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# Design Guideline for the Construction of Electric Powered Shuttle Cars for Use in Coal Mines

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MDG 9



NSW DEPARTMENT OF  
**PRIMARY INDUSTRIES**

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## 1. **Scope**

Clause 28 of the Coal Mines Regulation Act 1982 (Transport - Underground Mines) Regulation 1984, requires that all vehicles operated in an underground coal mine shall be approved by the Chief Inspector.

A "vehicle" means a rubber tyred or caterpillar tracked vehicle propelled by electrical or mechanical means and used for the purpose of transporting persons, materials, coal or stone, whether by carrying, towing or otherwise, and includes a shuttle car.

The following guide-lines are intended to help electric powered shuttle car designers and repairers by indicating those parameters which will be considered in an approval assessment of an electric powered shuttle car.

The guide-lines do not generally give quantitative information as it is not intended to restrict innovative design. Where specific values or test procedures are required, advice should be sought from Inspectors of Mechanical Engineering, Coal Mining Inspectorate of the Department of Mineral Resources.

NOTE "shall" and "should"

- (a) "shall" means that the requirement is mandatory if it is applicable to the type of vehicle under consideration.
- (b) "should" means recommended. If not adopted the decision shall be justified by a documented risk review.

1.3 Unless otherwise specified, the appropriate Australian Standards shall apply.

### 1.4 **Approval Procedure**

Approval applications shall be supported by:-

- 1.4.1 A brief statement of compliance, variation or reason for non compliance with each item mentioned in these guide-lines. A marked up and signed copy of these guide-lines may be used.
- 1.4.2 A documented risk review of the vehicle which shall include but is not necessarily limited to:-
  - (a) A review of previous accidents with comparable vehicles.
  - (b) The items mentioned in this guide-line that are listed as "should" but which have not been adopted.
  - (c) Any new features.
- 1.4.3 All information as requested in Appendix A1 for Electric Powered Shuttle cars.

- 1.4.4 Documentation covering electrical aspects as required by the Department of Mineral Resources Applicants Guide to obtaining an approval from the Chief Inspector of Coal Mines or an Accredited Assessing Authority.

All electric apparatus shall comply with the requirements of the Coal Mines Regulation Act 67/1982, subsequent Regulations and relevant Australian Standards.

1.5 **Limits of Applications**

The manufacturer must clearly specify the limits of application of the shuttle car including but not limited to:-

- 1.5.1 The maximum operating grades, including side grades.  
1.5.2 The maximum payload.  
1.5.3 The minimum roadway height.

**NOTE** The maximum speed of travel of a shuttle car when receiving power through a trailing cable shall not exceed 10 kilometres per hour.

2. **Control Functions**

- 2.1 The operating controls shall be clearly marked to show their function and mode of operation. Direction of movement is specified below:

Function	Direction
EMERGENCY STOP	Push a large red button
ON	Down, right, forward, clockwise, pull (push/pull type switch)
OFF	Up, left, backward, anti-clockwise, push

Function	Direction
RIGHT	Clockwise, right
LEFT	Anti-clockwise, left
FORWARD	Forward, down
REVERSE	Backward, up
RAISE	Up, back
LOWER	Down, forward
RETRACT	Up, backward, pull
EXTEND	Down, forward, push
INCREASE	Forward, away, right, clockwise
DECREASE	Backward, toward, left, anti-clockwise
OPEN VALVE	Anti-clockwise
CLOSE VALVE	Clockwise

**NOTE**

The details of all controls shall comply with the minimum ergonomic requirements as detailed in British Coal Corporation - published by the Scientific Services-Ergonomics Technical Department; published date: 10 August, 1990 - Report Number SSL/90/173- Titled "Ergonomics Principles for the Design of Free-Steered Vehicles"; by S. Mason and G.C. Simpson.

**2.2 Personnel Protection**

**2.2.1 Ergonomics**

All relevant ergonomic aspects of the shuttle car shall be addressed by the manufacturer in the design and manufacture of the shuttle car. A suitable person shall review the ergonomic aspects to ensure compliance with good practice.

2.2.2 The control cabin shall have sufficient structural integrity to protect the driver. This includes but is not limited to collisions, and falling roof cross supports.

