

Australian Standard™

Lifts, escalators and moving walks

**Part 3: Passenger and goods lifts—
Electrohydraulic**



This Australian Standard was prepared by Committee ME-004, Lift Installations. It was approved on behalf of the Council of Standards Australia on 16 November 2002 and published on 31 December 2002.

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Australian Standard™

Lifts, escalators and moving walks

Part 3: Passenger and goods lifts— Electrohydraulic

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PREFACE

This Standard was prepared by the Australian members of Joint Standards Australia/Standards New Zealand Committee ME-004, Lift Installations, to supersede AS 1735.3—2001.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to provide requirements for electrohydraulic lifts that carry passengers and goods.

The objective of this revision is to update the Standard, and to harmonize its requirements with BS EN 81-2:1998.

This Standard forms Part 3 of the AS 1735 series of Standards.

Other Parts in this series are as follows:

- Part 1: General requirements
- Part 2: Passenger and goods lifts—Electric
- Part 4: Service lifts —Power-operated
- Part 5: Escalators and moving walks
- Part 7: Stairway lifts
- Part 8: Inclined lifts
- Part 9: Special purpose industrial lifts
- Part 10(Int): Tests
- Part 11: Fire-rated landing doors
- Part 12: Facilities for persons with disabilities
- Part 13: Lifts for persons with limited mobility—Manually powered
- Part 14: Low-rise platforms for passengers
- Part 15: Low-rise passenger lifts —Non-automatically controlled
- Part 16: Lifts for persons with limited mobility — Restricted use — Automatically controlled
- Part 17: Lifts for people with limited mobility —Restricted use — Water-drive
- Part 18: Passenger lifts for private residence — Automatically controlled

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

Statements expressed in mandatory terms in notes to tables are deemed to be requirements to this Standard.

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STANDARDS AUSTRALIA

Australian Standard

Lifts, escalators and moving walks

Part 3: Passenger and goods lifts—Electrohydraulic

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out requirements for electrohydraulic lifts for carrying passengers and goods.

This Standard is complementary to AS 1735.1 and AS 1735.2, but the requirements of this Standard take precedence over corresponding requirements of those Standards.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1210	Pressure vessels
1532	Short pitch transmission precision roller chains and chain wheels
1572	Copper and carbon alloys—Seamless tubes for engineering purposes
1735	Lifts, escalators and moving walks
1735.1	Part 1: General requirements
1735.2	Part 2: Passenger and goods lifts—Electric
1735.10(Int)	Part 10: Tests
3791	Hydraulic hose
3990	Mechanical equipment—Steelwork
4058	Precast concrete pipes (pressure and non-pressure)
AS/NZS	
4130	Polyethylene (PE) pipes for pressure applications
ISO	
4347	Leaf chains, clevises and sheaves
BS	
3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes

BS	
3602	Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties
3602.1	Part 1: Specification for seamless and electric resistance welded including induction welded tubes
3602.2	Part 2: Specification for longitudinally arc welded tubes
3603	Specification for carbon and alloy steel pipes and tubes with specified low temperature properties for pressure purposes
3604	Steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties
3604.1	Part 1: Specification for seamless and electric resistance welded tubes
3604.2	Part 2: Specification for longitudinally arc welded tubes
ASTM	
D97	Standard test method for pour point of petroleum products
D2270	Standard practice for calculating viscosity index from kinematic viscosity at 40 and 100°C

1.3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 1735.1 apply.

SECTION 2 SPEED

The rated car speed of an electrohydraulic lift in the upward direction, under full load conditions, shall be not more than 1 m/s.

The maximum car speed in the upward direction, under full load condition, shall not exceed any rated speed by more than 5%.

The speed in the downward direction, under full load conditions, shall not exceed the relevant maximum value given in Table 2, subject to a maximum car speed of 1.4 m/s in the downward direction.

TABLE 2
MAXIMUM CAR SPEED IN DOWNWARD DIRECTIONS

Type of lift	Maximum speed in downward direction (% of up car speed)	
	Where full rated load up speed ≤ 0.5 m/s	Where full rated load up speed > 0.5 m/s ≤ 1 m/s
Passenger	150	140
Passenger and goods	150	140
Goods	160	150*

* Subject to a maximum of 1.4 m/s.

