calculated using the algorithm defined in Section 13.4.2.2.

**13.4.2.2 Ride Index Algorithm**

The ride index algorithm is implemented as follows:

Acceleration data is weighted by the function:

$$R_i = 7.07\,(V_i)^{0.1}$$

where the i-th value refers to the peak amplitude of a frequency component derived from an FFT analyser.

The function $V_i$ is defined as follows:

| Frequency Range (Hz) | $V_i$ (Vertical) | $V_i$ (Lateral) |
|---|---|---|
| 0 - 6 | $0.32\ fa^3$ | $4.32\ a^3$ |
| 6 - 20 | $400\ a^3/f^3$ | $650\ a^3/f^3$ |
| 20+ | $a^3/f$ | $a^3/f$ |

where f = frequency, (Hz)

a = amplitude, g peak (1 g = 9.8 $m/s^2$)

**Adopted 15/3/92**

The total ride index is calculated from the i values by:

$$RI_{total} = [\Sigma_{i=1}^{i=n} (RI_i)^{10}]^{0.1}$$

Notes:

1. Frequency analysis will utilise FFT analysis of at least 400 lines with 0.25 Hz resolution. Data shall be averaged over 32 averages to minimise statistical error. 16 averages is acceptable for comparative evaluations only.

2. Analysis shall be restricted to the 0.5 to 50 Hz band.

3. Weighting filters implementing the above weightings are acceptable provided:

   (a) integration is performed over 10-15 second periods.
   (b) the integrated values are recorded over at least 3 km of track and reported as a mean and sample variance.

4. Data for analysis shall come from samples at substantially constant speed (variance ± 5 km/h).

**13.4.2.3 Ride Quality Testing**

All ride quality testing shall be conducted with the accelerometers mounted as close as possible to the bogie centre pivot on the locomotive floor.
Locomotive ride quality testing shall be performed under the following guidelines:

(a) Accelerometers of appropriate sensitivity shall be utilised for measurement of ride parameters.

(b) The locomotive ride shall be tested at speeds up to maximum operating speed on suitable track for which track condition parameters will be established prior to testing.

(c) Analysis of the acceleration recordings shall be based on 10 second periods (minimum) over the entire test section.

### 13.4.3 VIBRATION

#### 13.4.3.1 General Requirements

The locomotive structure, all panel work, auxiliaries and other fixtures shall be designed and constructed with due regard to minimising vibration and noise emissions.

The transmission of vibration from any equipment shall be such that no damage or malfunction is caused to any structure or equipment contained in or on the locomotive.

Rotating equipment and associated driver components shall be designed so that resonances are absent in the normal operating speed range.

All locomotive body, bogie and axle mounted components shall have structural integrity and mounts which are designed to prevent amplification of component resonance.

The locomotive structure when treated as a simply supported beam shall have a beam natural frequency of vertical vibration of not less than 10 Hz.

Acceleration (rms) levels due to vibration in the range of 1 Hz to 80 Hz in the longitudinal (z) plane and the transverse (x) and (y) planes shall not exceed the 8 hour fatigue decreased proficiency boundary defined in AS 2670 "Vibration and Shock - Guide to the evaluation of human exposure to whole body vibration" at any seat in the locomotive cab.

When the locomotive is stationary with all equipment running vibration at any seat location in the locomotive cab shall not exceed the 24 hour reduced comfort boundary of AS 2670 in any axis measured on the floor.

Particular attention shall be made to ensure minimal transmission of vibration likely to cause crew discomfort as outlined in Table 13.4.

**TABLE 13.4**

**ISOLATION OF VIBRATION FOR CREW COMFORT**

| Frequency Range | Direction | Comment |
|---|---|---|
| 3 - 10 Hz | Vertical | Minimise |
| 1 - 3 Hz | Lateral | Minimise |
| 〈 0.5 Hz | Roll | Avoid |

#### 13.4.3.2 Vibration Test Procedure

Vibration is to be measured in three orthogonal axes, preferably simultaneously, using accelerometers placed between the seat and the driver/second person. Instrumentation and analysis methods are to be in accordance with AS 2670. The mass of the driver/second person under which the accelerometer is placed is not to exceed 85 kg.

Test run sample lengths shall be at least 1 hour with less than 15% of the time stationary. Sample, time, start location, total time stationary and weighted rms acceleration in each axis or vector sum shall be reported together with allowable exposure for the fatigue decreased proficiency boundary.

## 13.5 THROUGH WORKING REQUIREMENTS

**Compliance with these requirements is mandatory.**

### 13.5.1 GENERAL DESCRIPTION

The driving position and controls shall be located on the left hand side of the cab (when facing the direction of travel). Each driving position shall be fitted with a vigilance control system.

The cab shall be so equipped as to be suitable for both one and two person operation.
The cab shall be separate from the underframe and body, and resiliently mounted.
Where the locomotive is to be suitable for bi-directional operation and has a single cab, dual controls and seating shall be provided.

Where practicable for main-line locomotives, access to the driver's cab shall preferrably be via a vestibule located immediately behind the cab. The vestibule shall extend the full width of the locomotive, and the access door to the cab from the vestibule shall be on the longitudinal centre line of the locomotive and shall open into the vestibule. For wide body locomotives, side access doors to the vestibule shall be located directly opposite each other, and shall open inwards into the vestibule. For narrow body (hood type) locomotives, the vestibule access doors shall be at the rear on each side of the engine compartment and shall open outwards against the engine compartment walls.

Equipment and tool storage boxes and cab doors shall be secured with a lock which accepts the ROA-1 key.

### 13.5.2 PRINCIPAL DIMENSIONS

The locomotive shall comply with the following dimensions:

(a) Standard (1435 mm) or broad (1600 mm) gauge track
(b) Automatic coupler height 880 mm to 890 mm above rail in roadworthy condition with new wheels.
(c) Unrestricted Maximum Rollingstock Outline to Diagram 18.1.
(d) Kinematic Rollingstock Outline. This is defined as the translation of the Static Outline by 75 mm and rotation of the Static Outline by $2^{o}$ about a point 610 mm above rail level.

Clauses 13.5.2(c) & (d) superseded by AS 7507

### 13.5.3 LOCOMOTIVE EQUIPMENT

The following equipment shall be provided on each locomotive at the time of construction and maintained at all times thereafter while the locomotive is in service.

#### 13.5.3.1 Train Equipment

Brake pipe continuity tester with shoulder strap
End of train marker
Track circuit jumper cable- `clip over rail head' type
Audible Track Warning Devices (A.T.W.D. or detonators)
First aid kit and storage box with provision for a seal or lock
Flags, two red and one green
Air hoses 25 mm and 32 mm diameter (Complete with heads assembled)
Emergency towing chain and shackles

#### 13.5.3.2 Tools

Hammer
Large shifting spanner
Small shifting spanner
Pin punch
Cold chisel
Reducing bushes:32NB male/25NB female and 32NB female/25NB male

#### 13.5.3.3 Miscellaneous Equipment

Bannister brush
Dust pan
Two round wooden tapered plugs suitable for plugging pipes up to 32 mm diameter
Four wooden chocks
Four flat wooden wedges (for contactors)
Hand lamp
Twenty litre plastic water container
Drinking water container- glass, 2 litre capacity
Cleaning rags
Ticket and staff holder

#### 13.5.3.4 Equipment Storage

Shadow board and equipment to diagram 13.1
A.T.W.D. (detonator) box with facility for a lock
Tool storage box with provision for a lock: box shall be built into control stand or cab wall to eliminate protrusion into floor area.

#### 13.5.3.5 Fire Protection Equipment

Dry chemical fire extinguishers shall be provided in the cab, vestibule and engine room.

#### 13.5.3.6 Radio Facilities

Portable Radio:

Provide an approved portable radio with suitable housing and battery charging facility in an accessible location for the driver.

Train Radio:

An approved train radio system shall be provided to enable the driver to communicate with other trains and wayside locations. The microphone, holder and volume control shall be located within easy reach of the driver.

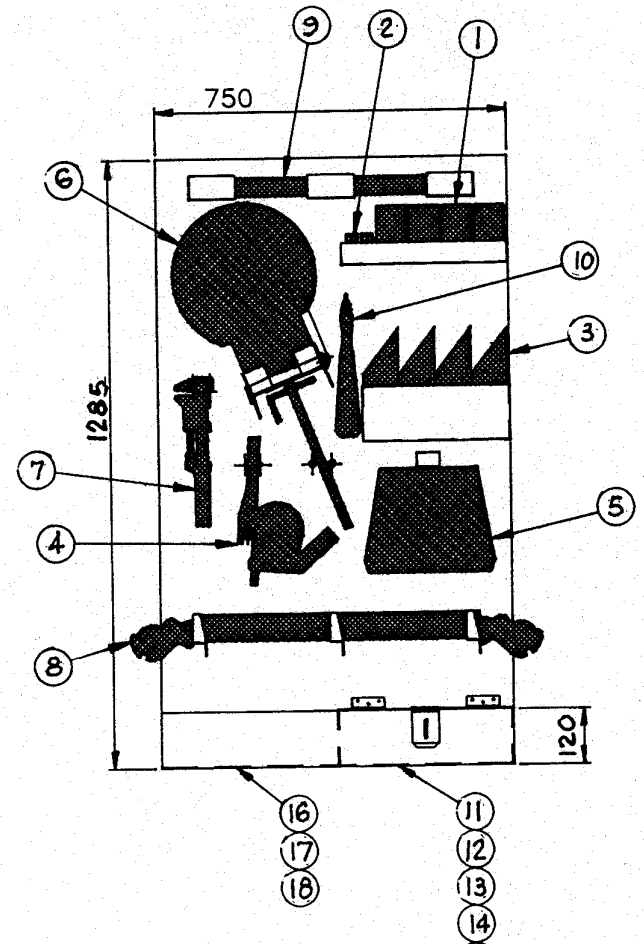
Radio frequencies shall be as agreed by ROA and the Department of Transport and Communications.

**DIAGRAM 13.1**

**SHADOW BOARD EQUIPMENT**

| ITEM | DESCRIPTION | / ASS'Y |
|---|---|---|
| 18 | ROUND WOODEN CHOCK | 2 |
| 17 | SHACKLE | 2 |
| 16 | EMERGENCY TOWING CHAIN | 1 |
| 15 | REDUCING BUSH | 1 |
| 14 | COLD CHISEL | 1 |
| 13 | PIN PUNCH | 1 |
| 12 | SMALL SHIFTING SPANNER | 1 |
| 11 | HAMMER | 1 |
| 10 | BRUSH | 1 |
| 9 | FLUORESCENT LAMP GLOBE | 2 |
| 8 | AIR HOSE | 2 |
| 7 | ADJUSTABLE WRENCH | 1 |
| 6 | W.B. LAMP | 1 |
| 5 | DUST PAN | 1 |
| 4 | CONTINUITY TESTER | 1 |
| 3 | CHOCK | 4 |
| 2 | SMALL LIGHT GLOBE | 4 |
| 1 | LARGE LIGHT GLOBE | 4 |

DIMENSIONS IN MILLIMETRES.




**Adopted 15/3/92**

## 13.5.4 CAB EQUIPMENT AND FACILITIES

### 13.5.4.1 Vigilance Control

The operation of the vigilance control system shall be in accordance with Diagram 13.2, Vigilance System Specification in Flow Chart Form.

The timing of the system between the initial responses (acknowlegements) shall be speed dependent to provide equivalent levels of safety when running at high and low speeds. The timing shall vary linearly between 90 seconds at a speed of 40 km/hr or less and 15 seconds at 120 km/hr.

Acknowledgment by the driver and/or observer shall require a deliberate and conscious arm movement which cannot be made sub-consciously. Movement which involves only the wrist and/or fingers is not acceptable.

Automatic acknowledgment shall be provided on each notch position of the throttle and by operation of the dynamic brake, air brake controls etc.

Manual acknowledgement shall be provided by a raised push-button on the control panel on both the driver's and observer's sides.

An elapsed time indicator is required, positioned on the centre line of the cab. An audible warning bell is also required. Flashing indicator lights shall be provided. White lights which are easily visible in bright daylight shall be provided on both the driver's and observer's sides. A single blue light located centrally above the windscreen shall be provided for night use. These lights shall be provided with switching for side/centre and dim/bright operation.

### 13.5.4.2 General Layout

The driving cab shall be ergonomically designed and in accordance with Diagrams 13.3 and 13.4, Standard Cab Layout and Diagrams 13.5 to 13.11, Desk Controls and Equipment. Equipment layout shall maximise the amount of leg and knee room provided in both the seated and access positions.
The location of all equipment specified hereafter shall be as shown on the above diagrams.

### 13.5.4.3 Control Equipment

The following equipment shall be provided:
Desk top control stand
Throttle
Dynamic brake
Reverser
Vigilance control
Independent and pressure maintaining automatic brake
Manual power control
Manual sand pedal

### 13.5.4.4 Instrumentation

13.5.4.4.1 The following instruments shall be provided as the minimum requirements:

Speed indicator and odometer recorder
A seperate distance counter for low speed use, switchable by the driver and indicating distance moved in 50 metre increments.
Load Ammeter
Air brake gauges (brake pipe, main reservoir, brake cylinder, equalising reservoir, etc), spring parking brake indicator
Fuel gauge
Control and lighting switches, including a master light switch.

13.5.4.4.2 Fault, alarm and status indicators shall be provided, including the following:
(Colours of the display shown in parentheses)
-Ground relay (blue)
-Wheelslip relay (white)
-Engine protection (yellow)
-Hot engine (red)
-Brake cylinder pressure warning light (red)
-Engine test warning light (green)
-Fault indicator for remote locomotives (yellow)
-Compressor low oil (red)
-Safety control light (pks)- (red)
-Manual power control (green)
-Dynamic brake (white)
-Aux. Gen-Alt. failure (blue)
-Low voltage (blue)
-Turbo. light (green)
-Pre-lube light (green)
-Sand indicator light (green)
-Hand/park brake on (red)
-Engine room light on (red small l.e.d.)
-Demister on (red, small l.e.d.)
-Headlight `ON' indicator (blue, small l.e.d., to extinguish when both sealed beam lamps have failed)
Note that with micro-processor controlled locomotives, some of the above indications may be provided on the display unit.

13.5.4.4.3 The following fault indicators shall be provided on the instrument panel of the drivers control desk, as shown on Diagram 13-6:
Brake cylinder pressure
Hand/park brake on
Wheelslip
Fault
Safety control
Dynamic brake on
Manual power on
Sanding on

13.5.4.4.4 An auxiliary indicator panel shall be provided in a readily visible position incorporating the following indicators:
Turbo lubrication pump on
Auxiliary generator/alternator failure
Engine protection
Hot engine
Ground relay
Compressor low oil

13.5.4.4.5 Fault and status indicators shall be of translucent material of the colours specified above with the name of the indicated fault permanently marked thereon, and shall be back-lit in the `On' condition. The light intensity shall be sufficient to ensure that the indicators are easily visible within the cab in bright sunlight.

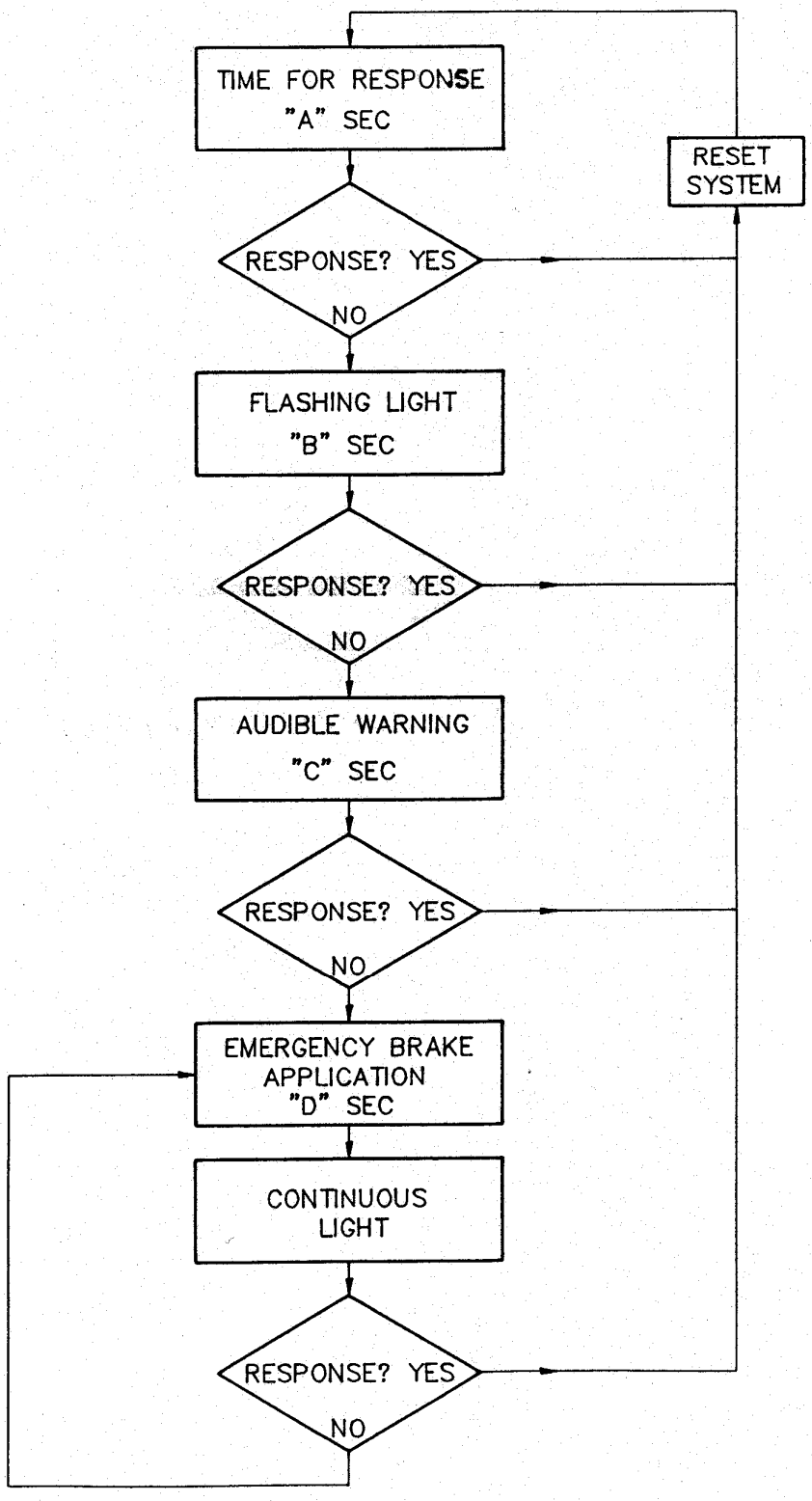
**13.5.4.5 Other Features**

In addition to the above equipment, the following equipment and facilities shall be provided:
Air conditioning (preferably reverse cycle)
Refrigerator
Ventilation- natural (direct) and via the air conditioning unit
Hot plate
Kettle
Heater
Windscreen demister
Windscreen wipers and washers
Warning horns
Rear vision mirrors
Clip for timetables and safeworking forms