2.2.3 Appropriate protection shall be provided to protect the driver from injury caused by contact with roof or roadway protuberances such as cross supports, pipes, ducting, etc.

It is preferred that falling object protection "F.O.P.S." in accordance section 2.2.4 be provided, however the minimum legislative requirements is for a protective device to protect drivers from falling cross supports.

The protective devices are required to satisfy the test requirements as stipulated in Appendix 2.

- 2.2.4 Alternatively "F.O.P.S." to Australian Standard AS2294 or SAE J1040 or ISO 3449 may be provided to protect shuttle car drivers.
- 2.2.5 Protective devices should be so designed that only that part of the device which is above the general profile of the shuttle car is readily removable. (to retain some protection if the top of the device is removed.)
- 2.2.6 The top of the protective device should be at least 100 mm. above the top of the driver's head when in the seated position. The vertical height of an upright seated 95th percentile male from the top of the seat to the top of his safety helmet is 1020mm. If there is a possibility of the drivers head hitting the underside of the protective device then adequate clearance to prevent this shall be provided. These minimum dimensions may be varied when a sloping seat is used.
- 2.2.7 The entrance to and driver compartment shall be designed to prevent personnel being thrown out. The design shall be such that it comfortably contains the driver within the compartment.
- 2.2.8 There shall be no sharp edges in any compartment. Against which a driver could be thrown in the event of a collision.
- 2.2.9 Protection shall be available to minimise the possible ingress of substantial materials from the surrounds of the shuttle car into the drivers compartments.
- 2.2.10 The ergonomics of the driver should be considered when designing his seat. Seats should be resilient, provide at least some side support above waist level and the back should extend at least 375 m.m. above the horizontal top of the seat.
- 2.2.11 The operator's seats shall be designed and positioned so the seated operator has controls within easy and comfortable reach in either direction of operation and take into account the operators cap lamp battery and self rescuer.
- 2.2.12 The service brake controls shall be positioned for operation by the operator's right foot.
- 2.2.13 The speed and service brake controls are to be of the pendulum type, suspended above the compartment floor.

2.2.14 The maximum allowable load shall be clearly displayed adjacent to the entrance of the operator's compartment.

2.2.15 An adequate audible warning device shall be fitted.

### **3. Brakes**

The following requirements for braking system are specifically confined to mechanical systems and are additional to any alternative methods of braking which may be incorporated in the vehicle.

3.1 Mechanical braking systems for electric powered shuttle cars shall consist of:-

3.1.1 Service brakes to be used as the principal mechanical braking system.

3.1.2 Parking brake

3.1.3 Emergency brake

#### **3.2 Brakes - General**

3.2.1 Brake systems may use common components, but any one failure in the common components shall not reduce the capability of the emergency brakes to stop the shuttle car safely.

3.2.2 At least one of the braking systems must be operated by direct mechanical action by the driver. Brakes applied by springs on the release of fluid pressure satisfy this requirement.

3.2.3 No power assisted mechanical or fluid braking systems shall be rendered ineffective by non-rotation of the shuttle car drive motor.

3.2.4 Where the operation of a braking system depends on accumulated hydraulic or pneumatic power, the system must include a reservoir capable of sustaining at least five consecutive applications of the brakes with the power source inoperative. Devices shall be provided to prevent the vehicle being moved under its own power unless the braking system is in operating condition.

3.2.5 Hydraulic or pneumatic braking systems shall include a pressure gauge clearly marked to indicate the minimum safe brake operating pressure. The gauge shall be easily visible from the drivers seat.

3.2.6 Hydraulic braking systems shall use approved fire resistant oil or fluid except where hydrostatic service braking is used or oil immersed brakes are used.

3.2.7 The emergency and park brake once applied should require the control to be reset before the brakes may be released.