SECTION 3 PRESSURE TEST AFTER ERECTION

After erection, but before being put into service, all the hydraulic equipment supporting the load shall be subjected to a hydraulic pressure test as described in AS 1735.10(Int), except that where a stored energy pumping system is used (see Clause 7.8), the test pressure shall be 125% of the maximum stored pressure or double the full load pressure.

SECTION 4 BEAMS, SUPPORTS, AND FOUNDATIONS FOR CYLINDERS, MACHINES AND OVERHEAD SHEAVES

Beams, floors, and other structures for the support of cylinders, machines, diverting sheaves or overhead sheaves shall comply with the relevant requirements of AS 1735.1 and Sections 3 and 4 of AS 1735.2.

SECTION 5 MACHINERY LOCATIONS

5.1 GENERAL

Hydraulic lift machinery, other than rams and cylinders, shall be located in a machine room or a machinery enclosure.

Machine rooms and machinery enclosures shall comply with the relevant requirements of Section 5 of AS 1735.2, excluding Clause 5.1.2.

The equipment accessibility and clearances for machine rooms shall be as shown in Figure 5.1.

5.2 MACHINE ROOM LOCATION RELATIVE TO LIFTWELL

Machine rooms shall be located beside, above or below the liftwell, unless this is prevented by special circumstances such as a hazardous location, e.g. explosives factory or chemical works.

If the machine room is not located beside, above or below the well, the hydraulic piping and the electric wiring connecting the machine room with the lift well shall be installed in a duct or trough or in a section of a duct or trough, specially reserved for this purpose and be accessible for inspection.

5.3 COMMUNICATIONS

For machine rooms located as described in Clause 5.2, one of the following communication methods shall be provided:

- (a) A fixed wire mesh or an expanded metal panel that—
 - (i) is not installed in front of any car entrance throughout the travel and overtravel of the lift;
 - (ii) has a clear opening of at least 0.1 m²;
 - (iii) is made of either crimped or welded wire not less than 3.0 mm in diameter, or expanded metal not less than 1.5 mm thick; and
 - (iv) rejects a 32 mm diameter ball, and any aperture has a major diagonal dimension of not more than 45 mm or, where the screen is within 75 mm of any moving surface, the screen rejects a 12 mm diameter ball.

Where a sliding or hinged cover has been fitted over the panel, means of opening and closing the cover shall be not more than 1800 mm above the machine room floor. Where a glass panel is used, it shall comply with the relevant requirements of AS 1735.2.

- (b) An intercom system or similar device, powered by an emergency power supply, shall be installed to allow communication between inside the car and the machine room/enclosure.

5.4 LIFT MOVEMENT OBSERVATION

For machine rooms located as described in Clause 5.2, one of the following methods shall be provided so that observation of lift movement can be made from the machine room:

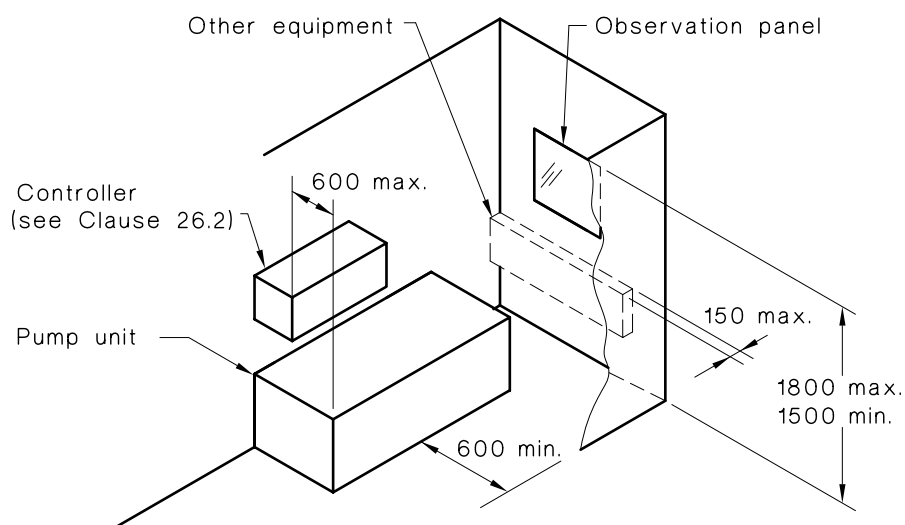
- (a) A wire mesh or an expanded metal panel complying with Clause 5.3(a) but with minimum area of 0.2 m^2 with at least one side 450 mm, with the top of the panel not more than 1800 mm nor less than 1500 mm above the machine room floor. Standing room of not less than $600 \times 600 \text{ mm}$ shall be provided on the machine room floor in front of the panel, provided that other equipment attached to the wall, above or below the panel, does not project more than 150 mm.