Timetable light
Log book holder
Retractable clothes hooks- 3 in cab; 2 in vestibule (if applicable)
Ashtrays
Tray top for utensils, with non-slip surface
Toilet and water service- chemical or storage type
Cabinet for crew to store personal items
Fluorescent lighting
Footrests each side
Holder for Train Examiner/Reverser Keys

**DIAGRAM 13.2**

**VIGILANCE SYSTEM SPECIFICATION IN FLOW CHART FORM**

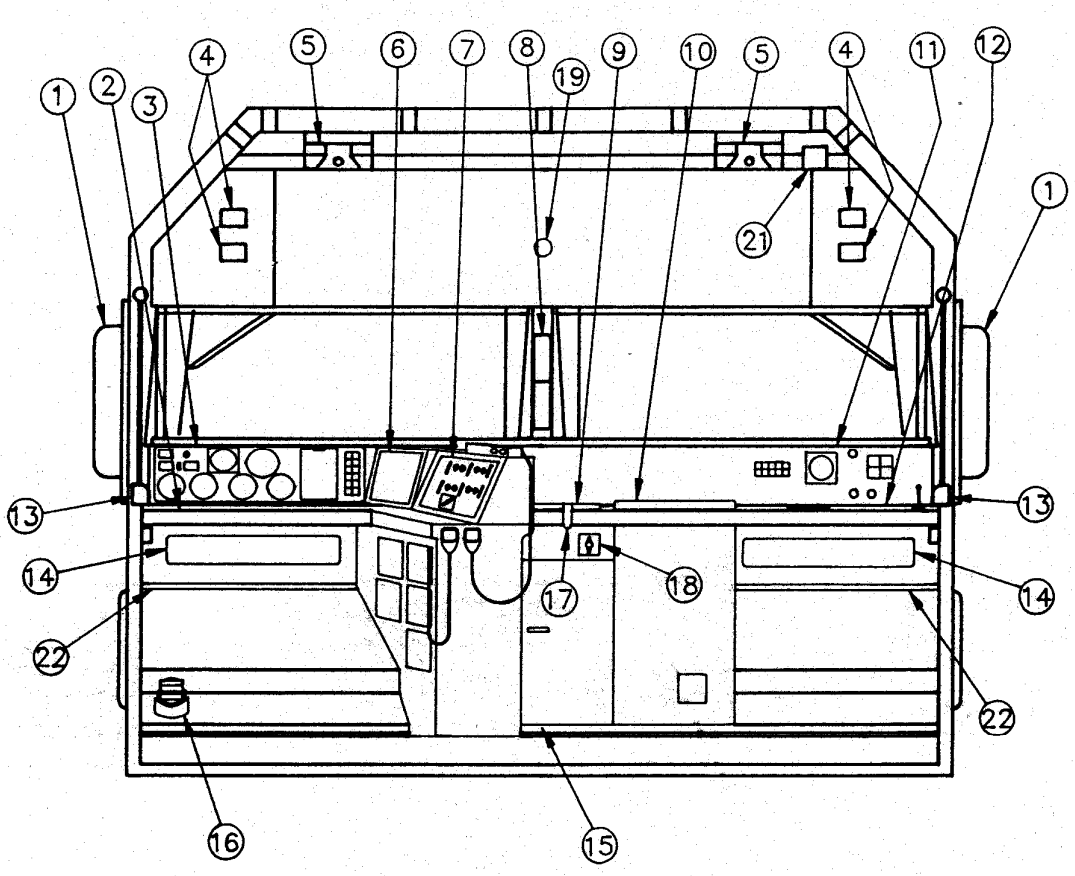



**Adopted 15/3/92**

**DIAGRAM 13-3**

**TYPICAL CAB LAYOUT**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



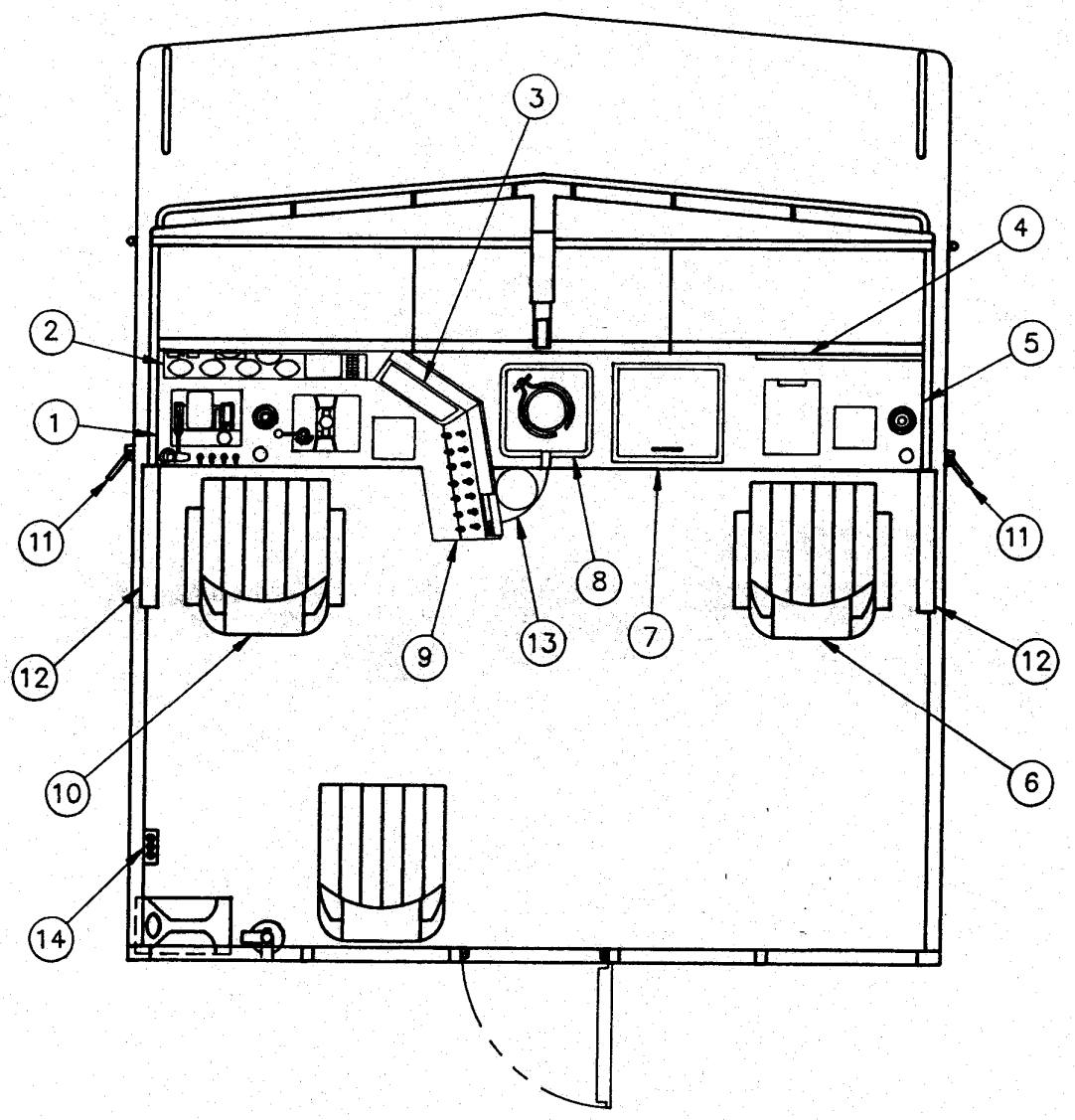

| REF. | DESCRIPTION | REF. | DESCRIPTION |
|---|---|---|---|
| 1 | REAR VISION MIRROR | 12 | OBSERVERS DESK TOP |
| 2 | DRIVERS DESK TOP | 13 | ARM REST |
| 3 | DRIVERS GAUGE PANEL | 14 | HEATER |
| 4 | RADIO SPEAKERS | 15 | EQUIPMENT LOCKER |
| 5 | CAB LIGHTS | 16 | MANUAL SANDING FOOT SWITCH |
| 6 | FUTURE EQUIPMENT LOCATION | 17 | FRY PAN HANDLE RECESS |
| 7 | SWITCH PANEL STAND | 18 | HOT PLATE ON/OFF SWITCH |
| 8 | VIGILANCE ELAPSED TIME INDICATOR | 19 | CENTRE V.C. LIGHT (BLUE) |
| 9 | HOTPLATE | 20 | . |
| 10 | FRIDGE | 21 | OBSERVERS DESK LIGHT |
| 11 | OBSERVERS GAUGE PANEL | 22 | FOOTREST BAR |

**Adopted 15/3/92**

**DIAGRAM 13-4**

**TYPICAL CAB LAYOUT**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**




| REF. | DESCRIPTION |
|---|---|
| 1 | DRIVERS DESK TOP |
| 2 | GAUGE PANEL |
| 3 | FUTURE EQUIPMENT LOCATION |
| 4 | OBSERVERS PANEL |
| 5 | OBSERVERS DESK TOP |
| 6 | OBSERVERS SEAT |
| 7 | FRIDGE |

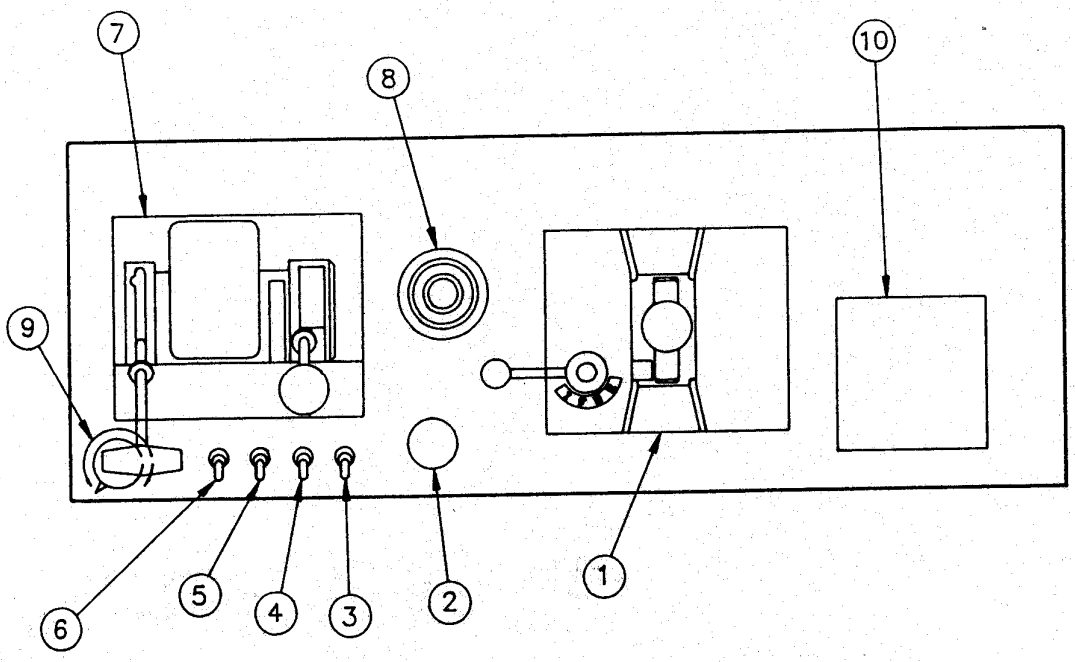
| REF. | DESCRIPTION |
|---|---|
| 8 | HOT PLATE |
| 9 | SWITCH PANEL STAND |
| 10 | DRIVERS SEAT |
| 11 | REAR VISION MIRROR |
| 12 | ARMREST |
| 13 | KETTLE RETAINING BRACKET |
| 14 | FLAGS |

**Adopted 15/3/92**

**DIAGRAM 13-5**

**DESK-TOP CONTROLS**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



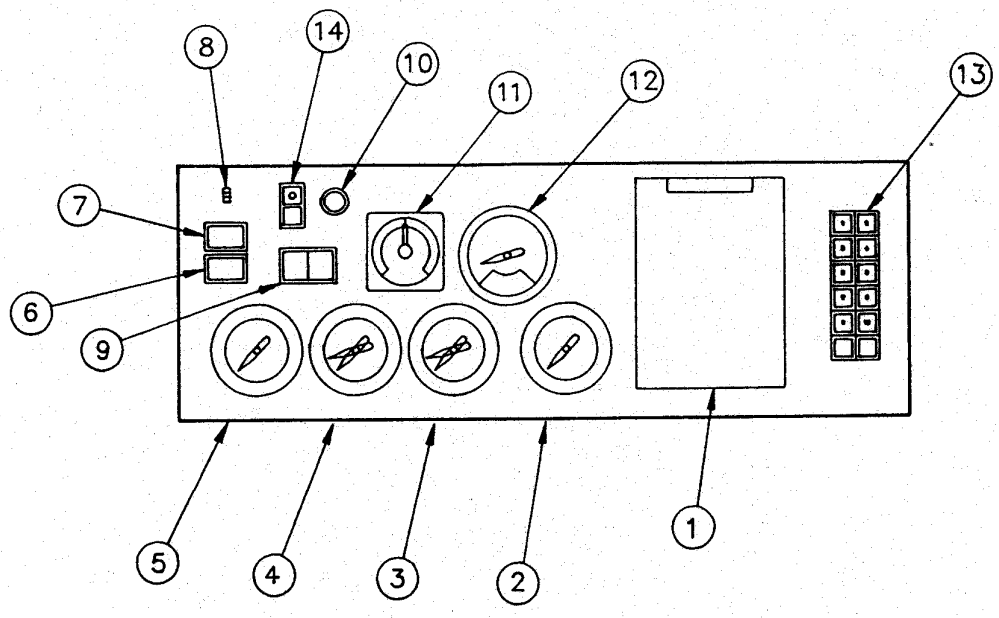

| REF. | DESCRIPTION |
|---|---|
| 1 | MASTER CONTROLLER |
| 2 | VIGILANCE CONTROL BUTTON |
| 3 | FOG LIGHT SWITCH |
| 4 | REAR HEADLIGHT SWITCH |
| 5 | FRONT HEADLIGHT |
| 6 | DIM/BRIGHT SWITCH |
| 7 | AUTOMATIC & INDEPENDANT BRAKE VALVE |
| 8 | HORN |
| 9 | MANUAL POWER CONTROL |
| 10 | FOOD & BEVERAGE AREA |
| | |

**Adopted 15/3/92**

**DIAGRAM 13-6**

**DRIVER'S GAUGE PANEL**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



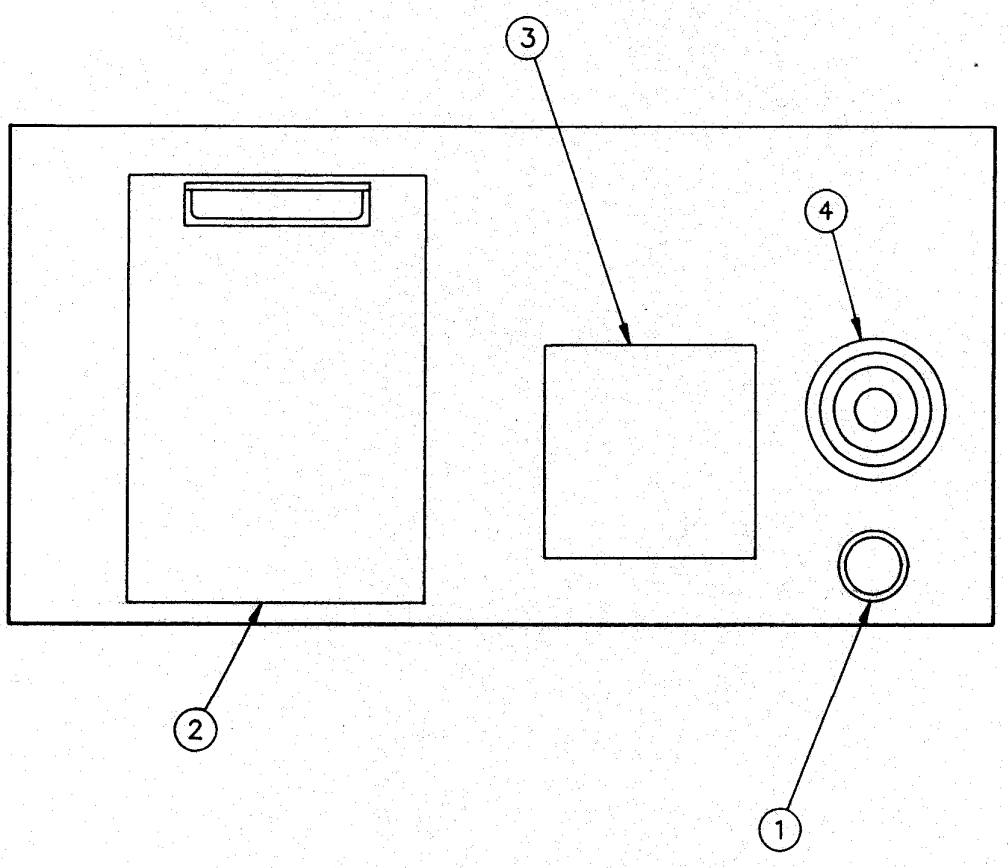

| REF. | DESCRIPTION |
|---|---|
| 1 | TIMETABLE CLIPBOARD |
| 2 | BRAKE PIPE METER |
| 3 | BRAKE CYLINDER No.1 & No.2 ENDS |
| 4 | MAIN RESERVOIR & EQUALISING RESERVOIR |
| 5 | FLOW METER |
| 6 | 50m COUNTER |
| 7 | ODOMETER |
| 8 | 50m RESET SWITCH (ON/OFF) |
| 9 | MANUAL POWER SPEEDOMETER |
| 10 | VIGILANCE CONTROL LIGHT (WHITE) |
| 11 | SPEEDOMETER |
| 12 | LOAD AMMETER |
| 13 | INDICATOR LIGHT PANEL |
| 13.1 | BRAKE CYLINDER |
| 13.2 | HAND BRAKE |
| 13.3 | WHEELSLIP LIGHT |
| 13.4 | FAULT |
| 13.5 | SAFETY CONTROL |
| 13.6 | DYNAMIC BRAKE |
| 13.7 | MANUAL POWER |
| 13.8 | SAND |
| 13.9 | SPARE |
| 13.10 | SPARE |
| 14 | DRIVERS VIGILANCE CONTROL LIGHT (ON/OFF) |