- 3.2.8 An effective interlock should be provided to protect against the shuttle car being driven with the brakes applied.
- 3.2.9 A clearly identifiable means of externally monitoring brake wear and the required adjustment range shall be displayed.
- 3.2.10 All mechanical brakes shall be oil immersed and fully enclosed and shall include a means of limiting maximum surface temperature to less than 150 degrees Celsius.
- 3.2.11 All brakes shall act on all 4 wheels.
- 3.2.12 Braking systems must be designed to prevent the generation, in any part of the system, of temperatures capable of igniting combustible material likely to be present in the vicinity of that part. Brake linings must be of a type designed to minimise incendiary sparking by frictional contact and shall not contain asbestos.
- 3.2.13 All mechanical braking systems except service brakes shall fail to safety.
- 3.3 The service brake shall:-
  - 3.3.1 Be so constructed that the response time between initiation and commencement of braking does not exceed 0.7 seconds (excludes human response time).
  - 3.3.2 Be capable of stopping the shuttle car when carrying the manufacturers stated maximum permissible load including that obtainable with the maximum sized "hungry boards" on a level concrete surface in the distance specified in the following table when travelling at its maximum speed. This shall be achieved by the use of reasonable foot pressure. (These performance requirements exclude human response time).

<b>TABLE</b>	
<b>Brake Performance Requirements</b>	
Shuttle Car Speed (km/h)	Stopping Distance (metres) (based on SAE J2337a) retardation approx. 2.8 m/s <sup>2</sup>
6	0.31
8	0.85
10	1.47

- 3.3.3 The service brake system should not incorporate the use of a master cylinder.
- 3.4 The emergency brake system shall:



- 3.4.1 Be applied automatically within 1.5 seconds on the loss of any brake fluid or air pressure (fail-safe) ,
  - 3.4.2 Be capable of stopping the shuttle car in not more than double the stopping distances as specified in 3.3.2.
  - 3.4.3 If the application of the brakes requires the release of fluid then this is not to be achieved by use of indirect or pilot operated spool valves.
- 3.5 The parking brake system shall:-
- 3.5.1 Be fail-safe e.g. spring applied .
  - 3.5.2 Be capable of holding the shuttle car, including the maximum permissible load which may be carried or hauled thereby, stationary on the maximum gradient on which the shuttle car is designed to operate.

3.6 **Electric Regenerative Braking**

Is permitted provided that it can readily be replaced or supplemented by mechanical service braking during normal driving.

3.7 **Hydrostatic Service Brakes**

Is permitted provided it can be replaced or supplemented by mechanical service braking during normal driving.

Hydrostatic service braking should be provided with dual circuits such that the failure of one circuit will not prevent the other circuit from acting to apply the respective brake.

Hydrostatic service braking shall include adequate factors of safety in the design of the system and components.

**4. Cable Reeling Compartment and System**

- 4.1 The cable reeling compartment shall have sufficient structural integrity to protect the internal cable reeling components from damage.
- 4.2 The compartment's side doors shall be designed so that they cannot intrude inside the compartment, and are secured by positively retained quick release catches. Provision shall be made to ensure that the cable does not come into contact with any protruding attachments or catches, etc, when backspooling.

- 4.3 The compartment's top covers are to be designed and constructed in such a manner that the potential to injure personnel opening and closing them is minimal. Covers should be designed so they can be fully opened within the minimum operating seam height. In all instances cover weights are to be kept minimal.
- 4.4 The design of the compartment should incorporate the elimination of the potential to allow loose material to accumulate within the reeling compartment. Provision shall be made to easily remove any accumulation which could occur.
- 4.5 The cable reel system shall be fitted with device/s which effectively prevents:-
- (a) tensioning of the cable exceeding the cable design capacity.
  - (b) unreeling of the cable to an extent that tension is placed on the plug connecting the cable to the machine.
  - (c) excess reeling of the cable on the drum to such an extent that the cable exceeds the diameter of the flanges of the reel.
- 4.6 A cable reeling system shall incorporate a constant pressure in both the reeling in and reeling out modes. Such tension shall only be high enough to prevent a shuttle car from running over its own trailing cable under any conditions of shuttle car operation.
- 4.7 Cable reels and spooling devices shall be constructed from, or insulated with, non flammable material.
- 4.8 The indexing unit shall be positively supported and positioned as near as practicable to the outbye end of the compartment so that the hairpin length is minimal and accumulation of loose material upon the unit is negligible.
- 4.9 A cable reeling system shall be reliable. It is recommended that alternatives to chain drives should be considered.
- 4.10 Chain drives where used shall comply with the following:-
- (a) The tension in all chain drives shall be adjustable, and adequate to accept multiple lengths of chain pitch.
  - (b) All sprockets shall be fixed to their respective mounting shafts by positive means such as full depth keys or splines. In addition both sprockets and shafts shall be restrained from end floating by positive means, not by light section circlips. An identification plate identifying sprocket ratios shall be fitted within the compartment.
- 4.11 Diameters of cable reel and sheaves should be large enough to prevent undue bending strain on cables.