Where the observation is to be through the machine room floor, the wire mesh or expanded, metal panel shall be on an enclosed stand not less than 900 mm above the floor and not less than 300 mm square or round.

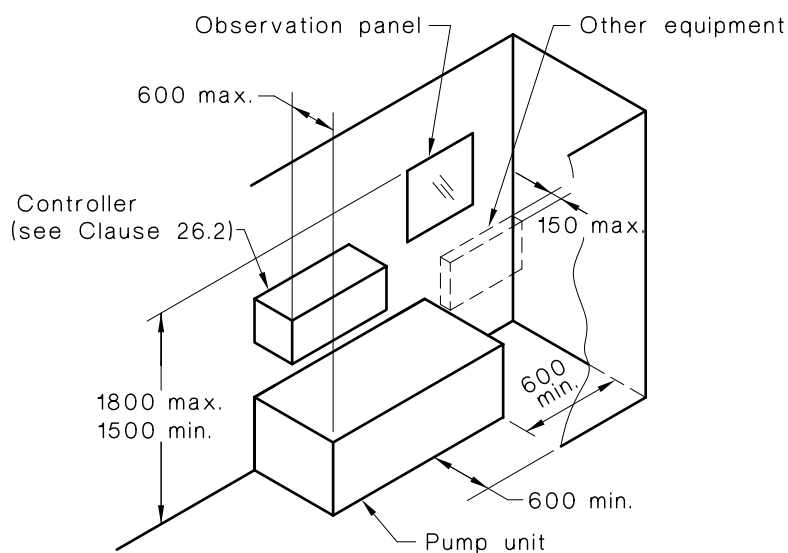
- (b) An indicator to show lift movement shall be provided in the machine room/enclosure. Such indicator shall still be operable in the event of a mains power failure.

NOTE: A governor in the machine room would comply with this requirement if it clearly indicates movement of the lift car without the removal of any covers.

- (c) For lifts that serve more than two levels, it shall be possible to check from the controller whether the car is in an unlocking zone. Such means shall still be operable in the event of a mains power failure.