**Adopted 15/3/92**

**DIAGRAM 13-7**

**OBSERVER'S DESK TOP**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



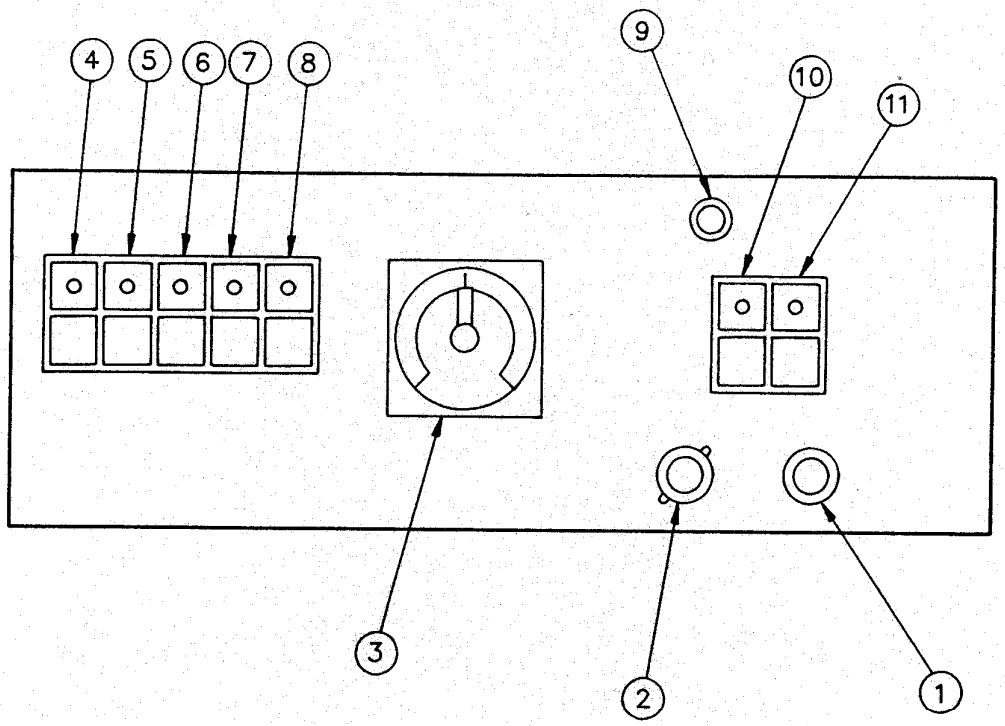

| REF. | DESCRIPTION |
|---|---|
| 1 | VIGILANCE CONTROL BUTTON |
| 2 | TIMETABLE CLIPBOARD |
| 3 | FOOD & BEVERAGE AREA |
| 4 | HORN |
| | |

**Adopted 15/3/92**

**DIAGRAM 13-8**

**OBSERVER'S GAUGE PANEL**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



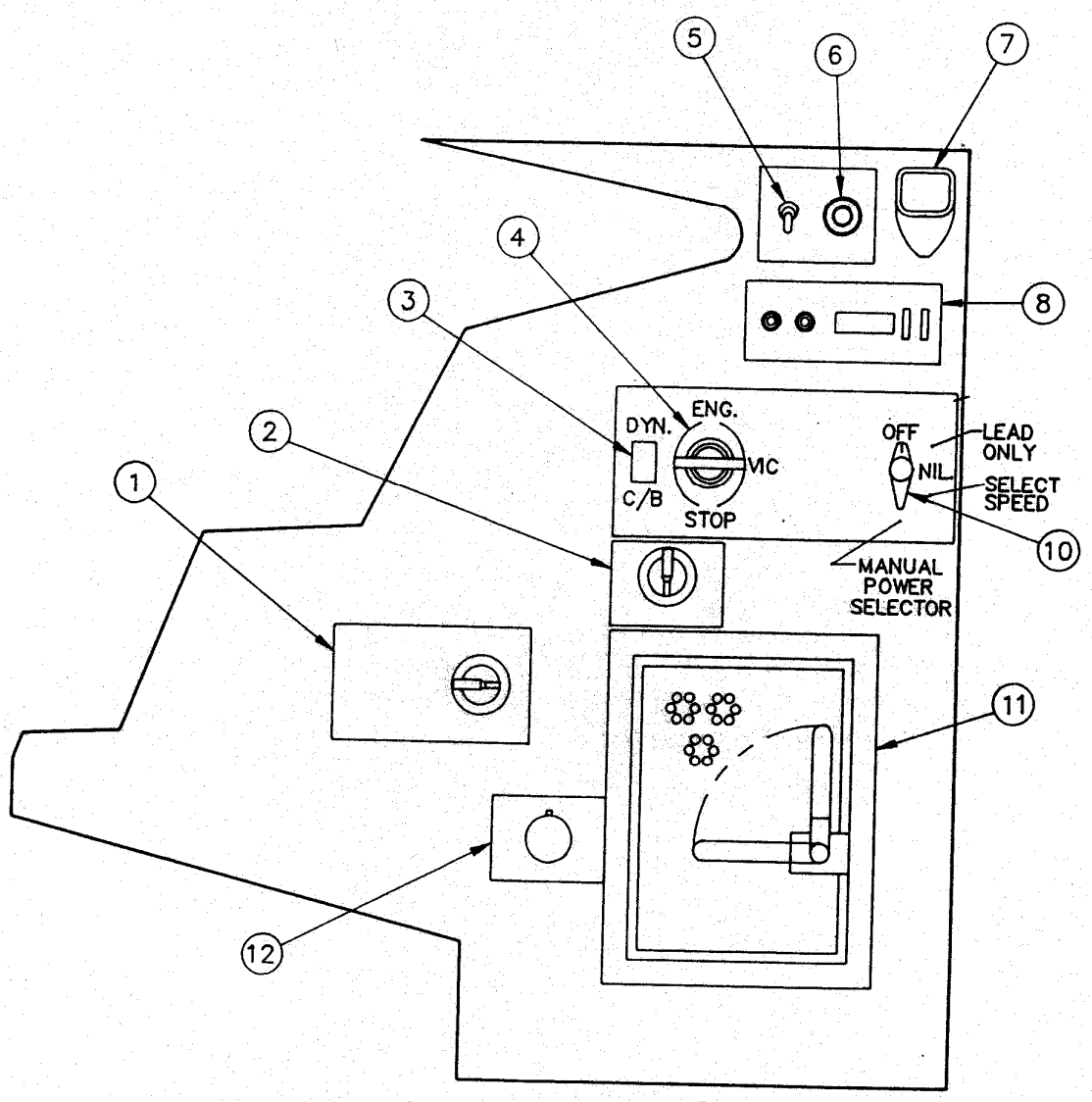

| REF. | DESCRIPTIOPN |
|---|---|
| 1 | WINDSCREEN WASHER CONTROL |
| 2 | WINDSCREEN WIPER CONTROL |
| 3 | SPEEDOMETER |
| 4 | HEATER FAN SWITCH |
| 5 | HEATER ELEMENT "A" SWITCH |
| 6 | HEATER ELEMENT "B" SWITCH |
| 7 | DESK LIGHT SWITCH |
| 8 | CAB LIGHT SWITCH |
| 9 | VIGILANCE CONTROL LIGHT (WHITE) |
| 10 | V.C. (DIM/BRIGHT) SWITCH |
| 10 | V.C. (CENTRE/SIDE) SWITCH |
| | |

**Adopted 15/3/92**

**DIAGRAM 13-9**

**CONSOLE RETURN**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**



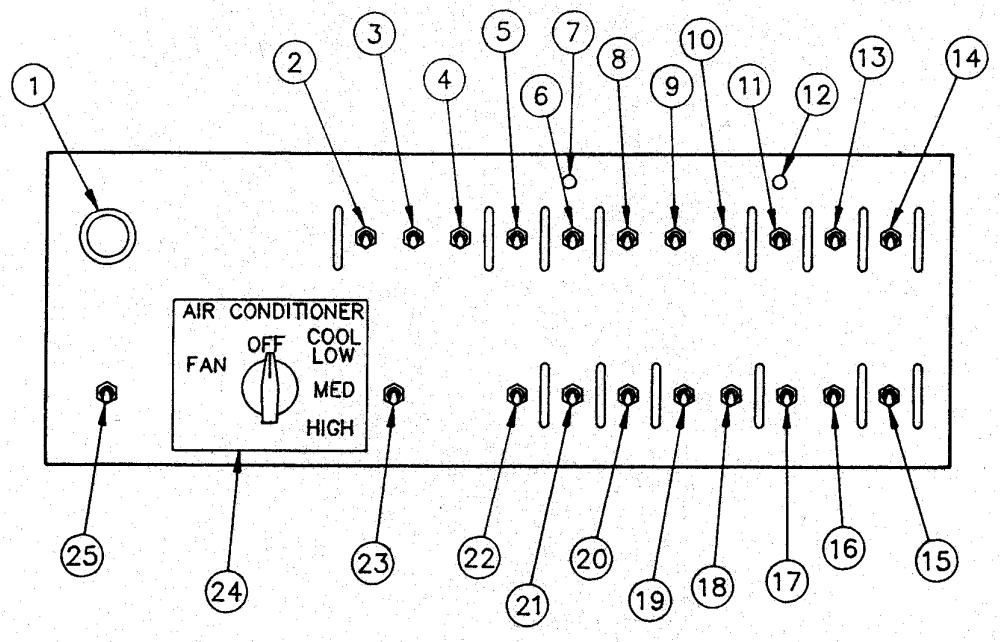

| REF. | DESCRIPTION |
|---|---|
| 1 | MULTIPLE UNIT DUAL PORTED CUT–OUT COCK |
| 2 | MAINTAINING CUT–OUT SWITCH |
| 3 | DYNAMIC BRAKE CIRCUIT BREAKER |
| 4 | ENGINE STOP |
| 5 | TIMETABLE LIGHT SWITCH |
| 6 | GROUND RELAY RESET |
| 7 | RADIO MICROPHONE |
| 8 | FUEL SAVER |
| 9 | |
| 10 | MANUAL POWER CONTROL |
| 11 | EMERGENCY BRAKE PIPE COCK |
| 12 | TRAIN EXAMINER KEY HOLDER |

**Adopted 15/3/92**

**DIAGRAM 13-10**

**SWITCH PANEL**

**TO BE FINALISED ON MOCKUP OF SRA T1 AND T2 CONTRACT**




| REF. | DESCRIPTION |
|---|---|
| 1 | INSTRUMENT PANEL LAMP DIMMER |
| 2 | ENGINE RUN |
| 3 | GENERATOR FIELD |
| 4 | CONTROL & FUEL PUMP |
| 5 | RADIO |
| 6 | WINDSCREEN DEMISTER |
| 7 | DEMISTER INDICATOR LIGHT |
| 8 | HEATER FAN |
| 9 | HEATER ELEMENT 'A' |
| 10 | HEATER ELEMENT 'B' |
| 11 | ENGINE ROOM LIGHT |
| 12 | ENGINE ROOM INDICATOR LIGHT |
| 13 | GAUGE & NUMBER LIGHTS |
| 14 | DRIVERS CAB LIGHT |
| 15 | STEPWELL LIGHT |
| 16 | REAR MARKER LIGHT–RIGHT(RED/OFF/WHITE) |
| 17 | REAR MARKER LIGHT–LEFT(RED/OFF/WHITE) |
| 18 | FRONT MARKER LIGHT–RIGHT(RED/OFF/WHITE) |
| 19 | FRONT MARKER LIGHT–LEFT(RED/OFF/WHITE) |
| 20 | SAND |
| 21 | SPARE |
| 22 | SPARE |
| 23 | AIR CONDITIONING FAN (HIGH/LOW) |
| 24 | AIR CONDITIONER (FAN/OFF/LOW/MEDIUM/HIGH) |
| 25 | LAMP TEST SWITCH |

NOTE :

1. FOR DOUBLE ENDED LOCOMOTIVES
   16=18
   17=19
   18=20
   19=SPARE
   20=SPARE

**Adopted 15/3/92**

### 13.5.5 OPERATING REQUIREMENTS

#### 13.5.5.1 Speed

The maximum service speed shall be not less than 115 km/h.

#### 13.5.5.2 Operating Range

The locomotive shall be capable of hauling the full sectional load as specified by each operating System between the following locations without requiring to take on additional fuel or sand enroute:

Sydney - Melbourne
Melbourne - Sydney
Melbourne-Adelaide
Adelaide- Melbourne
Sydney - Brisbane
Brisbane - Sydney
Lithgow-Broken Hill
Broken Hill-Lithgow
Adelaide - Broken Hill
Broken Hill - Adelaide
Adelaide - Cook
Cook - Adelaide
Cook - West Kalgoorlie
West Kalgoorlie - Cook
Tarcoola - Alice Springs
Alice Springs - Tarcoola
Forrestfield - West Kalgoorlie
West Kalgoorlie - Forrestfield

#### 13.5.5.3 Servicing Requirements

The location of the filling positions for servicing of locomotives shall be suitable for all Systems' facilities.

Fuel filler: nominal height above rail shall be 1200 mm
Sand filler: maximum height above rail shall be 2600 mm.

The fuel filler connection shall be a `dry break' system with automatic shut-off and for locomotives intended for intersystem operation it shall be compatible with an Aeroquip system with a four inch coupling. This may be achieved by the provision of suitable adaptors.

#### 13.5.5.4 Supplies

Supplies of fuel oil, lubrication oil, coolant inhibitor treatment, sand and grease lubricants shall be compatible with the supplies used by all Systems and in accordance with the equipment manufacturer's recommendations.

#### 13.5.5.5 Brake blocks

Brake blocks shall be standard high friction type to AAR Specification M 926.

### 13.5.6 MULTIPLE LOCOMOTIVE OPERATION

#### 13.5.6.1 Consist

The electrical cables in the multiple-unit control circuits through the locomotive(s) and jumper couplings shall be capable of operating over a minimum consist of six (6) locomotives.

#### 13.5.6.2 Brake System

The air-brake system shall be compatible in operation and performance with the Westinghouse 30-CDW and/or 26 L, A8-EL, B7-EL, and A7-EL brake systems.

#### 13.5.6.3 Jumper Coupling

A semi-fixed 27 pin jumper coupling shall be fitted to each side of each end of the locomotive. The coupling shall be compatible with the Pyle National Type WWRB 527 coupling. The socket shall be not more than 1750 mm above rail, and a dummy socket provided to store the coupling when not in use.

#### 13.5.6.4 Train Wire Designation and Function

The train wire pin allocation, designation and function shall be in accordance with Columns 1, 2 and 3 of Table 13.5A. Spare pin/wire numbers shall only be used by a system after consultation and agreement with all other systems; once a currently spare position has been so allocated it shall be used by all systems for that function, and shall not be used by any system for any other function.

The train wire functions allocated by the various systems as at October, 1991 are listed for reference purposes only in Table 13.5B.

#### 13.5.6.5 Piping

The air brake pipe, main reservoir pipe, control pipe and independent brake release pipe shall be bifurcated and the locations shall comply with Diagrams 13.12 and 13.13.

#### 13.5.6.6 Air Hoses

Material:
Generally to AS 2435: Elastomeric Hose for Railway Air Brakes

Internal diameters (nominal bore):
35 mm (brake)
29 mm (main reservoir)
12 mm (control)
12 mm (independent brake release)

Coupling heads:
32 mm coupling hose head (brake pipe) and cock to Diagram 7.15
25 mm coupling hose head (main reservoir)
12 mm coupling hose head (independent brake release)
19 mm coupling hose head (control)

Provision shall be made to secure hoses by the use of dummy couplers or receptacles.

13.5.6.7 **Automatic Coupler and Draft Gear**

The automatic coupler and draft gear shall comply with the requirements of Section 13.8.

## 13.5.7 ENVIRONMENTAL AND SAFETY REQUIREMENTS

Design, construction and operation of the locomotives shall comply with all applicable environmental and safety regulations, standards, and codes which are in effect in each State or Territory at the time of locomotive manufacture.

**TABLE 13-5A**

**STANDARD TRAIN WIRE DESIGNATIONS AND FUNCTIONS**

| Pin No.<br><br>Column 1 | Standard Function<br><br>Column 2 | Standard Code<br><br>Column 3 |
|---|---|---|
| 1 | Spare | |
| 2 | Alarm signal | SG |
| 3 | Engine speed | DV |
| 4 | Negative | N |
| 5 | Manual power control set-up | |
| 6 | Generator field | GF |
| 7 | Engine speed | CV |
| 8 | Forward | FO |
| 9 | Reverse | RE |
| 10 | Wheel Slip | WS |
| 11 | Manual Power Control | - |
| 12 | Engine speed | BV |
| 13 | Pos Control | PC |
| 14 | Brake cyl. pressure | BCP |
| 15 | Engine speed | AV |
| 16 | Engine run | ER |
| 17 | Dynamic brake set-up | B |
| 18 | Select-a-power | - |
| 19 | Spare | |
| 20 | Brake warning light | BW |
| 21 | Dynamic brake | BG |
| 22 | Compressor | CC |
| 23 | Sanding | SA |
| 24 | Brake control-Dynamic brake excitation | BC |
| 25 | Park Brake On | |
| 26 | Park Brake Off | |
| 27 | Spare | |

**TABLE 13-5B**

**PRACTICE OF SYSTEMS AS AT OCTOBER 1991**

(For reference purposes only)

| Pin No. | State RailAuthority of NSW | Public Transport Corporation of Vic | Australian National | Westrail |
|---|---|---|---|---|
| 1 | Spare | Spare | Spare | Spare |
| 2 | SG | SG | SG | SG |
| 3 | DV | DV | DV | DV |
| 4 | N | N | N | N |
| 5 | Manual power Control set up | TS man. power Control set up | Man. power | Manual Power |
| 6 | GF | GF | GF | GF |
| 7 | CV | CV | CV | CV |
| 8 | FO | FO | FOR No.1 | FO |
| 9 | RE | RE | REV No.1 | RE |
| 10 | WS | WS | WS | |
| 11 | Man power control | BA manual power control | Man power (variable signal) | Man power control |
| 12 | BV | BV | BV | BV |
| 13 | PC | PC | PC | PC |
| 14 | Brake cyl pressure warning | Brake cyl pressure warning | Brake cyl pressure | Brake cyl pressure warning |
| 15 | AV | AV | AV | AV |
| 16 | ER | ER | ER | ER |
| 17 | B | B | B | B |
| 18 | Spare | Select-a-power | Select-a-power | Spare |
| 19 | NN 2nd neg | Spare | Spare | Spare |
| 20 | BW | BW | Fault light | BW |
| 21 | BG | BG | BG | BG |
| 22 | CC | CC | CC | CC |
| 23 | SA | SA | SA | SA |
| 24 | BC | BC | Dyn brake (Var signal) | BC |
| 25 | Spare | Spare | Spare | Spare |
| 26 | Spare | Spare | Spare | Spare |
| 27 | Spare | Spare | Spare | Spare |

## 13.6 RELIABILITY AND AVAILABILITY

### 13.6.1 RELIABILITY

Reliability is defined as the probability that an item will perform its designed tasks, under stated conditions for a given period of time. It may be considered as the mean distance between failures (km/failure) and/or the mean distance between casualties (km/casualty) depending upon the scale on which the reliability is being measured.