- 4.12 Cooling slots should be provided in the flanges of cable reel drums and should be designed to prevent the extrusion of loose cable loops through the slots.
- 4.13 A device or systems shall be fitted to prevent cable reel overrun occurring during deceleration.
- 4.14 The outrigger section should incorporate features that prevent the cable from being crushed by accidental contact with external objects, and minimise friction to the cable. Sharp edges are to be avoided.
- 4.15 A pressure gauge shall be fitted in the operator's compartment to indicate the cable reeling system pressure.
- 4.16 Means shall be provided for disconnecting the cable reel drive for the purposes of replacing cables.

## **5. Fluid Power Systems**

- 5.1 Hydraulic systems and components shall comply with Australian Standard AS 2671 Fluid power - hydraulic systems and components.
- 5.2 All operating controls for systems powered hydraulically shall be designed to automatically return to the OFF position on loss of pressure. This is to avoid inadvertent start-up when the electrical power supply to the shuttle car is energised.
- 5.3 Flexible hoses shall be compatible with hydraulic fluid used and the maximum system pressure and temperature.
- 5.4 The hose factor of safety shall be a minimum of 4 to 1 based on hose burst pressure to maximum working pressure.
- 5.5 Hydraulic hose shall comply with the provisions of AS 3791-1991 Hydraulic Hose and the requirements for flame resistance shall be in accordance with testing to AS1180-10B and acceptance to AS2660 or alternately satisfy the flame test requirement of the U.S.A. Code of Federal Regulations Title 30 Part 18 Section 18.65 or comply with type 1 or 3 hose specifications as listed in ISO 6805.
- 5.6 Where a hydraulic system incorporates an accumulator the attachment to the accumulator shall be by means of a minimal length adaptor and flexible hose. Fittings shall be located or otherwise guarded to provide mechanical protection. A manual bleed valve shall be fitted to allow pressure relief for maintenance. Fluid should return to tank.
- 5.7 Accumulators shall be securely installed.

- 5.8 Discharge conveyor boom hydraulic lift cylinder/s shall be fitted with load locking valves attached directly to the cylinders.

In all respects the device shall comply with the requirements of the Mine Safety and Health Administration of the U.S. Department of Labour issued on 17th October, 1980 attached as Appendix A3.

- 5.9 The use of nylon or PVC piping for pneumatic control systems will be acceptable only in cases where loss of pressure within these systems cause the system to fail to

safety. All such piping shall be adequately protected and shielded from contact with hot and/or sharp surfaces.

- 5.10 Air and water hoses shall be in accordance with AS2660-1983 unless otherwise specified.

- 5.11 Elastomeric (rubber type) hose shall not be used between an air compressor and air receiver. Teflon with steel braid is satisfactory.

- 5.12 Air compressors shall be of the liquid cooled type in accordance with AS 3584.

- 5.13 Pressure vessels shall comply with at least one of the following standards.

- (a) AS2971 - Serially produced pressure vessels (maximum capacity limited to 150 litres)
- (b) AS1210 - Unfired pressure vessels, where capacity exceeds 30 litres.
- (c) SAE-J10 - Automotive and off-highway air brake reservoir performance and identification requirements.

## **6. Towing of Shuttle Cars**

- 6.1 For the purpose of towing a shuttle car with fail safe brakes provision shall be provided to release said brakes as required.

- 6.2 Provision shall be made to allow the shuttle car to be steered as required, by interconnection to the tow vehicle.

- 6.3 A towing attachment shall be fitted on each end of the shuttle car.

- 6.4 The towing attachment shall be designed to a minimum factor of safety of 2.5 the rated maximum gross weight of the loaded shuttle car.

- 6.5 Each shuttle car shall be provided with a rigid draw bar for towing purposes. The bar shall be compatible with the towing attachments.