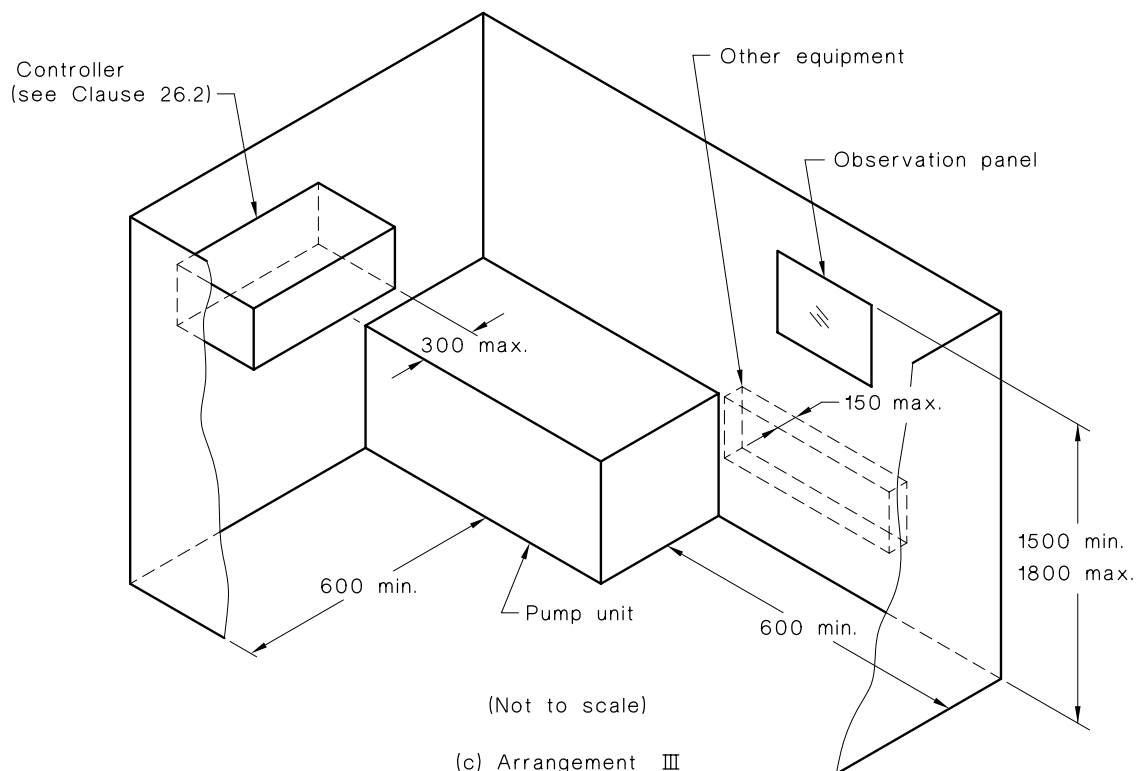
(a) Arrangement I



(b) Arrangement II

DIMENSIONS IN MILLIMETRES

FIGURE 5.1 (in part) TYPICAL EQUIPMENT LOCATION ARRANGEMENTS



DIMENSIONS IN MILLIMETRES

FIGURE 5.1 (in part) TYPICAL EQUIPMENT LOCATION ARRANGEMENTS

SECTION 6 ACCESS TO OVERHEAD SHEAVES

Where an electrohydraulic lift has overhead sheaves, such as for counterweight ropes, access to these shall be provided by means of a sheave room or platform.

Such a sheave room or platform shall comply with the relevant requirements of Section 6 of AS 1735.2.

SECTION 7 HYDRAULIC EQUIPMENT

7.1 GENERAL

This Section applies to all hydraulic equipment for direct or indirect acting electrohydraulic lifts.

For the purpose of this Section, the notation given in Appendix A applies.

7.2 RAMS

7.2.1 General

Rams may be single or multistage. They shall be of uniform diameter and have a uniform smooth finish on the outside, to ensure maximum life of packings and minimum oil leakage. Where rams are of hollow construction, they shall have a substantially uniform wall thickness.

7.2.2 Material

Rams shall be of steel or other approved ductile metal. Grey cast iron or other brittle material shall not be used for the ram or its connecting couplings to the car.

7.2.3 Ram design

7.2.3.1 General

Rams shall be designed and constructed in accordance with Clauses 7.2.3.2, 7.2.3.3 and 7.2.3.4. The maximum permissible slenderness ratio (λ) of a hollow ram shall be 300, or of a solid ram shall be as calculated by the following equation:

$$\lambda = 0.67 \sqrt{\frac{EA_n}{M}}$$

Having regard to the requirements of Section 21 of AS 1735.2 that guide shoes be provided at the top and bottom of each car frame, rams shall not be subjected to eccentric loading.

7.2.3.2 Buckling calculations

Solid or hollow rams under compressive loads shall be designed and constructed such that in their fully extended position, and under the forces resulting from a pressure equal to 1.4 times full load pressure, a safety factor of at least 2 against buckling is assured. The calculation shall be carried out in accordance with the equations given in Figures 7.2.3.2(A), 7.2.3.2(B) or 7.2.3.2(C), as appropriate.

7.2.3.3 Pressure calculations

Hollow rams subjected to external pressure shall be designed such that under the forces resulting from a pressure equal to 2.3 times the full load pressure, a safety factor of at least 1.7 referred to the proof stress $R_{p0.2}$ is assured. The calculations shall be carried out in accordance with Clause 7.3.2.