#### 13.6.1.1 Reliability (Failures)

A failure is defined as an incident that occurs to a passenger or freight train, caused by equipment malfunction, whereby a substitute (or relief) locomotive is sought or the service is cancelled. Target reliability (failures) is 130,000 km between failures for the first five (5) years of service life and 100,000 km thereafter.

#### 13.6.1.2 Reliability (Casualties)

A casualty is defined as an incident that occurs to a passenger or freight train, caused by equipment malfunction, with a resultant delay to the train. The duration of the required delay is 〉 5 minutes for a passenger train and 〉 10 minutes for a freight train. Target reliability (casualties) is 40,000 km between casualties for the first five (5) years of service life and 30,000 km thereafter.

### 13.6.2 AVAILABILITY

Availability is defined as the ratio of serviceable number of days per scheduled maintenance period to the total number of days in this period.

$$Overall\ Availability = \frac{MTBM}{MTBM + MTR + MLT}$$

MTBM: Mean time between corrective maintenance
MTR : Mean time to repair
MLT : Mean lost time, made up of waiting, removal, ready time, transport, administrative reaction time etc.

Target availability is 95% for the first five (5) years of service life and 90% thereafter.

## 13.7 BODY AND UNDERFRAME

**Compliance with these requirements is mandatory.**

### 13.7.1 DESIGN LOADS AND STRESSES

#### 13.7.1.1 Stress Limits

The underframe and superstructure shall be capable of absorbing vertical and end loads without exceeding the corresponding stress limits as detailed below.

13.7.1.1.1 The critical design stresses shall be taken as either the yield stress or the critical buckling stress for the structural members involved, whichever is applicable.

13.7.1.1.2 The safeworking stress for underframe and superstructure members shall be taken as follows:

The maximum combined stress shall be taken as one half of the yield strength or critical buckling stress or one third of the ultimate strength, whichever is the greater, but shall not exceed two thirds of the yield strength of the material.

The maximum direct stress shall be taken as one half of the yield strength or one third of the ultimate strength of the material, whichever is the lesser.

For columns whose ratio of length to least radius of gyration is less than 40 the combined and direct stresses as above shall apply, but when the ratio exceeds 40 the section shall be determined by a suitable column formula.

13.7.1.1.3 The underframe and superstructure shall, when assembled on the bogies in a roadworthy condition, be parallel with the top of the rail within the following tolerances.

a) a positive camber of 1.25 mm per 1000 mm width of locomotive length

b) 4 mm per 1000 mm of locomotive width

13.7.1.1.4 The design against fatigue failure is based on a stress range ratio of

Install Equation Editor and double-click here to view equation.

The fatigue stresses shall be calculated on this basis and shall be for steel. The loading condition for steel shall be taken as "over 2,000,000 cycles". The load for fatigue purposes shall be taken as +/- 25% of the live load specified in 13.7.1.2.1. The type of member or joint shall be taken into consideration and the stress shall not exceed that permitted by AS 4100.

#### 13.7.1.2 Shock Loads

13.7.1.2.1 Unless otherwise specified, the maximum accelerations to which all equipment is likely to be subjected in service shall be taken as:

| | | |
|---|---|---|
| (a) | Longitudinally | 4 g* |
| (b) | Transversely | 2 g |
| (c) | Vertically | 2 g |

13.7.1.2.2 For axle mounted components:

| | | |
|---|---|---|
| (a) | Vertically | 20 g |
| (b) | Other directions | 4 g |

* g being the gravitational acceleration of 9.81 m/sec$^2$

Section 13.7.1.2.2 superseded by AS 7519

#### 13.7.1.3 Loading Criteria

The underframe shall be designed to withstand the following conditions, with the locomotive fully equipped.

13.7.1.3.1 A static end force of 2250 kN both tensile and compressive, applied at and acting along the centre line of the

draft gear without exceeding the safeworking stress for any member.

13.7.1.3.2 A compressive end force of 4450 kN applied at the centre line of draft gear without permanent deformation in any member of the vehicle structure.

13.7.1.3.3 The locomotive complete with bogies being lifted with one jack placed centrally near the drawgear carrier plate or from the coupler at either end of the locomotive without exceeding the critical design stress for any member with the locomotive supported on the other bogie.

13.7.1.3.4 The locomotive complete with bogies being lifted from the jacking pads and lifting brackets at the sides of the locomotive, without exceeding the safeworking stress for any member.

13.7.1.3.5 A longitudinal shock load, as specified in Clause 13.7.1.2.1 applied to any component attached to the underframe without exceeding the critical design stress for any member.

13.7.1.3.6 A vertical live load as specified in Clause 13.7.1.2.1 comprising the weight of all fully serviced components supported by the underframe, without exceeding the critical design stress on any member.

13.7.1.3.7 A vertical load of 225 kN applied to the coupler at the pulling line, both upwards and downwards, without exceeding the safe working stress for any member.

**13.7.1.4 Collision Protection**

Anti collision beams shall be provided and vertical members shall generally be in accordance with the requirements of AAR S580. These beams shall extend to the window height of the cab. The cab sheeting shall be designed to minimise the risk and extent of structural damage and injury to the train crew due to impacts from protruding loading on passing trains, equipment fouling the track, or collisions.

**13.7.2 BODY DETAILS AND FACILITIES**

**13.7.2.1 Air Conditioning**

Air conditioning shall comprise a suitable packaged unit to supply conditioned air to each operating cab. Provision shall be made for the simultaneous operation of both units under full load.

The fresh air intake shall be so positioned that the risk of drawing in exhaust fumes, radiator exhaust air and dust is minimised. The return air vent shall be located within the cab.

The air conditioning unit shall be designed such that the equipment can be readily removed from the locomotive for workshop servicing. Large access panels for maintenance or inspection of components shall be provided.

In the cab, head room clearances will be important and no impairment of normal crew functions will be allowed. The unit casing shall have sufficiently large edge radii to reduce the seriousness of accidents to the locomotive crew.

The equipment shall be electrically driven and suitable for operation from the locomotive auxiliary generator system.

The unit shall be fitted with suitable suppressors to prevent interference with locomotive radio equipment.

**13.7.2.1.1 Performance**

Unit components shall be designed and suitably sized for the maximum capacity and to meet the temperature limitations stated below. The fresh air make-up shall not be less than 10% of the total air supply.

The equipment shall be capable of continuous operation in ambient shade temperatures of $50^{o}$C. Suitable allowance shall be made, however, in the design and capacity of the plant to allow for the air temperature surrounding the equipment to be up to $60^{o}$C.

Under normal ambient conditions the cab temperature shall be maintained at 24$^{o}$C dry bulb (DB) and 19$^{o}$C wet bulb (WB). At high ambients, the temperature of the cab can vary in relation with ambient but, in any case shall not exceed the value given by the following formula:

Install Equation Editor and double-click here to view equation.

The cab air humidity shall be kept below 70% RH. A suitable condensate drain shall be provided in the side of the evaporator unit.

**13.7.2.1.2 Equipment Control**

A control panel shall be provided on the driver's control stand. The panel shall incorporate ON/OFF switches together with switches for LOW COOL, MEDIUM COOL, FULL COOL and VENT, and if applicable LOW HEAT, MEDIUM HEAT and FULL HEAT capacity control.

Provision shall be made for two (2) evaporator fan speeds and a Cooling Test function. The air velocity on exit from the diffuser at `Low' fan speed shall not exceed 1.5 m/second.

The control system shall provide for manual starting and stopping of the equipment.

A lockout device shall prevent the unit remaining in the ON position during locomotive diesel engine start up and shutdown procedure.

**13.7.2.1.3 Filtration**

The areas in which the equipment will operate are subject to strong hot winds heavily laden with fine dust. Primary air filters shall be of the self cleaning type, while return air filters shall be of the dry (washable or disposable) type or other approved design.

The filters shall be of approved manufacture, complete with metal frame and shall be easily accessible for removal replacement and inspection.

**13.7.2.2 Seating**

Seats shall be provided for the driver, the second person and an inspector.

(a) The seats shall comply with AAR S504 Clauses 3 and 4 with respect to construction and testing. No equipment in the cab shall impede access to or from the driver's and second person's seats.

(b) The driver and second person's seats shall be fitted with dual hinged arm rests (where applicable ), headrest, lumbar support, high strength base and shall be adjustable for height, cushion tilt, backrest angle (which shall not be less than 60$^{o}$) and longitudinal position. Suspension shall be by mechanical means. Nominal dimensions are as follows:

| | |
|---|---|
| Cushion Width | 450 mm |
| Backrest Height | 500 mm |
| Backrest Width | 450 mm |
| Suspension | 100 mm vertical stroke |
| Height adjustable | 400-500 mm above floor level |

The selected seats shall be subject to the approval of the National Cab Committee.

(c) An additional folding seat shall be provided for the use of trainers and inspectors. The seat shall be of similar size to the driver's seat but with a folding seat base and no arm-rests. It shall be covered with the same upholstery as that used for the driver's seat. The seat shall provide an uninterrupted view through the windscreen.

**13.7.2.3 Windows and Mirrors**

**13.7.2.3.1 Front Windscreen**

The front windscreen(s) shall comply with AS 2080 and satisfy the requirements of FRA Standard 49 CFR Part 223 with respect to impact resistance.

**13.7.2.3.2 Side Windows**

All side windows shall comply with strength requirements detailed in Clause 13.7.2.3.1 and shall be tinted, with a minimum light/heat transmission of 35% unless otherwise specified. Side windows shall be of the horizontal sliding type.

**13.7.2.3.3 Rear-of-Cab Windscreens**

All rear-of-cab windscreens shall comply with the requirements of 13.7.2.3.1.

**13.7.2.3.4 Rear Vision Mirrors**

Rear vision mirrors shall be provided on both the driver's and observer's sides. The mirrors shall be the full height of the side windows and shall have a minimum clear vision width of 90 mm. The mirrors shall be so mounted that they can be turned inwards and folded back against the body when not in use, and shall be free from the effects of vibration .

**13.7.2.4 Blinds**

Guided blinds shall be provided for each window in the locomotive cab excluding door windows. They shall be adjustable with a positive locating and latching device providing adjustments at 25 mm intervals. Material shall have a reflective silver backing.

**13.7.2.5 Steps, Handrails and Walkways**

13.7.2.5.1 Steps and handrails shall be provided for access to the locomotive from formation level and at each corner of the locomotive for shunters use.

The lowest portion of the handrails shall be no more than 1400 mm from rail level and the lowest step shall be no more than 350 mm from rail level.

13.7.2.5.2 Step spacing shall be uniform and be within the following limits: 300 mm - 500 mm
Minimum dimensional requirements for recessed step pockets are 120 mm high x 150 mm deep x 350 mm. Other steps shall have a minimum width of 350 mm for locomotives with full width carbody A step width of 600 mm may be required in narrow carbody applications. Steps shall have a non slip surface.

13.7.2.5.3 All walkways shall have a non-slip surface and flooring plates shall be sealed to prevent oil seepage.

13.7.2.5.4 Narrow body locomotives shall have guard rails extending the complete length of the walkways other than where provision is made for access. Guard rails shall be hinged or otherwise removable so as not to impede access to the engine compartment for service and maintenance purposes. Steps provided for access from ground level shall not be less than 1000 mm from the outer edge of the cab/vestibule access door when open.

13.7.2.5.5 The floor design shall be predominantly level and shall take into account ease of cleaning, maintenance and replacement.

**13.7.2.6 Lifting and Jacking**

Suitable jacking pads shall be supplied at the junction of underframe side sill and bogie centreplate transom.

**13.7.2.7 Vestibule and Cab Doors**

13.7.2.7.1 Exterior vestibule and cab doors of narrow body locomotives shall be fitted with three 100 mm heavy duty butt hinges or equivalent. The door latches shall be of the wedge-ramp type.

13.7.2.7.2 Exterior vestibule access doors of wide body locomotives shall be fitted with three 100 mm heavy duty butt hinges or equivalent. The door latches shall be of the sliding bolt type.

13.7.2.7.3 Doors between the cab and the vestibule shall be fitted with three 100 mm heavy duty butt hinges or equivalent. The door latches shall be of the wedge-ramp type. The door shall open from the cab into the vestibule in the direction of exit and shall not be obstructed or restricted by any equipment or structure.

13.7.2.7.4 The door between the vestibule and the clean air compartment shall be fitted with three 100 mm heavy duty butt hinges or equivalent. The door latch shall be of the wedge-ramp type.

13.7.2.7.5 The door between the clean air compartment and the engine room shall be fitted with three 100 mm heavy duty butt hinges or equivalent. It shall be fitted with a pneumatic type door closer with no latches.

13.7.2.7.6 For wide body locomotives with only one driving cab, the rear of the engine room shall be fitted with a door opening inwards to the engine room and fitted with wedge-ramp type door latches.

13.7.2.7.7 The driver's side external access door in each cab shall be fitted with a lock operable by the ROA1 key, and all other external doors fitted with internal pad or tower bolts.

**13.7.2.8 Toilet and Washbasin**

A retention toilet of the plain storage or chemical type shall be provided. It shall be located in a readily accessible position. A washbasin with a captive plug and piped water supply shall be provided adjacent to the toilet pedestal. A lockable receptacle for a liquid soap dispenser, towel rail and toilet paper holder shall also be provided.
The area in which the toilet is located shall be so constructed that no odours can enter the driver's cabs.

## 13.8 COUPLERS AND DRAFTGEAR

### Compliance with these requirements is mandatory.

**13.8.1 Design and Installation**

The coupler and draftgear assembly shall be installed at both ends of the locomotive and shall be designed to comply with all the draft and buff loads and track requirements of this Section without exceeding the design limits. In normal operations the installation shall not cause damage to the couplers and draftgear and shall not cause fouling or disconnection of air hoses and electrical jumper cables. The equipment shall not require overhaul for a period of at least ten (10) years.
The components and their installation shall conform to the minimum clearance and curve-negotiation requirements specified in Sections 8, 18 and 13.12.

13.8.2 **Coupler**

The automatic coupler shall be fully compatible with and capable of automatically coupling in service, without the use of adaptors, with the standard freight couplers specified in Section 9 and shown on diagram 9-1. It shall comply with the AAR specifications applicable to the coupler type, be of the swivel type with an alignment control feature, 10A contour and bottom shelf and shall incorporate a top or bottom operated uncoupling mechanism; top operation shall be used where the locomotive construction permits.

13.8.3 **Uncoupling Mechanism**

The uncoupling mechanism shall be capable of being operated from both sides of the locomotive, and shall operate without fouling any of the end-mounted equipment.

13.8.4 **Draft Gear**

The draftgear package shall be of a type specially developed or recommended for use in heavy duty freight locomotives. It shall comply with the relevant AAR specifications, and the draft gear pocket shall be dimensioned to suit the draft gear selected.

13.8.5 **Yoke, Follower and Pin**
The yoke and associated components shall be in accordance with the recommendations of the draft gear manufacturer.

13.8.6 **Coupler Height**
The height of the centreline of the coupler above rail with the locomotive in full working order and new wheels shall be 880 mm +10 mm, -0.

13.8.7 **Material**
Material for the coupler, yoke, follower and yoke pin shall be as specified for similar components in Section 9 or as recommended by the component manufacturer. Other steel castings shall conform to AAR Specification M201 Grade C, or approved equivalent.

Wear plates of 11-14% manganese steel or other approved material shall be applied to the coupler shank, coupler carrier, coupler pin retaining plate, yoke and yoke support plates.

13.8.8 The coupler carrier shall be designed to adequately support the coupler in the horizontal plane at the nominal height above the rail and shall be bolted to the headstock to facilitate easy adjustment or removal of the coupler.

## 13.9 BOGIES

**Compliance with these requirements is mandatory.**

### 13.9.1 General Requirements

Section 13.9.1 superseded by AS 7519

13.9.1.1 Bogies shall be of the Co-Co type, interchangeable within the locomotive, and be provided with steel coil spring primary and rubber secondary suspension to provide the riding qualities required by Section 13.4. Alternative configurations providing the required tractive effort, axle load, track forces and ride qualities will be considered.

13.9.1.2 The bogie shall be of robust design with the frame and bolster of cast or fabricated construction with a minimum service life of 25 years.

13.9.1.3 The bogies shall be capable of operating without major scheduled maintenance for not less than 1,500,000kms. Minimal maintenance, in addition to traction motor inspections, brake block and wheel renewal may be carried out within this period.

13.9.1.4 Bogie wheels shall have a minimum life of 400,000 km before condemning.

13.9.1.5 The bogie shall be interconnected to the mainframe to provide for lifting of the locomotive complete with bogies and to provide an anti-slewing feature in the event of a derailment.

13.9.1.6 The bogie shall be provided with lifting lugs for lifting of complete bogie assemblies.

13.9.1.7 To facilitate underfloor wheel lathe turning there shall be no infringement of the bogie frame or bogie components, other than readily removable items, within an area of 230 mm diameter about the axle centre.

13.9.1.8 Axlebox guides on the bogie frame pedestals, if utilised shall have wear plates of approved non metallic material, bolted to the pedestals and restrained at the top and bottom to prevent movement.

13.9.1.9 Axlebox wear plates, if utilised, shall be 11-14% manganese steel.

13.9.1.10 The bogie centre lining, if utilised, shall be of an approved non metallic material not requiring lubrication.

### 13.9.2 Track Forces

Section 13.9.2 superseded by AS 7508

13.9.2.1 Bogies shall be of the high adhesion type and axle to axle weight transfer under traction will be limited to 0.2 T where T is the Tractive Effort exerted at any one axle.

13.9.2.2 The vertical dynamic ($P_2$) force and the maximum flanging force or L/V ratio shall not exceed the values specified at Section 13.2.4.

13.9.2.3 The bogies when fitted to the locomotive shall accommodate a track twist over the locomotive wheel base as specified in Section 3.3.4 and the associated Table 3.1.

### 13.9.3 Traction Motors

13.9.3.1 The traction motor pinion and axle gear case shall have synthetic seals of an approved type. Seal design shall achieve minimum leakage in order to obtain the maximum service interval before top up is required. Alternative configurations shall be designed to allow maximum lubrication service intervals.