## 7. General

- 7.1 All belt drives shall be limited to auxiliary equipment only and shall be fire resistant, anti-static drive belts as per AS 2784.
- 7.2 No external surface temperature shall exceed 150 degrees C under any conditions of usage. This includes brakes, compressor and all other heat sources.
- 7.3 Shuttle cars shall, so far as practicable, be constructed of non-flammable material.
- 7.4 Exposed aluminium or light metal alloys shall not be permitted in the construction of shuttle cars. For specific guide-lines refer Appendix A4.
- 7.5 An approved portable fire extinguisher shall be installed on the shuttle car in a position easily accessible by the driver. The extinguisher shall have a minimum SAA rating of 80BE.
- 7.6 Reflective medium shall be provided at each end and side of the vehicle in a position where it can be easily seen.
- 7.7 Wheel rims incorporating safety and/or locking rim plus retainers should be positioned so that the locking device is furthest away from the outside of the car. If this is not possible then suitable locking rim retainers shall be fitted. The air fill point shall be located for safe access from the outside of the shuttle car.
- 7.8 Tyre pressure shall be clearly displayed in the vicinity of each tyre except where tyres are fitted with polyurethane or similar material, or solid, in which case there shall be sign in the vicinity of each tyre to that effect.
- 7.9 Power assisted steering shall be capable of manual operation in the event of loss of power assistance to enable the shuttle car to be brought safely to rest.
- 7.10 Integrated hydraulic lift cylinders incorporating load locks, shall be fitted as required to ensure that the car body can be safely raised to a sufficient height to allow routine tyre changes and maintenance to be carried out safely. The lift cylinders shall be fitted with load locking valves attached directly to the cylinders. Refer Appendix A3
- 7.11 Mechanical stops shall be provided for the discharge conveyor boom to enable safe access under the boom when maintenance is required. The stops shall be capable of being installed without requiring access beneath the boom.  
  
The mechanical stops shall be stored on the shuttle car and be easily accessible. Notices shall be provided stating that stops shall be used to support the boom prior to access.
- 7.12 Lights shall be fitted to the shuttle car. The number of lights and their location shall be so as to provide sufficient illumination under all conditions of shuttle car operation.

- 7.13 Reversing of the conveyor if required shall be so arranged that reverse operation will not occur inadvertently.

A spring loaded switch or valve having both depress and rotary motion to achieve reverse position is considered satisfactory. The switch or valve shall be biased to neutral.

7.14 **Noise**

Noise level during testing in an open area shall not exceed 83 dB(A) at the position of the operator's head.

7.15 **Manuals**

- 7.15.1 A recommended operating manual and maintenance manual shall be provided. Such manuals shall relate where required to general items under the CMRA 67/1982 section 101 Transport

Rules and Section 103 Schemes for the testing of electrical or mechanical apparatus.

- 7.15.2 Sufficient information shall be supplied by the manufacturer to ensure that the requirements of the Occupational Health and Safety Act, 1983. No 20 are complied with, this includes but is not limited to Clause 18.

**8. Labelling**

The labels required shall include but be not limited to the following where applicable:-

- 8.1 Identification of all controls and direction of the controls.
- 8.2 The date of manufacture.
- 8.3 The tare and gross weight of the shuttle car.
- 8.4 Maximum operating grade.
- 8.5 Towing instructions.
- 8.6 A warning at all accumulators that pressure must be safely released before work commences. (sect. 5.5)
- 8.7 A warning on any spring applied brake chamber that it contains a spring under compression.

- 8.8 An operator check list is to be provided within the control compartment denoting the minimum operator checks prior to operating the machine. The check list will be constructed of engraved "Traffolyte" or similar. (See appendix A5).
- 8.9 Tyre pressure shall be clearly displayed in the vicinity of each tyre except where tyres are solid, filled with polyurethane or similar material, partial water fill, in which case there shall be a sign in the vicinity of each tyre to that effect.
- 8.10 Minimum safe operating pressure shall be marked on the pressure gauges of hydraulic and/or pneumatic braking systems.
- 8.11 A danger sign shall be placed in the proximity of the raising/lowering device instructing that the mechanical locking device (sect 7.11) shall be used before commencing maintenance.
- 8.12 A warning that the park brake shall be applied before leaving the vehicle.
- 8.13 Minimum safe operating pressure for the cable reel system shall be marked in the vicinity of the relevant pressure gauge.

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