7.2.3.4 Tensile stress calculations

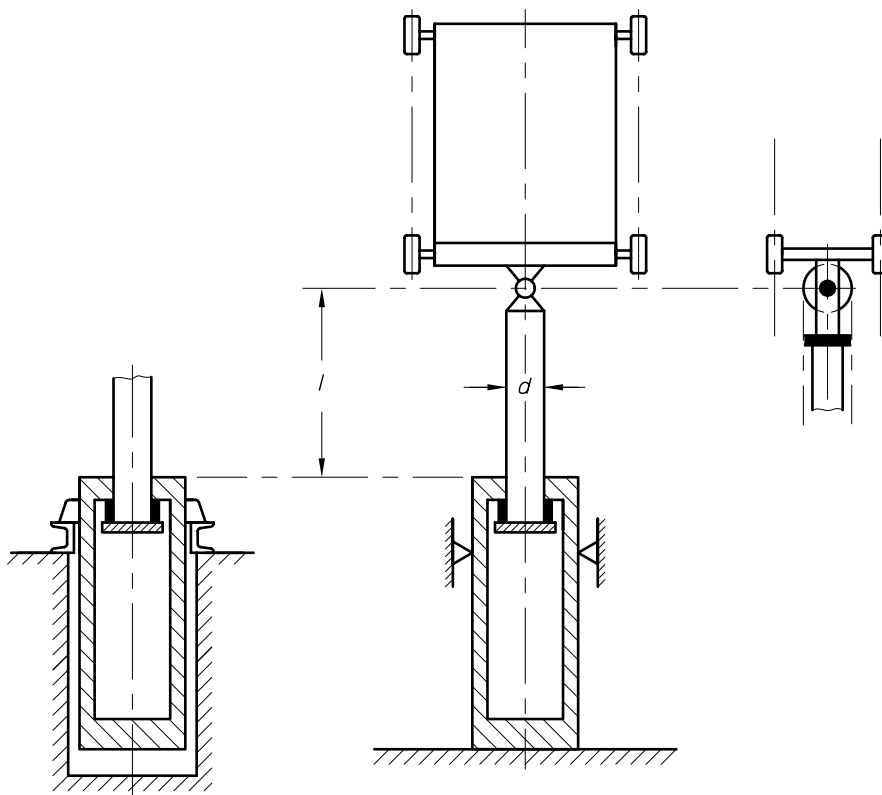
Solid or hollow rams under tensile loads shall be designed such that under the forces resulting from a pressure equal to 1.4 times full load pressure, a safety factor of at least 2 referred to the proof stress $R_{p0.2}$ is assured.

7.2.4 Ram connection

Any direct-acting ram shall be attached to the car frame with a connecting coupling of sufficient strength to support the mass of the ram with a factor of safety of not less than 4 on ultimate tensile strength. Such connections shall be designed to prevent eccentric loading of the ram.

Connection between car and ram shall be designed to a factor of safety of 4 on ultimate tensile strength, to prevent disengagement of the ram from the car when the ram strikes the ram stops, with the car travelling upward at rated speed.

When isolated ram connections are provided, measures shall be taken to ensure the rams do not become dislodged from the coupling.



For $\lambda_n < 100$:	For $\lambda_n \geq 100$:
$F_s \leq \frac{A_n}{2} \left[R_m - (R_m - 210) \left(\frac{\lambda_n}{100} \right)^2 \right]$	$F_s \leq \frac{\pi^2 E J_n}{2 \ell^2}$
$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh}]^*$	$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh}]^*$