13.9.3.2 The gear case design or alternative configurations shall have large openings for easy access for topping up with lubricant and shall provide a simple and quick method of checking the quantity of lubricant.

13.9.3.3 Adequate space shall be provided for ease of connection and disconnection of traction motor cables and for servicing and inspection of the traction motors and associated components whilst the locomotive is assembled on the bogies.

13.9.3.4 Each of the traction motors shall be supported by the driving axle and by a rubber pack or equivalent flexible suspension on the bogie transom to dampen the torque shocks of the traction motor to the bogie frame. The traction motor shall be supported on the axle by roller bearings. Alternatively, the traction motors may be frame or body mounted.

13.9.3.5 All motor nose suspension securing pin lug, brake lever and connecting rod holes shall be bushed and hardened pins and bushes shall be used.

**13.9.4 Bogie Brake Equipment**

13.9.4.1 All brake equipment shall comply with Section 13.9.

13.9.4.2 The brake cylinders shall be mounted on the bogie frame, with suitable rigging to apply a braking force to each wheel. Alternatively, unit brake cylinders may be offered.
There shall be one (1) brake block per wheel.

13.9.4.3 Spring parking brake cylinders shall be fitted to each bogie and it shall be possible to manually apply and manually release the spring park brake when there is no main reservoir air supply.

13.9.4.4 Brake cylinder piston travel indicators shall be provided.

13.9.4.5 Brake rigging levers where fitted shall be a minimum thickness of 24 mm and shall be so arranged that intermediate adjustment can be made to apply the full braking force for all conditions between new wheels and new brake blocks and fully worn wheels and fully worn brake blocks.
The brake rigging shall be designed to withstand the forces resulting from a brake cylinder pressure of 620 kPa.

13.9.4.6 A proven method of automatic slack adjustment shall be provided to compensate for brake block wear.

13.9.4.7 The brake rigging shall be such that brake blocks up to 50 mm thick are easily accessible and may be removed/renewed without the need to disconnect any of the brake rigging or to place the locomotive over a pit.

13.9.4.8 The brake head key shall be in accordance with Diagram 7.10.

13.9.4.9 The brake head friction pivot arrangement, incorporating a balance spring of an approved design shall be used to align the brake block to ensure that the brake block wears evenly.

13.9.4.10 The brake block shall be of the high friction, non-metallic, non asbestos type manufactured in accordance with AAR M926.

**13.9.5 Wheels and Axles**

Sections 13.9.5.1 & 13.9.5.2 superseded by AS 7514

13.9.5.1 Wheels shall be solid, 1016 mm diameter on the tread line and shall be of hardened steel to AAR M107, Class B. The nominal details of the standard wheel are shown on diagram 13-15.

13.9.5.2 The wheel profile shall be the ANZR-1 Profile shown on diagram 13-16.

Section 13.9.5.3 superseded by AS 7517

13.9.5.3 The distance between the inner flanges of each wheel (back to back) on the same axle shall be within the range of 1357 mm to 1360 mm for standard gauge and 1522 mm to 1525 mm for broad gauge.

13.9.5.4 Provision shall be made for removal of the wheel and the axle gear by the oil injection process. Details of the oil injection hole are shown on Diagram 13.15.

Section 13.9.5.4 superseded by AS 7514

13.9.5.5 Axles shall be manufactured in accordance with AAR Specification M101 Grade F or G. Axles shall be branded and centred in accordance with Diagram 13.17.

13.9.5.6 The axle shall be designed to permit subsequent reclaiming of wheel seats and bearing seats and to eliminate abrupt changes of section which may produce localised high stress levels. A stress relief groove shall be provided between the wheel seat and the axle gear seat.

Sections 13.9.5.5 to 13.9.5.7 superseded by AS 7515

13.9.5.7 The axle shall have a minimum fatigue life in service of 25 years.

Section 13.9.5.8 superseded by AS 7517

13.9.5.8 Assembly of the wheel, axle gear and axle shall be in accordance with AAR Recommended Practices.

13.9.5.9 Axlebox bearings shall be package bearing units in accordance with AAR Class GG.

Section 13.9.5.9 superseded by AS 7516

## 13.10 BRAKE EQUIPMENT

**Compliance with these requirements is mandatory.**

### 13.10.1 PERFORMANCE

#### 3.10.1.1 Automatic and Independent Air Brake

The theoretical ratio of the total brake force at the brake blocks to the mass of the locomotive shall be:

30 to 35% for an Automatic brake application with a brake cylinder pressure of 350 kPa;

50 to 55% for an Independent brake application with a control pipe pressure of 350 kPa.

A full service application of the locomotive automatic brake shall be able to stop the locomotive on level tangent track, with dry rails, within the following maximum distances:

| From km/h | Composition Blocks (metres) | |
|---|---|---|
| 20 | 50 | |
| 40 | 150 | |
| 60 | 250 | |
| 80 | 400 | |
| 100 | 600 | |
| 120 | 800 | (extrapolated) |
| 140 | 1050 | (extrapolated) |

#### 13.10.1.2 Spring or Manual Parking Brake

A full application of the spring or manual parking brake shall be able to hold the locomotive (in full service condition) stationary on a grade of 1:30 for an indefinite period.

The spring parking brake shall be applied to the maximum number of axles as is practicable.

The status of each spring or manual parking brake shall be indicated in the cab. The status of the parking brakes shall also be train-lined as indicated in Table 13.5A so that any applied brake/s in a locomotive consist are indicated to the driver.

#### 13.10.1.3 Dynamic Brake

The locomotive shall be equipped with extended range dynamic brake. The system shall make the maximum possible use of the energy transfer capability of the traction system in order to provide the maximum braking effort from this feature. The dynamic brake shall provide a constant maximum braking effort over as wide a speed range as possible (nominally from 50 km/h to as near as possible to zero speed).

### 13.10.2 DESCRIPTION OF BRAKE EQUIPMENT

#### 13.10.2.1 General

The brake system shall consist of equipment providing for an automatic air brake system and a locomotive independent brake system.

The brake pipe pressure shall be maintained at the demanded pressure reduction whilst the train system is subject to a train brake pipe leakage of 50 kPa per minute.

The automatic brake shall be fitted with a minimum reduction feature which reduces the brake pipe pressure by 50 kPa on initial application.

Full service reduction of the automatic brake shall reduce brake pipe pressure by 150 to 175 kPa.

A separate emergency cock which is connected directly to the brake pipe shall be provided on the driver's

control stand and the exhaust piped externally.

**13.10.2.2 Spring Parking Brake**

The operation of the spring parking brake shall be in accordance with the following requirements:

(a) To apply, main reservoir air shall be released from the spring brake cylinder

(b) To release, main reservoir air shall be admitted to the spring brake cylinder

Provision shall be made for a manual quick release, together with a means of manually re-applying the brake when air pressure is not available. Following manual operation, restoration of main reservoir air pressure shall fully reset the brake for automatic operation.

**13.10.2.3 Main Reservoirs and Associated Equipment**

The combined capacity of the two main air reservoirs fitted to the locomotive shall be not less than 800 litres. A non-return valve shall be fitted between the No. 1 and No.2 reservoirs as shown on Diagram 13-18.

Both manual and automatic drain valves shall be provided on each main reservoir. The automatic drain valve function signal shall preferably be taken from the compressor unloader so that its operation is frequent. All drain pipes shall be directed toward the centre of the track.

The main reservoir air system shall be provided with suitable filtration equipment to ensure that any foreign matter or water and oil carry over into the system is kept to a practical minimum and that all pneumatic equipment will operate reliably.

Air drying equipment shall be fitted at the outlet of the No.1 main reservoir.

The main reservoirs shall be fitted with a safety valve set to discharge at 900 kPa and close at 875 kPa.

**13.10.2.4 Pipes**

13.10.2.4.1 Brake Pipe

The brake pipe shall be 32 mm NB pipe for the full length of the locomotive.

Bends and joints shall be kept to the absolute minimum.

The use of $90^{o}$ elbow fitting is prohibited in the brake pipe. The minimum bend radius of the brake pipe shall be 300 mm. Under no circumstances shall the cross section of the brake pipe be restricted at bends.

13.10.2.4.2 Main Reservoir Pipe

The main reservoir through pipe shall be 25 mm NB pipe for the length of the locomotive.
For the purposes of preventing undue main reservoir pressure loss in the event of a break away of the locomotive from the train, as indicated on Diagram 13-18 the main reservoir supply to the through pipe shall be such that:

(a) air being fed from another locomotive shall flow to the brake valve with minimal restriction

(b) air from the main reservoir on each locomotive shall flow to the through main reservoir pipe via an 8 mm choke or alternatively through a Westinghouse C1 cut-off valve or an approved equivalent

(c) Main reservoir air supplied from another locomotive shall pass through the local air drying equipment and filters before flowing to the the local auxiliaries and brake equipment.

13.10.2.4.3 Pipe work and Assembly

(a) The piping shall be arranged as shown on Diagram 13.18.

(b) Protection against flying ballast shall be provided for pipes which may be subject to damage.

(c) The exhaust from the driver's brake valves shall be piped external to the cab.

(d) All pipe joints shall be sealed with an approved jointing compound. Hemp compounds, lead compounds and synthetic sealing tape shall not be used. If an anaerobic thread sealing/locking compound is used, it shall have characteristics such that components are not damaged on disassembly. Where necessary, steel barrel unions of approved manufacture may be fitted.

(e) Where approved, nylon high pressure tubing, ozone resistant, may be used in covered areas for the piping of air control and brake equipment. Only fittings suitable for the type of tubing used shall be fitted. Flexible hose for the external connection of air brake equipment shall comply with AAR M618 or its equivalent.

**13.10.2.5 Cocks**

**13.10.2.5.1 General**

All isolating cocks shall be designed such that their handles are at right angles to the line of the pipe when closed and parallel to the line of the pipe when open and pointing in the direction of the equipment to be isolated.

Ball type cocks except end cocks shall have an approved spring loaded latching handle to prevent their accidental operation.

**13.10.2.5.2 Locomotive End Cocks**

All locomotive end cocks shall be approved ball type cocks with spring loaded or positively latching handles to prevent their accidental operation to the closed position. The brake pipe end cocks shall not be positively latched in the closed position. End cocks shall be readily accessible and adequately protected from damage in the event of collision. Handles shall be straight for the Main Reservoir Pipe and curved for the Brake Pipe.

**13.10.2.5.3 Brake Valve Cut-outs**

Isolating cocks shall be provide for the Automatic and Independent brake valves. The cock handles shall be horizontal in the open position and vertical in the closed position.
The isolating cock for the Independent brake valve shall be a dual ported cut-out cock.

**13.10.2.4 Air Pressure Gauges**

Air pressure gauges shall display the actual pressure within +/- 15 kPa.
The following air pressures shall be indicated on the driver's console.

(a) Main reservoir pressure
(b) Brake pipe pressure
(c) Equalising pressure
(d) Brake cylinder pressure - both bogies on a duplex gauge
(e) Flow meter

If the locomotive is fitted with a spring parking brake a gauge to indicate status of the spring parking brake shall be provided and shall be clearly visible to the crew.

Air pressures may be displayed by electronic means provided that analogue displays are also included in the system.

**13.10.2.5 Pressure Settings**

The standard pressure settings are:

| | |
|---|---|
| Main reservoir safety valves | 900 kPa |
| Brake pipe | 500 kpa |

Note: Brake pipe pressure shall be adjustable by hand by the driver in the range 400 kPa to 650 kPa

| | |
|---|---|
| Brake cylinder pressure: | |
| Automatic and emergency application | 350 kPa |
| Independent application (control pipe) | 350 kPa |
| Independent (brake cylinder pressure) | 560 kPa |
| Brake cylinder pressure warning light | 10 kPa cut out<br>40 kPa cut in |
| Additional settings: | |
| Vigilance suppression (b/c pressure) | 170 kPa |
| Dynamic brake interlock (b/c pressure) | 100 kPa |
| Spring parking brake release pressure not less than | 420 kPa |

All pressure governors (pressure switches) shall meet the following requirements:

| Governor | Contacts Close kPa | Contacts Open kPa |
|---|---|---|
| Compressor | 750 | 850 |
| Control(power out) | 350 | 250 |
| Parking brake 420 | 480 | |

All the above governor pressures are subject to a tolerance of ±15 kPa.

All governors shall be able to withstand a pressure of 1050 kPa.

**13.10.2.8 Timings**

13.10.2.8.1 Independent Brake

| | | |
|---|---|---|
| Application | 0-500 kPa | 2 seconds |
| Release | 300-30 kPa | 4-5 seconds |

**13.10.2.8.2 Automatic Brake**

| | | | |
|---|---|---|---|
| Full service: | | | |
| Equalising | | 500-350 kPa | 4.5-7 seconds |
| Brake cylinder | | 0-350 kPa | 8-10 seconds |
| Emergency: | | | |
| Brake cylinder | | 0-350 kPa | 8-10 seconds |
| Brake pipe | 500-30 kPa | 3-4 seconds | |
| Equal. reservoir | | 500-100 kPa then to zero | 20 seconds |
| Release: | | | |
| From full service: | | | |
| Brake cylinder | | 350- 30 kPa | 6-9 seconds |
| Equalising and brake pipe pressure | 350-30 kPa | 2 seconds | |
| From emergency: | | | |
| Brake cylinder | 350-30 kPa | 6-9 seconds | |

**13.10.2.8.3 Spring Parking Brake**

| | |
|---|---|
| Off to fully applied | 6-8 seconds |

## 13.11 PNEUMATIC EQUIPMENT (OTHER THAN AIR BRAKE EQUIPMENT)

### 13.11.1 COMPRESSOR GROUP

#### 13.11.1.1 Performance

A single air compressor shall be provided on each locomotive, capable of supplying the full air requirements for a train of up to 84 bogie wagons and two (2) kilometres in length when conveying the full train load and length under all operating conditions.

#### 13.11.1.2 Operation

The compressor shall operate on demand, ensuring that at all times the main reservoir pressure is maintained in the range of 750 kPa to 850 kPa. All compressors in a multiple unit consist shall contribute equally to the air supply. Synchronisation shall be on a `first one on -all on and last one out - all out' principle.

Lubrication - Compressor lubricant ISO 100.

The safety valve(s) shall have sufficient capacity to retain main reservoir pressure at a safe level with the compressor pumping continuously at full speed.
The compressor outlet safety valves shall be set to discharge at 1000 kPa.

### 13.11.2 PRESSURE VESSELS

The design and testing of pressure vessels shall be in accordance with the requirements of AS 1210 and AS 3788.

### 13.11.3 PNEUMATIC HORN

13.11.3.1 The warning horns shall be pneumatically operated and shall have the following minimum features:

(a) Compliance with the performance requirements of Clause 13.3.1
(b) Five chime or equivalent
(c) Bi-directional
(d) Low noise horn feature
(e) Valve operation shall be backward for the main signal and forward for the low noise facility.

13.11.3.2 The warning horns shall be resiliently mounted and the air supply connected with a flexible hose.

### 13.11.4 WINDSCREEN WIPER AND WASHER

The windscreen wiper/washer equipment shall:

(a) Be of the self parking type, electrically or pneumatically operated
(b) Cover the maximum practicable area of the windscreen
(c) Exhaust air outside the cab
(d) Have a desk mounted control with run, stop and park positions. The park position shall provide maximum visibility.
(e) Be adjustable to operate from ten to 90 strokes per minute
(f) Have the controls within easy reach of the driver
(g) Have a water storage capacity of not less than 9 litres
(h) Provision for filling the water reservoir from outside the cab
(i) Have a spray type washer jet

## 13.11.5 SANDING EQUIPMENT AND CONTROL

### 13.11.5.1 Operation

The sanding equipment shall comply with the operating range specified.

Manual operation shall be via a foot push button which is raised above the floor level and is positioned within easy foot reach from the driver's seat. Full sand operation shall be limited to low speed only or while the wheel-slip control is inoperative.

Sanding shall be available during dynamic brake operation.

### 13.11.5.2 Requirements

Sand traps shall have external access.

The sand flow rate shall be adjustable by maintenance staff.

### 13.11.5.3 Sand Removal

The locomotive shall be equipped with an effective system for removing sand from the rails immediately behind the last wheel of the trailing bogie in each direction of travel. The system shall be controlled by and operate concurrently with the sand application system.

Section 13.11.5.3 superseded by AS 7505

## 13.12 ELECTRICAL REQUIREMENTS

**Compliance with these requirements is mandatory.**

### 13.12.1 GENERAL

All terminals operating at higher than extra low voltage (not exceeding 115 volts direct current or 32 volts alternating current) shall be located outside areas where the crew have access.

The number of moving parts shall be minimised.

All major electrical functions shall be independent and able to be individually isolated.

All items of electrical equipment shall be suitably rated for the specified duty and shall be clearly identified.

Junction boxes for control cables shall be designed in such a manner as to provide for orderly termination of wires, ready identification, accessibility for fault rectification or testing and efficient sealing against entry of dust, water and oil.

The electrical power and control equipment shall be mounted on panels enclosed in pressure ventilated cubicles located in the clean air compartment. All control contacts and interlocks shall be fitted with dustproof covers and all wire terminations and connections shall be readily accessible to allow visual and physical checks to be made.

All circuits with the exception of the main traction circuits shall be protected by double pole circuit breakers; HRC fuses may be used in certain circumstances only on approval.

The circuit breakers shall be mounted on a hinged panel to allow ready access to all connections. The panel shall be arranged to allow circuit breakers to be replaced easily and quickly.

If electrical compartment doors are located in the cab they shall be designed and sealed to prevent fumes or noise entering the cab.

A self load test feature shall be provided which shall require only the setting of appropriate control switches for activation.

Earth fault protection shall be provided to protect traction and auxiliary circuits.

### 13.12.2 ELECTRICAL CABLES AND WIRING

All cables used for power, control and domestic circuits shall be fire retardant, halogen free and low in smoke, toxicity and acid evolution when subject to combustion and shall be suitably protected from possible mechanical damage.

Cables used for special purposes, eg high temperature situations, shall be submitted for approval.

Cable ducts shall be fitted with removable covers to facilitate inspection and repair. The covers shall effectively seal the ducts against the ingress of oil, water and other contaminants.

All cabling to removable hatches and hoods shall include suitable plug and socket fittings to facilitate rapid removal.

A permanent type cable marking and identification method shall be utilised on all terminations.

Negative wires from similar circuits shall be connected separately to a common link that is separately connected to the main negative in order to simplify the detection of individual earth faults.

**13.12.3 CONTROL SYSTEM**

The locomotive shall be capable of multiple unit operation with six locomotives coupled and compatible with 64-74 VDC control systems.

Proven traction equipment shall be provided, preferrably incorporating on board microprocessors for control functions, traction power regulation, adhesion management, monitoring and diagnostic display purposes.

The wheelslip/slide detection and control system shall optimise the use of the available wheel to rail adhesion.

The controls shall include a traction motor thermal protection system.

The control system shall include a means of easily isolating individual traction motors on both the positive and negative side of the motor circuit.

With traction motor(s) isolated, automatic current control shall be provided so that the maximum permissible traction motor output can be utilised without motor damage through overload.

Wheelslip/slide protection shall remain operative with traction motor(s) isolated.

The onboard monitoring system shall be capable of monitoring sufficient signals from the locomotive to provide key operational and maintenance information and fault indication functions.

The control stand/desk shall be mounted in front of the driver and shall include air brake gauges, the standard AAR load meter and the fault indicating system. The necessary control and lighting switches shall be located within easy reach of the operator.

The height of the control console shall not restrict the driver's visibility.

**13.12.4 MASTER CONTROLLER**

13.12.4.1 The master controller configuration shall provide suitable control handles for performing the following functions:

(a) Throttle - power output
(b) Dynamic brake
(c) Reverser - locomotive direction

Appropriate interlocking of the control handles shall be incorporated to ensure safe operation of the locomotive.

13.12.4.2 The controller assembly shall comply with the limiting dimensions shown on Diagram 13-11. The upper surface of the housing shall be smooth and provide comfortable operating conditions for the driver. The controller shall be designed for operation by the driver's right hand so that position indicators are readily visible under normal operating conditions.
The throttle (power) positions of the controller shall be positively located so that drivers can readily feel each notch position. In dynamic brake, the controller shall be notchless.

13.12.4.3 The controller shall be located as close as possible to the front edge of the driver's desk-top control stand, without adversely affecting leg or knee room or access to and from the driving position.

**13.12.5 MANUAL POWER CONTROL**

13.12.5.1 The locomotive shall include a manual power control system enabling the driver to reduce the power developed for a particular throttle position from maximum down to zero. The preferred method of control is by the use of the power throttle handle in conjunction with a control rheostat. Manual power control shall be train lined for multiple unit operation.

13.12.5.2 The manual power control system shall be initiated by a switch located on the hip panel of the driver's control stand. The control rheostat shall be located on the desk-top control panel as shown on Diagram 13-5.

13.12.5.3 A separate speed indicator shall be provided to indicate the speed when the manual power system is in

operation. It shall indicate the speed from 0.1 to 9.9 km/hr in increments of 0.1 km/hr, and shall be located on the instrument panel as shown on Diagram 13-6.

### 13.12.6 DYNAMIC BRAKE SYSTEM

Dynamic braking resistors, blowers and the necessary controls shall be provided.

Suitable interlocking shall be provided which shall prevent the operation of the locomotive brakes while the automatic air brake on the locomotive is in use and the dynamic brake is engaged. Sufficient time delay shall be provided following exit from dynamic braking to ensure that the locomotive air brakes cannot be applied while residual dynamic braking is present, except when the air brake is operated in emergency.

Provision shall be made for isolation of the dynamic brake feature without isolating the automatic air brake.
The maximum dynamic brake capacity shall be available through the full extended range dynamic brake speed range.
The power to dynamic brake switching procedure shall incorporate a time delay of ten (10) seconds.

The dynamic brake resistors shall be force-ventilated.

### 13.12.7 TRACTION MOTORS

The traction motors shall be suitably geared to give the required tractive effort at the speeds and loads specified. They shall be of robust and proven design with high reliability. The traction motors shall be efficiently cooled with filtered air, with air outlet openings fitted with meshing and located such that ingress of water and other contaminants is precluded.

### 13.12.8 BATTERY AND BATTERY BOX

A main battery switch shall be provided to isolate the electrical equipment from the battery.

The locomotive shall be provided with facilities to enable it to be started from an external source. A battery charging receptacle shall be provided on both sides of the locomotive.

Battery compartments shall be force-ventilated and corrosion resistant to battery electrolyte and water. Working space shall be provided to allow batteries to be serviced, etc.

The storage battery(s) shall be readily accessible and easily installed or removed with existing facilities. Batteries shall preferably be fitted in roll out trays which can be moved in and out by one person and be self supporting when fully extended. External access to the batteries shall be provided to permit removal by forklift.

### 13.12.9 LIGHTING

Section 13.12.9 superseded by AS 7531

#### 13.12.9.1 Headlights

Headlights, comprising two 350 watt sealed beam units, equipped with a dim feature, shall be provided at each end of the locomotive. Each lamp of the twin sealed beam light shall be supplied from a completely separate circuit and shall not use common components except the headlight circuit breaker and control switches. The headlights shall be capable of illuminating a person at least 240 m ahead and in front of the headlights. In the dim position the headlights shall not impair the vision of the crews of oncoming trains.

#### 13.12.9.2 Interior Lights

13.12.9.2.1 Interior cab lights shall be of a fluorescent type and shall remain operational with the locomotive engine not running and the battery switch closed. Lighting shall provide a minimum level of 100 Lux at the driver's control desk-top, and shall illuminate all controls without reflection. Lighting shall be provided to allow both driver and guard/observer to read printed matter. Recessed lights shall be provided at floor level to illuminate the entrance doorways to the locomotive. Provision shall be made for additional lighting, if necessary, for performing maintenance and inspection tasks. Wherever possible, interior cab lighting fittings shall be located

on the horizontal or near-horizontal surfaces of the cab ceiling.

13.12.9.2.2 Lights for the entrance vestibule shall be controlled by parallel switches, one switch located in the cab adjacent to the cab-vestibule door and one switch located adjacent to each external access door.

13.12.9.2.3 Engine room lights shall be controlled by parallel switches, one on each driver's control stand and one located immediately adjacent to the rear engine room door of wide body locomotives with only one cab. A light shall be provided on each control stand immediately above the light switch to indicate when the engine room light is on.

13.12.9.2.4 Toilet compartment lights shall be controlled by a light switch depending on the toilet location. If the toilet is located in or accessed from the vestibule the lights shall be controlled from the vestibule light switch. If the toilet is located in the engine compartment the lights shall be comtrolled from the engine room light switch.

**13.12.9.3 Instrument Lights**

All gauges and switches shall be illuminated using back lighting. Switches shall be identified by translucent plates with the function permanently marked thereon in black.

Gauges shall be fitted with anti-glare face glass.
All gauges shall be so positioned that there is no reflection of gauge illumination onto the windscreen.
All gauges and number lights shall be controlled by the one switch.
A dimmer control shall be provided for a range of illumination levels from zero to full brilliance.
Provision shall be made for the brake cylinder pressure light to be automatically reduced to the dim position when the gauge lights are switched on.

**13.12.9.4 Marker and Number Lights**

Marker lights shall be provided at each end incorporating separate red and white lenses which shall be switchable from the cab. Three (3) position switches mounted on the driver's control stand shall be used for the switching of marker lights and shall illuminate only those marker lights required for the direction of travel. The switch positions shall be centre for "Off", up for "Red" and down for "White".

Number boxes shall be internally illuminated.

**13.12.9.5 Coupler Lights**

Protected coupler lights shall be provided to illuminate the front of the locomotive in the vicinity of the coupler and the ground below without projecting light forwards. Switches for these lights shall be located on both sides of the locomotive at both ends and shall be accessible from track formation level.

**13.12.9.6 Step Lights**

Lighting shall be provided to illuminate all steps and the surrounding ground and cab area.

**13.12.9.7 Timetable Lights**

A timetable light to illuminate documents at the timetable clip shall be provided. The light shall not cause any distraction to the driver's vision and shall have provision for easy adjustment of the light beam.

Section 13.12.9 superseded by AS 7531

**13.12.9.8 Low Visibility Lights**

Section 13.12.9 superseded by AS 7531

Two quartz halogen lights for use in low visibility conditions shall be rigidly mounted below the anti-climb beam and not more than 1200 mm above rail at each end of the locomotive. The lights shall be fitted with a means to adjust the direction of the beam.

**13.12.9. CAB HEATER**

Fan forced electric heating shall be included in the driver's cab. No air from the traction motor cooling air ducts shall be used for the forced supply. The preferred location of the heater is the vicinity of the operator's feet. Heaters shall be connected so that operation is only possible while the engine is running. The heaters shall consist of two (2) 500 Watt electric elements, seperately switched so that the driver may select either or both of the elements.

**13.12.10 WINDSCREEN DEMISTER**

The windscreen shall have a deposited film electrically operated demisting element. Thermal protection for the windscreen shall be included.

The two demisters in each cab shall be controlled by separate switches. Each switch shall be fitted with a red L.E.D. `On' indicator.

**13.12.11 HOT PLATE**

A hot plate shall be provided in the cab for heating food and water. The hot plate shall be fitted to the front control stand as shown on Diagram 13-4 and shall include a three-position heat mode switch (low, medium, high ), protection rails and a stainless steel drip tray with external drain.

**13.12.12 REFRIGERATOR/WATER COOLER**

A refrigerator shall be fitted in the driver's cab, located as shown on Diagram 13-4. The refrigerator shall have a minimum internal volume of 20 litres and be capable of holding a glass water bottle of 2 litres capacity.

**13.12.13 RADIO EQUIPMENT**

Approved VHF/UHF radio communication equipment shall be fitted. Refer to section 13.2.3.6.

## 13.13 TRACTION POWER UNIT

**Compliance with these requirements is mandatory.**

### 13.13.1 GENERAL REQUIREMENTS

13.13.1.1 The locomotive shall have a diesel engine as the principal traction power source. The diesel engine shall have a high thermal efficiency over a wide operating range.

13.13.1.2 The diesel engine shall be reliable and fuel efficient. It shall require minimum maintenance and shall have easy access to components for routine and major maintenance purposes.

13.13.1.3 The diesel engine shall be fitted with a reliable and easily maintained and operated monitoring system which shall comply with the requirements of Section 13.14.

### 13.13.2 DIESEL ENGINE

13.13.2.1 The engine power shall be sufficient to satisfy the performance and duty requirements specified in Section 13.2.5 and auxiliary demands.

13.13.2.2 All engine protective devices shall have an approved type of operational indicator.

13.13.2.3 The engine shall be designed to operate efficiently using fuel to AS 3570. Exhaust gas emission shall comply with the requirements of all relevant State and Federal regulations.

### 13.13.3 STARTING SYSTEM

13.13.3.1 An electric starter switch and solenoids suitable for local start shall be provided. Stop/start buttons, isolation switch, and pre-lubrication pump start and `On' indicator light shall be provided in the vestibule. If a seperate starter motor is used, it shall be automatically isolated when the engine starts.

13.13.3.2 The engine starting system shall be so designed that damage shall not result from a hydrostatic lock due to the leakage of fuel, oil or water into the cylinders.

13.13.3.3 The engine shall be provided with a facility for both local and remote shut-down. Local shut-down controls shall be located in the vestibule, and an emergency stop button shall be provided on the driver's control stand fitted with a raised surround and bars to prevent accidental operation.

### 13.13.4 FUEL SYSTEM

13.13.4.1 Priming of the fuel system shall be performed by an electric pump.

13.13.4.2 The fuel system on the engine shall be fitted with a suitable sight glass(es) to indicate the presence of air or combustion gases in the fuel system. A fuel flow indicator shall also be fitted.

13.13.4.3 All pipes shall be held firmly in position with approved retaining clamps. All piping shall be protected by rubber or other approved sheathing where clamped or where contact with other equipment may occur.

### 13.13.5 AIR INDUCTION SYSTEM

13.13.5.1 The engine air induction system shall consist of self-cleaning inertial primary filters with pleated paper secondary filters. Air inlet protection shall be provided to prevent large particles and debris from blocking or becoming lodged in the primary filters.

13.13.5.2 The locomotive design shall minimise the intake of exhaust gases, cooling system outlet air, traction motor cooling outlet air and crankcase exhaust gases and similar products into the air induction system.

### 13.13.6 EXHAUST SYSTEM

13.13.6.1 The engine shall be fitted with an easily removable exhaust system. The system shall include an exhaust

silencer of suitable capacity for the engine and shall comply with the noise level requirements of Section 13.4. An inspection port shall be fitted where the system incorporates a turbo-exhaust screen.

13.13.6.2 The silencer shall be provided with inspection and cleaning holes. Exhaust gases shall be discharged clear of the locomotive roof, and located so the entry of gases to any fresh air inlets or the cab ventilating and air-conditioning systems is minimised. The system shall prevent the emission of burning or hot particles from the exhaust stack.

13.13.6.3 Provision shall be made to permit exhaust gas sampling and the fitting of engine spectrographic probes.

### 13.13.7 LUBRICATION SYSTEMS

13.13.7.1 Fill and drain points for lubricating oil shall be fitted on both sides of the locomotive and shall be easily accessible under normal service conditions.

13.13.7.2 The engine lubricating systems shall be fitted with cartridge type pleated paper filters. the system shall embody the full flow principle, i.e. all oil circulating in the diesel engine lubricating system shall pass through the filters before entering the engine. The cartridge paper filters shall be suitable for a minimum of 92 days operational service between changes without plugging or causing engine shut-down due to low lubricating oil pressure.

13.13.7.3 Lubricating oil capacity shall enable locomotive operation for a minimum of 14 days normal service without replenishment.

13.13.7.4 Lubricating oil shall comply with 13.5.5.4.

13.13.7.5 A prelubrication system shall be provided which enables the lubrication system to be pressurised prior to engine start-up.

### 13.13.8 COOLING SYSTEM

13.13.8.1 The cooling system shall be pressurised. The coolant inhibitor treatment shall comply with Section 13.5.5.4.

13.13.8.2 To improve fuel economy, the cooling fan(s) shall be operated on demand ensuring that at all times the coolant temperature is maintained within the range specified by the engine manufacturer.

13.13.8.3 The design of the cooling system shall optimise fuel economy and provide for automatic temperature and may incorporate sequential fan operation, variable speed control and similar features. The cooling system shall be capable of maintaining the engine temperature within safe limits with 10% of the radiator tubes blocked while operating under full load. The ambient operating parameters are specified at 13.2.1.

13.13.8.4 The radiator design shall be submitted for approval before manufacture. The mounting holes in both the radiator and the mounting frame shall be jig-drilled to ensure interchangeability between locomotives of the same class. The fin to core bonding operation shall include full hot solder dipping of the core.

13.13.8.5 The radiator and mounts shall be capable of withstanding without failure the loads and stresses specified in Section 13.2.

13.13.8.6 Self-draining vent lines shall be provided from the high points in the engine and radiators to the expansion tank.

13.13.8.7 The expansion tank shall be removable as a unit and have a capacity between "full" and "low" of at least 15% of the total capacity of the cooling system, and shall permit the expansion of the coolant, at the "full" level and a temperature of $4^{o}$C, up to the maximum permissible engine operating temperature without overflow.

13.13.8.8 The expansion tank shall be fitted with a sight glass or equivalent device tp indicate the "full" and "low" levels and the filling capacity. The sight glass shall incorporate a drain valve to give positive level indications and isolating valves tp prevent the loss of coolant should the sight glass be broken.

13.13.8.9 Coolant drain outlets shall be provided on both sides if the locomotive beneath the underframe and be fitted with pipe plugs.

13.13.8.10 The header tank pressure shall be vented away from the operator during filling with the filler caps and venting valves suitable interlocked to prevent opening while under full pressure. The filling system shall be so designed and installed that the coolant can be replenished from ground level and minimum treated coolant will be lost.

**13.13.9 PIPING- COOLANT, FUEL AND LUBRICATING OIL**

13.13.9.1 All pipework shall be installed free of stresses and shall be securely supported and retained against vibration.

13.13.9.2 Flexible couplings shall be used on the engine for lubrication oil and coolant connections and couplings. The seal shall be unrestrained and the material shall be suitable for application with lubricating oil and treated coolant at service temperatures and pressures.

**13.13.10 ENGINE SPEED CONTROL**

13.13.10.1 Normal control of the traction engine and transmission of the power unit shall be from the driver's cab.

13.13.10.2 Additional controls shall be provided locally at the power unit to permit testing and maintenance operations remote from the cab.

**13.13.11 MOUNTING AND PROTECTON**

13.13.11.1 The engine and alternator shall be easily and individually removable. Mounting holes shall be jig-drilled to permit interchangeability. The alternator shall be removable from the locomotive without also requiring removal of the engine, and only removal of a minimal amount of other components or equipment.

The engine , alternator and mountings shall be capable of withstanding without failure the loading requirements of Sections 13.7.1.2, 13.4.2.1 and 13.4.3.1.

13.13.11.2 Suitable collision blocks shall be provided to prevent displacement of the power unit. Alignment of the engine and alternator shall be easily achieved.

13.13.11.3 A separate drip pan (tundish) shall be provided under both the engine and alternator. They shall be adequately drained and graded to prevent the formation or retention of pools of liquid. The drains shall be fitted with valves located outside the locomotive to permit emptying and to prevent leakage onto the track and formation in compliance with relevant State and Commonwealth requirements. The drain shall be a minimum of 80 mm diameter, free from sharp bends and readily accessible for cleaning. A suitable mesh shall be provided for the drain inlet.

**13.13.12 ENGINE ACCESSORIES**

13.13.12.1 The engine shall be fitted with all the accessories and attachments normally required for the efficient and safe operation and maintenance of the engine and shall include the following:

(a) Emergency manual stop control at the engine and in the cab

(b) Provision to operate the throttle at the engine but without the facility to engage the traction power system

(c) Governor to control engine speed and alternator loading

(d) A lubricating oil by-pass filter (optional)

(e) Primary and secondary fuel filters
Note that if these are separated, the secondary shall be of the `spin-on' type

(f) Lubricating oil cooler

(g) Primary fuel supply pump, electrically driven

(h) Remote indications of automatic shut-down

(i) Glycerine filled gauges to indicate engine oil pressure, coolant temperature, fuel pressure and turbo boost pressure.

(j) Automatic safety controls with remote indication to protect the engine in the event of :
(1) High engine coolant temperature (reduce engine speed)

(2) Low engine lubricating oil pressure (engine shut-down)

(3) Low engine coolant level (engine shut-down)
(4) Engine overspeed limiting device which shall not affect the normal operaton of the engine control system. On reaching an overspeed condition the limiting device shall override the engine control systems, shut down the engine and be automaticallly latched in the shut-down position; the device shall require manual resetting after shut-down.

(5) The appropriate components of the safety control system shall be automatically isolated during engine starting.

(k) Engine turning gear of a type which is easily operated by one person.

(l) The application of thermocouples for test purposes is desirable and holes shall be tapped RP ½/15 (1/2" BSP) in a position adjacent to the exhaust in each cylinder and be fitted with a removable plug.