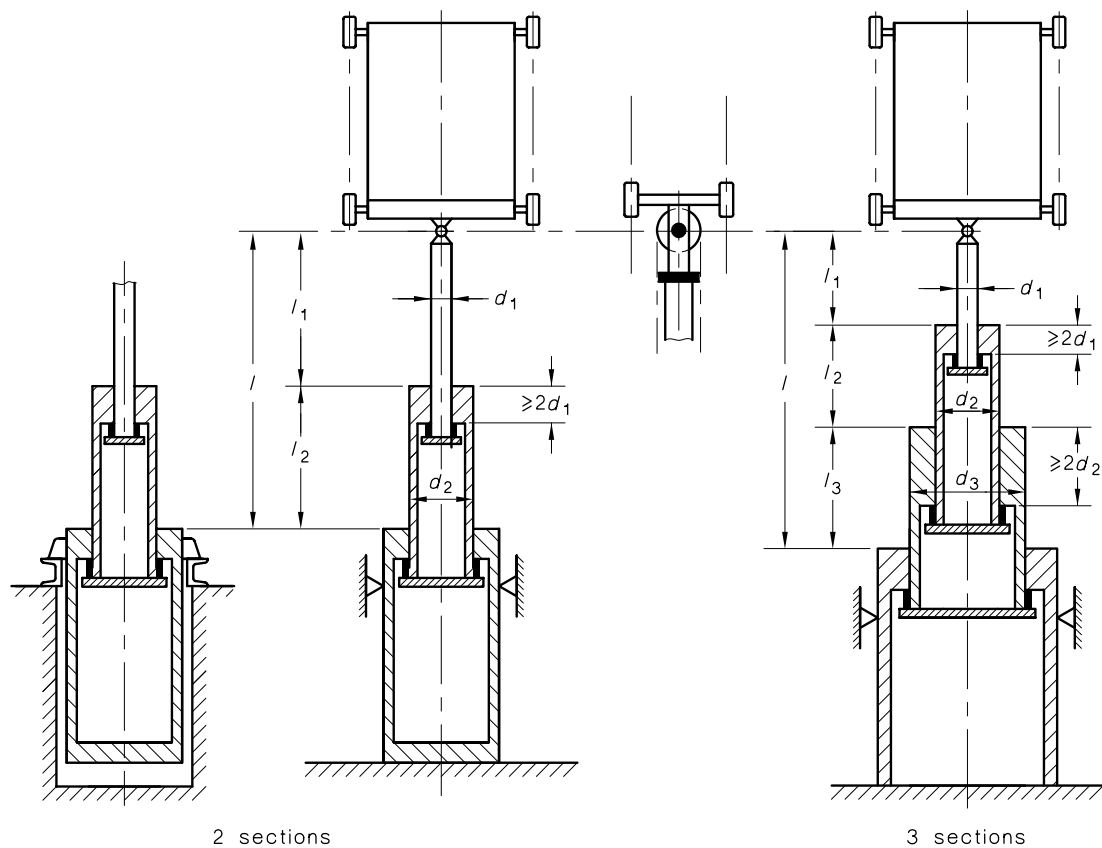
* Valid for rams extending in upward direction.

FIGURE 7.2.3.2(A) SINGLE STAGE RAM AND CYLINDER

7.2.5 Ram joints

Rams composed of more than one section shall have the joints designed and constructed to—

- (a) carry in tension the mass of all ram sections below the joint; and
- (b) transmit in compression the gross load on the ram with a factor of safety of not less than 5, based on ultimate tensile strength.



2 sections

3 sections

2 Sections:

$$l = l_1 + l_2, \quad l_1 = l_2$$

$$v = \sqrt{\frac{J_1}{J_2}}; \quad (J_2 \geq J_1)$$

$$\phi = 1.25v - 0.25$$

3 Sections:

$$l = l_1 + l_2 + l_3, \quad l_1 = l_2 = l_3$$

$$v = \sqrt{\frac{J_1}{J_2}}; \quad (J_3 \geq J_2 > J_1)$$

(assumption for simplified calculation: $J_3 = J_2$)

$$\phi = 1.5v - 0.2; \quad \text{for } 0.22 < v < 0.65$$

$$\phi = 0.65v + 0.35; \quad \text{for } 0.65 < v < 1$$

$$\lambda_e = \frac{l}{i_e} \quad \text{with } i_e = \frac{d_m}{4} \sqrt{\phi \left[1 + \left(\frac{d_{mi}}{d_m} \right)^2 \right]}$$

For $\lambda_e < 100$:

For $\lambda_e \geq 100$:

Calculation of the section with the smallest solid cross-section

$$F_s \leq \frac{A_n}{2} \left[R_m - (R_m - 210) \left(\frac{\lambda \lambda_n}{100} \right)^2 \right]$$