**13.13.14 EQUIPMENT COMPARTMENT VENTILATION AND PRESSURISATION**

13.13.14.1 All air entering the clean air equipment compartment shall be filtered. The radiator cooling air need not be filtered but shall be drawn from and discharged to the exterior of the locomotive.

13.13.14.2 The filter air entry shall be so located as to avoid drawing air from low on the body side where there may be excessive dust and shall be designed to minimise the intake of hot air from the radiators and of exhaust gases. Adequate drainage of the air filter housing shall be provided.

13.13.14.3 Secondary filtration shall be provided for equipment which requires cleaner air than is provided by the primary filtration. All filters shall be of the pleated paper type or other approved material and shall be readily accessible for maintenance purposes.

13.13.14.4 The engine compartment shall be adequately ventilated to assist the cooling if this compartment when the engine is shut down.

13.13.14.5 The engine room and electrical compartments shall be seperated so that the air fron the engine room cannot pass into the electrical area. The traction alternator cooling air may be used to pressurise the engine room. Adequate exhaust vents shall be provided to permit the free egress of ventilating air.

13.13.14.6 A suitable system for readily determining the condition of all air filters shall be provided.

## 13.14 ON-BOARD MONITORING AND RECORDING EQUIPMENT

13.14.1 The locomotive shall include a proven monitoring, indicating and logging system for the purpose of optimising performance and minimising maintenance.

Functions performed by this system shall include:

(a) speed and operation monitoring (Driver actions)
(b) fault monitoring (locomotive performance); and
(c) condition monitoring (optional)

**13.14.2 Speed and Operation Monitoring**

**13.14.2.1 General Requirements**

The following functions shall be monitored:

locomotive speed - time (on a 24 hour basis) and distance travelled
automatic/independent brake application
brake pipe pressure
power controller setting (power on/off)
driver's V.C. acknowledgment
observer's V.C. acknowledgment
emergency V.C. (alternatively locolog or dead man's pedal)

Monitoring of the following operational parameters shall be optional, to suit system requirements:

dynamic brake
horn operation
headlights on/off
brake cylinder pressure
notch settings
A valve
B valve
C valve
D valve
transition relay (as required)
wheel slip lamp
forward/reverse
sanding switch operation
generator field contactor
main compressor
fuel savers
manual power control
vigilance control mode
penalty brake application
hot engine alarm
head end power supply (415v) - optional
field shunt (as required)
74 V supply
radio system

These parameters shall be monitored and recorded in a scrolling short-term memory bank giving data for at least 15 minutes prior to the current time.

For multiple unit consists, faults on trailing locomotives shall be logged on the monitors on the locomotive on which the fault occurs and a remote fault indication shall be indicated on the lead locomotive.

A hard copy facility for the locomotive's history shall be available, via either software or a built-in printer.

An operator's manual shall be provided.

**13.14.2.2 Odometer/Speed Indicator/Recorder**

13.14.2.2.1 The unit shall be capable of indicating and recording speeds 25% in excess of the maximum design speed of the locomotive. The speed shall still be indicated while the locomotive is switched off line. An analogue display is preferred. The unit shall incorporate a clock which can be set by the train crew as required.

13.14.2.2.2 The monitor shall be capable of displaying the cumulative kilometres travelled by each locomotive. This information shall also be included in any hardcopy of fault monitor information.

The distance travelled shall only be incremented while the engine is running and the locomotive is moving.

The odometer shall have a range of 0 to 9,999,999 km

A facility shall be available for the manual input of kilometres travelled, in the case of a failure resulting in the loss of data.

13.14.2.2.3 A calibration feature to compensate for variations in wheel diameter shall be provided.

13.14.2.2.4 The unit shall be so located that it is not subject to the direct impact of sunlight and is easily and readily visible to the driver fron the normal driving position. Where possible, the unit shall be mounted at the top of the instrument panel on the control desk.

13.14.2.2.5 Provision shall be made for a distance travelled display which shall indicate the distance travelled in 50 metre increments. This display shall be capable of being switched on or off as required by the driver and shall be automatically reset to zero when switched off.

**13.14.2.3 Input**

The preferred arrangement is an electronic measuring unit with a pulse generator mounted on the end of one axle. This same generator shall be used for speed indication, wheel slip/slide and automatic train control (if used).

**13.14.3 Fault Monitoring**

The fault monitoring system shall monitor all alarm signals and equipment operation.

**13.14.3.1 Parameters to be Measured/Recorded**

Fault recording shall be provided to log the following parameters into non-volatile memory at the time of occurrence of the fault:

(a) power/braking notch settings
(b) time, date and speed
(c) the nature of any faults, and corrective action taken by the crew (eg. reset, cut out)

**13.14.3.2 System Composition**

The fault monitoring system shall give clear, concise instructions to the driver via a display unit screen in the driver's cab. Indicator lights and alarms shall be used to issue warnings to the driver.

Signal transducers shall be provided to input information to the data processing unit.

The locomotive fault monitor shall include a data logging facility.

This data logging unit shall be compatible with IBM or IBM-compatible depot computer (PC) facilities.

Flag relays shall be provided to give specific information about the nature of faults.

A hardcopy facility is required.

#### 13.14.3.3 Equipment to be Monitored and Recorded

Equipment to be monitored shall include the following items, if fitted:

(a) traction equipment
(b) dynamic brake grid
(c) diesel engine
(d) auxiliary power supply equipment
(e) main compressor
(f) air conditioning and ventilation
(g) control equipment
(h) batteries
(i) automatic train protection (ATP) equipment

#### 13.14.3.4 System Operation

Three levels may be provided for access to information:

(a) Driver
(b) Maintenance staff
(c) Management

Corrective actions to be taken by the Driver:

(a) hit reset button or circuit breaker
(b) contact control
(c) bring locomotive in for major faults

Trade staff will then read information from fault monitoring system and consult maintenance manuals.

History of faults recorded since the last time memory was cleared shall be able to be downloaded to a P.C. The memory shall be cleared after down loading.

### 13.14.4 Condition Monitoring (Optional)

Parameters and equipment to be monitored may include the following:

(a) diesel engine
(b) electrical equipment, including
    traction motor
    main generator/alternator
    three phase drive equipment (if fitted)
    auxiliary power supply
    others (main rectifier, battery voltage, battery charger, etc)
(c) main compressor
(d) air conditioner

Equipment requiring logging will vary accordingly to engineering and maintenance requirements. Components to be monitored are those which:

(a) have an existing record of failure
(b) have high replacement cost
(c) could cause significant interference with equipment productivity
(d) could produce catastrophic failure of itself or other equipment
(e) are capable of having failures predicted by the measuring of various parameters.

A software package shall be provided to be used by the depot facilities to perform the analysis of this information.

The information shall be retrieved and downloaded to the depot computer facilities. The information will be used to detect systems or equipment operating outside their design limits. To assist in maintenance, operating parameters shall be recorded at regular intervals. The information will be accumulated for the period between each down loading of the information. Provision shall be made for storing this information in non-volatile memory.

## 13.15 MAINTENANCE AND SERVICING

### 13.15.1 MAINTENANCE REQUIREMENT

#### 13.15.1.1 Inspection Period

Locomotives shall be capable of operating without inspection for a minimum period of fourteen (14) days.

#### 13.15.1.2 Major Maintenance Periods

The locomotive shall be designed and constructed to operate for 1,500,000 kms before scheduled major maintenance is required.

### 13.15.2 SERVICING REQUIREMENTS

#### 13.15.2.1 Minimum Servicing Period

Locomotives shall be designed to operate without servicing for a minimum period of 92 days.

## 13.16 MISCELLANEOUS

### 13.16.1 QUALITY ASSURANCE AND QUALITY CONTROL

Contractors shall comply with the requirements of AS 3901, AS 3902, AS 3903, AS 3904, AS 2415 and AS 3563 or approved equivalents. Contractors systems to AS 1821-1823 shall be upgraded to meet the requirements of AS 3901-3903. The following notes summarise the most important requirements of AS 3901-3904:

(a) All suppliers to railway authorities shall have a quality system in place, with approved certification or third party accreditation.

(b) Sub-contractors shall have their own quality systems in place.

(c) Periodic audits shall be carried out.

(d) Traceability of locomotive components shall be ensured by means of adequate marking or labelling of locomotive axles, wheel discs, bogies etc.

(e) The contractor's quality manual, quality plan and inspection and test plan shall be supplied to the purchaser for approval before construction work commences.

(f) Document control shall be ensured by the prompt issuing of revised versions of drawings, manuals and documents. All design changes made by the contractors shall be subject to approval by the Principal.

(g) Functions to be controlled shall include:

contract review
design
document control
purchasing product
traceability and product identification
process control
inspection and testing of product
control of non-conforming product
corrective action
handling, storage, packaging and delivery
quality records
internal quality audits
staff training

### 13.16.2 TESTING, INSPECTION AND COMMISSIONING

#### 13.16.2.1 Test Certificate

A test certificate shall be provided, showing design values and tolerances, and actual measured values.

#### 13.16.2.2 Tests Required

All testing of locomotives shall be carried out in accordance with IEC 490 (diesel electric locomotives).

A gauge test shall be performed in accordance with IEC 490, clause 4. This test is a routine test to be performed for all locomotives.

A weighing test shall be performed to determine the mass of locomotive components, in accordance with IEC 490, clause 5. The requirements of section 13.2.3 shall be achieved. This test is a routine test and shall be performed on all locomotives.

Noise level tests shall be performed in accordance with the requirements of Section 13.4.1.

Performance of the braking system shall be tested. These tests shall include the main braking system, emergency braking, parking brakes, brake rigging and slack adjuster, in accordance with IEC 490, clause 7.

The requirements of Section 13.10 shall be satisfied. These tests shall be routine tests performed on all locomotives.

Air and water tightness shall be tested. Water tightness tests shall determine resistance to heavy driving rain, and also to high pressure water cleaning, as per IEC 490, clauses 6 and 8. These tests shall be routine tests performed on all locomotives.

Electrical equipment shall be subjected to the following type tests:

(a) temperature test
(b) voltage withstand test
(c) wiring/insulation test
(d) sequence test
(e) circuit operation test

Electrical tests shall conform to the requirements of BS173, BS 2618, IEC 490 clause 17 and IEC 77. The requirements of Section 13.12 shall also be satisfied.

Vibration and ride quality test shall be performed, in accordance with the requirements of Section 13.4.

The compressed air system shall be routine tested as per IEC 165, clause 5. The requirements of Section 13.11 shall be satisfied.

Control and communications equipment shall be tested as required by BS 2618. Indicating instruments shall also be tested. The requirements of Section 13.12.3 and 13.10.2.6 shall be met.

Cab horn, lighting and windscreen wipers shall be tested.

Prototype windscreens shall be subjected to impact tests in accordance with AS 2080 and FRA 49 CFR part 223. All windscreens shall comply with the requirements of Section 13.7.2.3.1.

Air conditioning and ventilation equipment shall be tested. The requirements of Section 13.7.2.1.1. shall be satisfied.

A general visual inspection shall be performed on the completed locomotive.

The complete locomotive shall be tested under load, by itself and also as part of a multiple unit consist. The locomotive shall be required to run through a typical operating schedule, in accordance IEC 165, clause 26. The requirements of sections 13.2.5.1 and 13.5 shall be satisfied.

Starting/acceleration performance, and resistance to motion shall be determined, in accordance with IEC 165, Clauses 14 and 23. The traction performance requirements of Section 13.5 shall be satisfied.

Correct operation of the locomotive for curved track shall be verified, in accordance with IEC 165, clause 109. The requirements of Section 13.13.5 shall be satisfied.

Locomotive energy consumption shall be determined, in accordance with IEC 165, clause 25.

### 13.16.3 COMPONENT MARKING AND UNITS

Rail System's logo shall be painted or cast on locomotives

Locomotive number and class shall be displayed on the locomotive body, and/or displayed on an illuminated panel for the full bodied locomotives. For narrow bodied locomotives, the number shall be displayed at both ends.

At least one manufacturer's name plate, showing date of manufacture, contract number and contractor's name is required.

Stencils shall be used for painting numbers and lettering, to ensure standardisation and legibility.

Where a painted finish is brush-applied, care shall be taken to ensure a good visual finish by reducing brush marks to a minimum.

Axles, motors, bogie frames, gears, pinions, axle boxes and armature shafts shall be marked with the maker's initials, serial number and year of manufacture.

Any diagrams required to indicate the mode of operation or function of any component shall be provided by approved, self-adhesive decals or equivalent.

Lengthy or detailed instructions shall also be given on self-adhesive decals or equivalent.

Decals or equivalent shall be placed adjacent to all air cocks used by drivers to indicate the orientation and function of the cock handle.

Decals or equivalent shall be provided for identification of the locomotive on-board monitoring unit, soil outlet, tank filling and tank overflow.

The direction of rotation of electric motors, fans, pumps and compressors shall be clearly indicated.

Component function/location/identification labels shall be placed near the component to be identified rather than on the component itself.

Component type/part No. labels shall be placed on the actual component they are to identify.

All labels apart from decals shall be made from black-on-white traffolyte, metal or equivalent and shall be permanently fixed in place using mechanical fasteners such as rivets or other mechanical devices.

All units used for drawings, manuals and component manufacture shall be metric, except for pipes and fittings, which may be BSP or NPT. Proprietary items manufactured overseas which are not metric shall be subject to approval.

### 13.16.4 INSTRUCTION BOOKS, DRAWINGS AND DOCUMENTS

At least one complete set of reproducible drawings shall be provided. Two copies of a drawing and an approval sheet shall be supplied before commencing manufacture.

Drawings shall be made on autoreversal polyester film 0.1 mm thick, matt finish both sides. Drawings shall conform with the requirements of AS 1100, part 101.

Copies of spare parts catalogues shall be provided.

Copies of the Maintenance and Operations Instructions Manual shall be supplied.

The spare parts catalogue shall comprise an illustrated list of all parts on the locomotive in question. This catalogue shall be the latest issue showing all updates.

One (1) copy of an acceptance book shall be supplied on offering each locomotive for acceptance.

The acceptance book shall contain the following information:

(a) a signed certificate of compliance
(b) references to tests performed on the following items:
    traction equipment for:
    locomotive on-board monitoring unit power/brake controller
    air conditioner
    voice radios
    brake rack and distributor
    automatic and independent brake controller
    all reservoirs
    main compressor
    refrigerator
    locomotive body and underframe
    bogies including wheelsets
    engine
    alternators
    traction motors
    equipment blowers (motor assembly)
    masses of individual components (breakdown) eg. engine, alternator, compressor, carbody, bogies, radios.

**13.16.5 TRAINING AND TECHNICAL SUPPORT**

A comprehensive "train the trainer" programme shall be supplied for:

(a) Maintenance Staff
(b) Operations Staff
(c) Technical Staff

This programme shall be include formal tuition, supported by the appropriate written documentation including diagrams, parts catalogues and manuals.

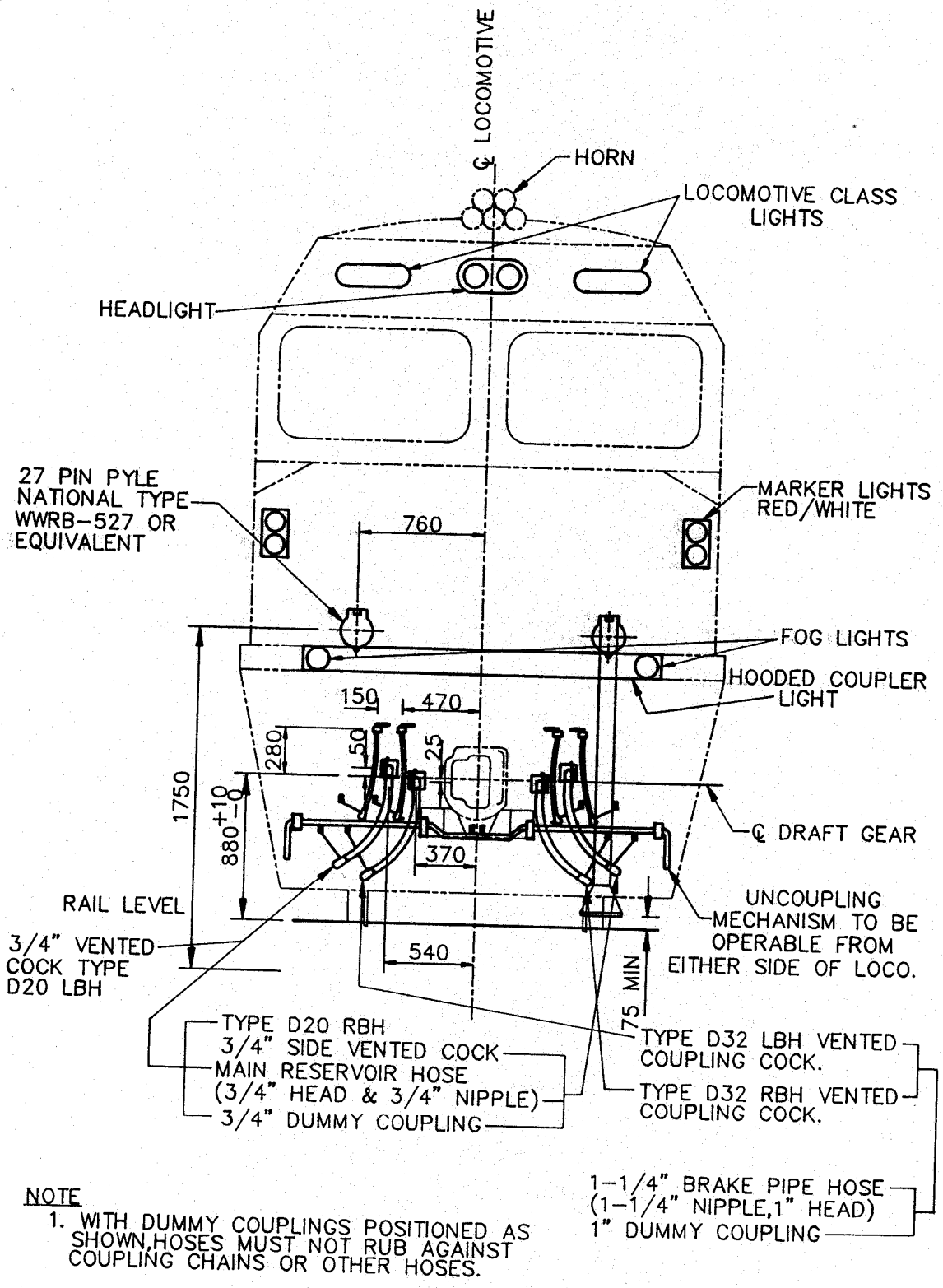
A mockup of the cab, and models shall be used to simulate locomotive operation.

The course schedule shall be submitted for approval.

Diagram 13-12 superseded by AS 7531

**DIAGRAM 13-12**

**STANDARD LOCATION OF END EQUIPMENT**



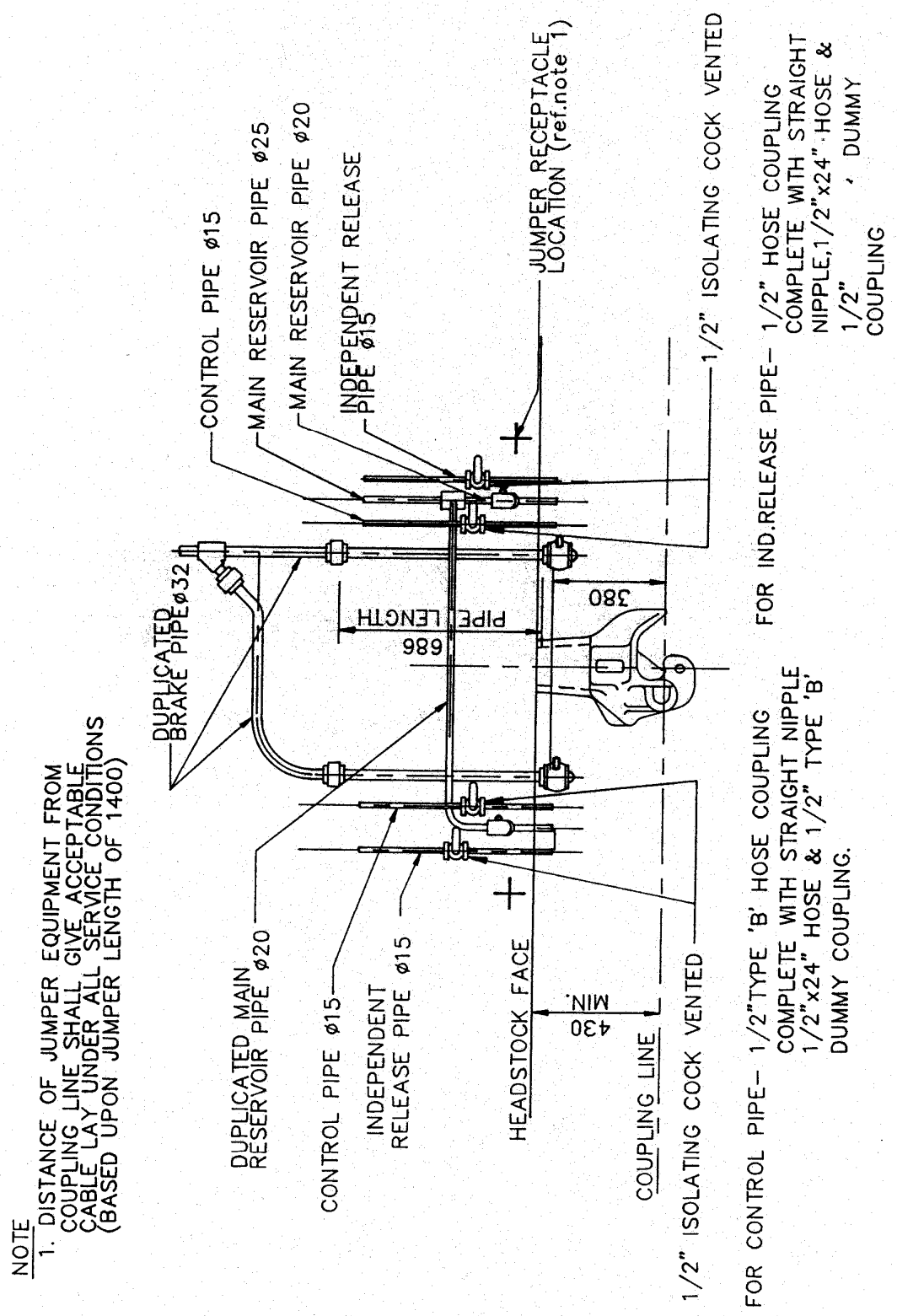

NOTE

1. WITH DUMMY COUPLINGS POSITIONED AS SHOWN,HOSES MUST NOT RUB AGAINST COUPLING CHAINS OR OTHER HOSES.

**Adopted 15/3/92**

**DIAGRAM 13-13**

**STANDARD LOCATION OF AIR CONNECTIONS AT END**




**Adopted 15/3/92**

**DIAGRAM 13-14**

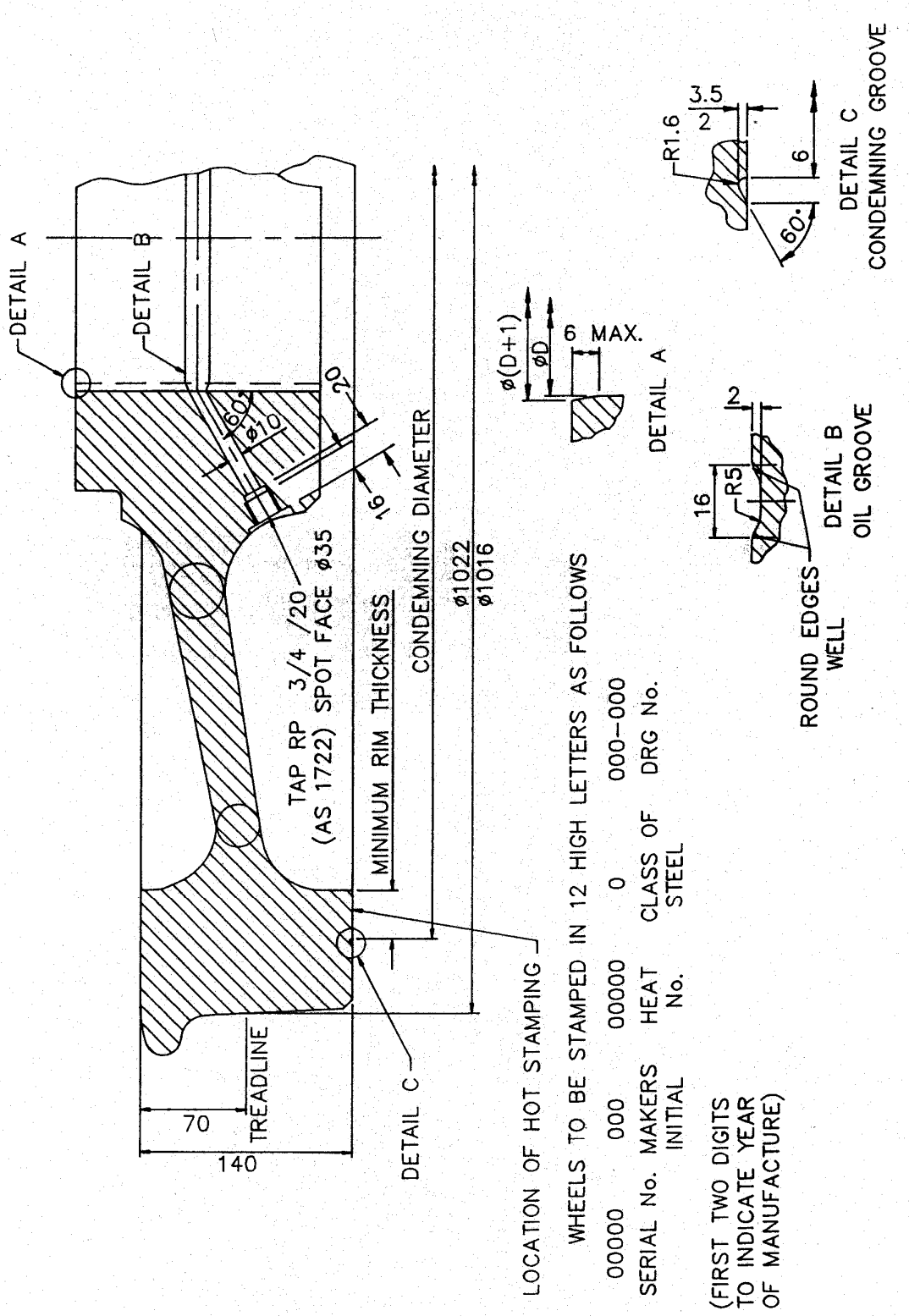
**LIFTING BRACKET**

NO DIAGRAM IN ORIGINAL
PRINTED DOCUMENT

Diagram 13-15 superseded by AS 7514

## DIAGRAM 13-15

## STANDARD WHEEL-NOMINAL DIMENSIONS

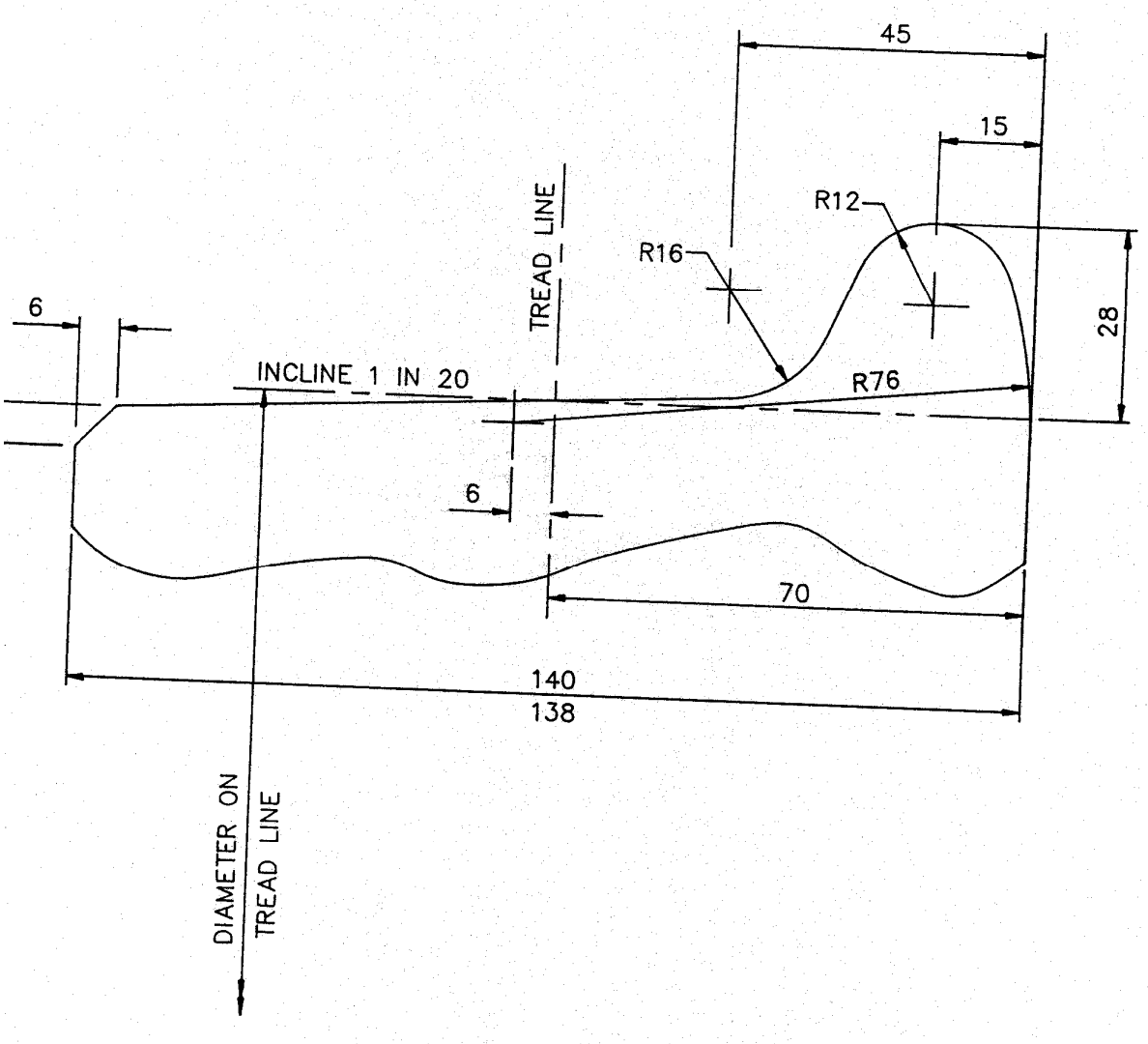



**Adopted 15/3/92**

Diagram 13-16 superseded by AS 7514

**DIAGRAM 13-16**

**STANDARD WHEEL PROFILE**

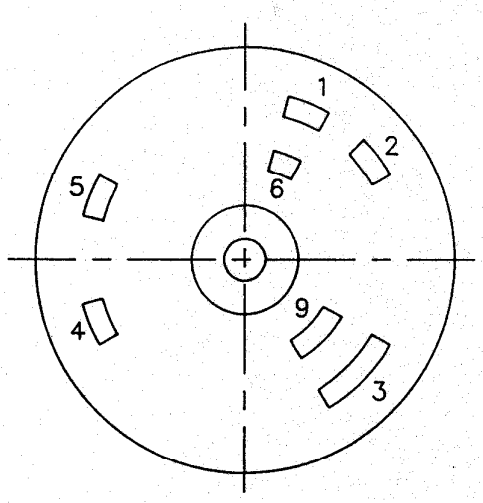



**Adopted 15/3/92**

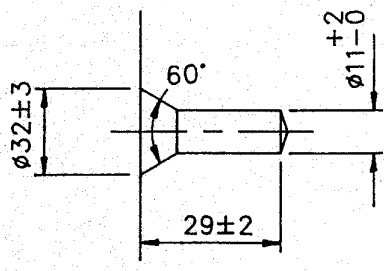
Diagram 13-17 superseded by AS 7515

## DIAGRAM 13-17

## STANDARD AXLE MARKINGS




BRAND MARKINGS




DETAIL OF CENTRE

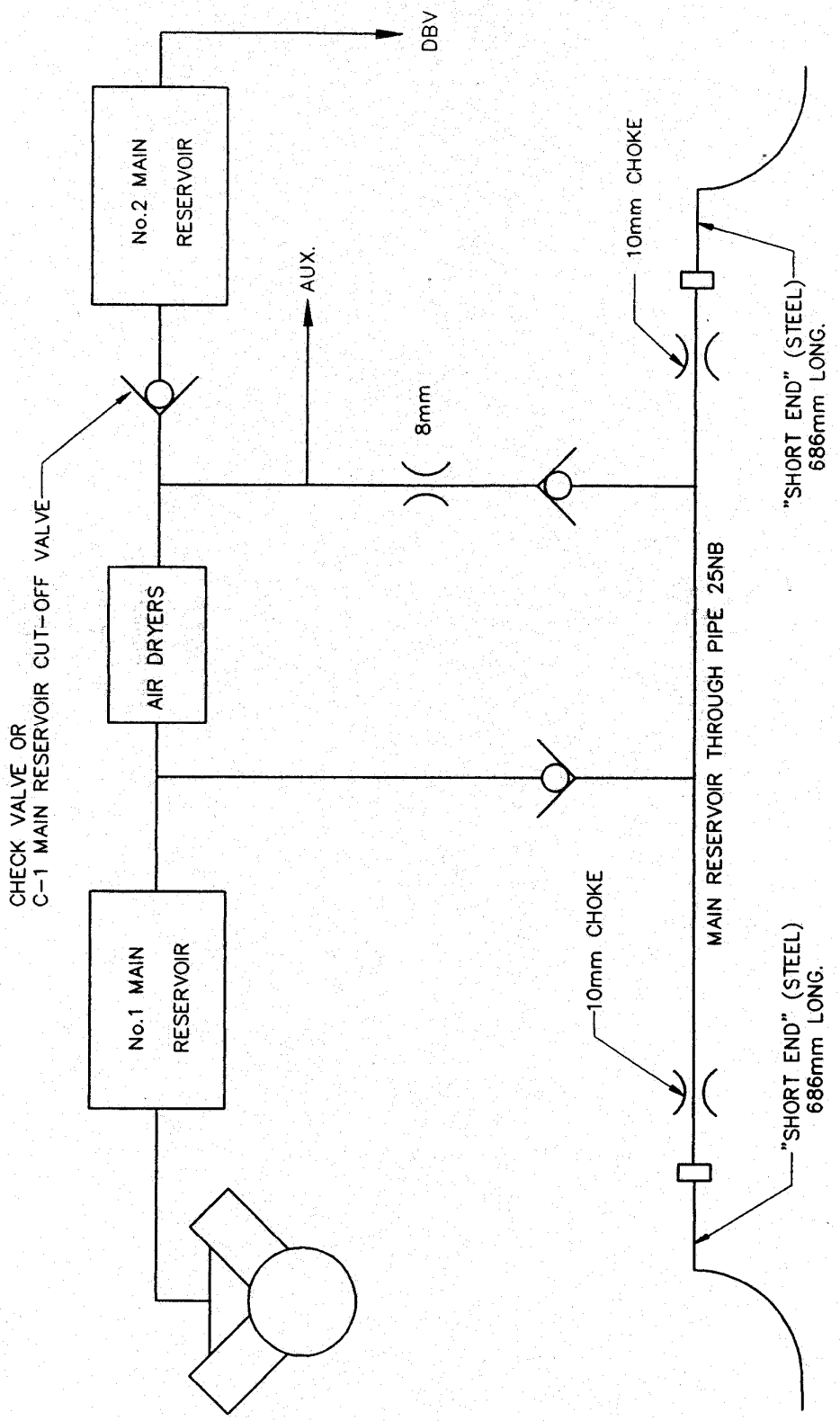
1. OWNER'S INITIALS.
2. MANUFACTURER'S NAME OR INITIALS.
3. AXLE SERIAL NUMBER. (ALLOTTED BY SYSTEM OR MANUFACTURER)
4. HEAT NUMBER
5. YEAR ULTRASONICALLY OR MAGNETICALLY TESTED.
6. WHEEL MOUNTING FIRM'S NAME OR INITIALS.
7. SIZE OF BRANDING 5mm MIN. TO 8mm MAX.
8. THE AXLE NUMBER SHALL BE STAMPED ON BOTH, THE LEFT AND RIGHT HAND ENDS OF THE AXLE. ALL OTHER BRANDINGS SHALL BE ON THE RIGHT HAND END OF THE AXLE ONLY.
9. L AND R TO BE STAMPED ON THE LEFT AND RIGHT HAND ENDS OF EACH AXLE.

NOTE: TO FACILITATE ULTRASONIC TESTING ALL BRANDING TO BE DRESSED FLUSH.

**Adopted 15/3/92**

**DIAGRAM 13-18**

**MAIN RESERVOIR AIR SCHEMATIC**




**Adopted 15/3/92**