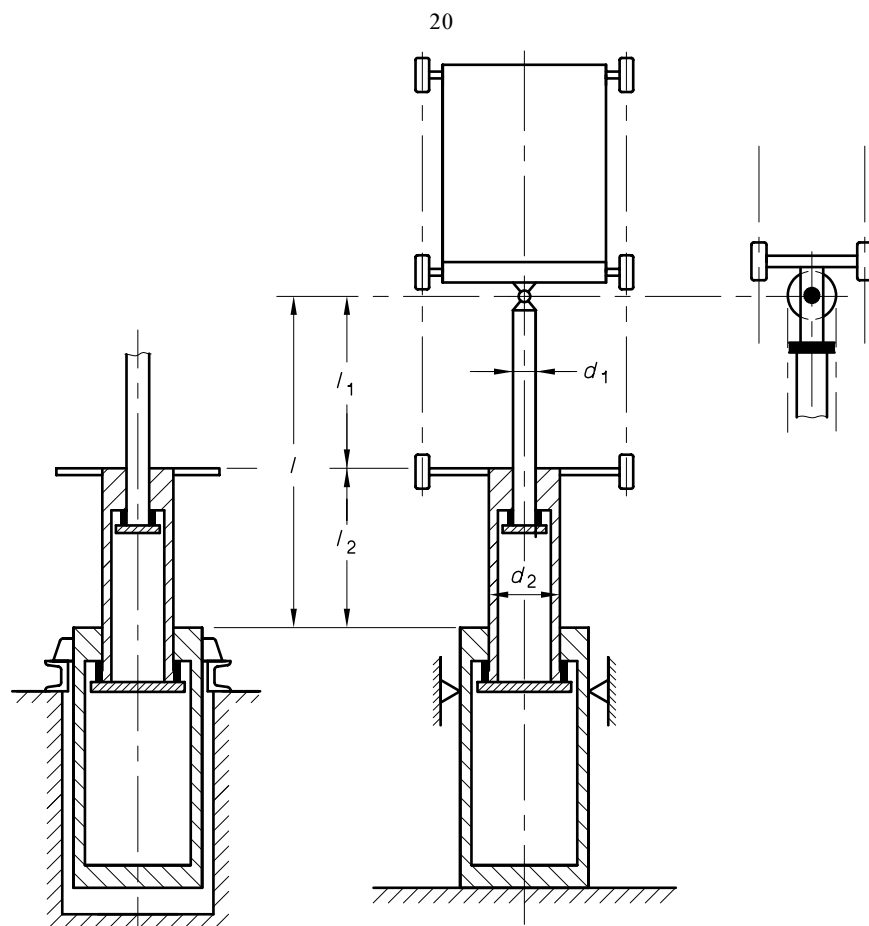
$$F_s \leq \frac{\pi^2 EJ_2}{2l^2} \cdot \phi$$

$$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh} + P_{rt}]^*$$

$$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh} + P_{rt}]^*$$

* Valid for rams extending in upward direction.

FIGURE 7.2.3.2(B) TELESCOPIC RAM AND CYLINDER WITHOUT EXTERNAL HEAD GUIDANCE

For $\lambda_n < 100$:For $\lambda_n \geq 100$:

Calculation of the section with the smallest solid cross-section

$$F_s \leq \frac{A_n}{2} \left[R_m - R_m - 210 \left(\frac{\lambda_n}{100} \right)^2 \right]$$

$$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh} + P_{rt}]^*$$

$$l = l_1, l_2$$

$$F_s \leq \frac{\pi^2 E J_n}{2 l^2}$$

$$F_s = 1.4 g_n [c_m (P_3 + Q) + 0.64 P_r + P_{rh} + P_{rt}]^*$$

* Valid for rams extending in upward direction.

NOTE: As a deviation from the buckling equations above, more complex calculation methods may be used provided that at least the same safety factor is assured.

FIGURE 7.2.3.2(C) TELESCOPIC RAM AND CYLINDER

7.2.6 Ram stops

Stops shall be provided to prevent rams from moving out of their cylinders under full load pressure at maximum speed.

The stops shall be of solid metal. They may be provided with hydraulic cushioning.

Where ram stops are used as car stops, they shall—

- maintain the clearances required in Section 8;
- maintain the lift car level; and
- prevent the car leaving its guides.

A hydraulic cushioned stop or a top overtravel limit switch shall be provided for lifts with full load-up speed of more than 0.5 m/s.

The cushioned stop shall retard the lift to a maximum speed of 0.5 m/s with a retardation not greater than 1g before reaching the limit of travel. The top overtravel limit switch, complying with Clause 31.3, shall cause the lift to retard to a maximum speed of 0.5 m/s with a retardation not greater than 1g.

7.2.7 Car stops for upward travel

Car stops may be provided to limit the top overtravel where a ram stop does not provide the required limit.

Car stop devices shall—

- (a) be of the impact-absorbing type;
- (b) be external to the ram;
- (c) be outside the car roof area;
- (d) maintain the clearances required in Section 8;
- (e) maintain the lift car level;
- (f) prevent the car leaving its guides; and
- (g) be able to absorb the mechanical energy of the system—
 - (i) under full load pressure at maximum speed;
 - (ii) within their strokes;
 - (iii) without permanent deformation of the equipment;
 - (iv) without causing eccentric loading on the ram; and
 - (v) at a retardation not greater than 1g.

7.2.8 Ram ends subject to fluid pressure

Ram ends subject to fluid pressure shall comply with the requirements of Clause 7.3.4.

7.2.9 Ram-follower guide

Ram-follower guides may be used on single stage rams. In such cases, the guide shall be roped to the car so that it is always approximately at the midpoint of the extended part of the ram. Means shall be provided to open the control circuit should the supporting ropes of a ram-follower fail.

7.2.10 Head guide

Head guides for telescopic rams and cylinders, where required, shall be designed to prevent lateral movement of the head.

7.3 CYLINDERS

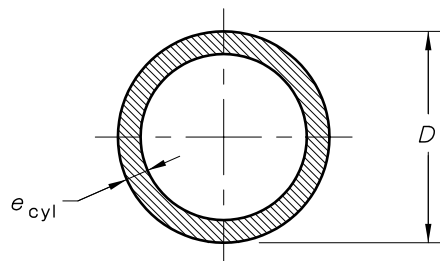
7.3.1 Materials

Cylinders shall be of steel or other approved ductile metal.

7.3.2 Cylinder design

Cylinders shall be designed such that under the forces resulting from a pressure equal to 2.3 times the full load pressure, a safety factor of at least 1.7 referred to the proof stress $R_{p0.2}$ is assured. The calculations shall be carried out in accordance with the equation given in Figure 7.3.2.

For the calculation of the various elements of a telescopic ram and cylinder assembly that has hydraulic synchronization, the full load pressure shall be replaced by the highest pressure that occurs in an element because of hydraulic synchronizing.



$$e_{\text{cyl}} \geq \frac{2.3 \times 1.7 \times p}{R_{p0.2}} - \frac{D}{2} + e_o$$

e_o = 1.0 mm for wall and base of cylinders and rigid pipes between the cylinder and the rupture valve, if any

= 0.5 mm for rams and other rigid pipes

2.3 = factor for friction losses (1.15) and pressure peaks (2)

1.7 = safety factor referred to the proof stress

FIGURE 7.3.2 CYLINDER WALL THICKNESS

7.3.3 Clearance at bottom of cylinder

Clearance shall be provided at the bottom of the cylinder so that the bottom of the ram will not strike the bottom of the cylinder when the car is resting on its fully compressed buffer.

7.3.4 Cylinder and ram ends

7.3.4.1 General

Ends of cylinders and ends of rams shall be welded or positively retained.

7.3.4.2 Thickness of cylinder end

The thickness of the cylinder ends (e_1 , e_2 and e_3) shall be determined by the equations given in Figure 7.3.4.2.

7.3.4.3 Dished seamless ends convex to pressure

Dished seamless ends, convex to pressure, shall have a maximum allowable working pressure of not more than 60% of that for ends of the same dimension with pressure on the concave sides.

7.3.4.4 Reinforced ends

Reinforced ends shall be designed and constructed so that the maximum stress at rated capacity does not exceed the limits specified in Clauses 7.3.2, 7.3.4.2 and 7.3.4.3.

7.3.4.5 Ends subject to mechanical loads, in addition to fluid pressure loads

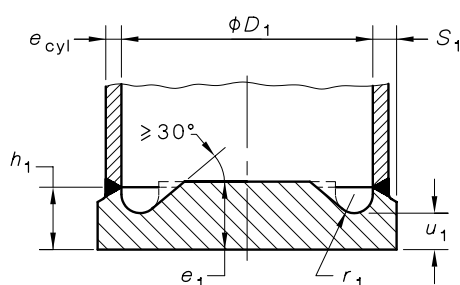
Pressure ends subject to mechanical load, in addition to fluid pressure loads, shall be designed and constructed so that the combined stresses do not exceed the limits specified in Clauses 7.3.2, 7.3.4.2 to 7.3.4.3.

7.3.5 Collection of oil leakage

Means shall be provided to collect any oil leakage from the cylinder-packing gland for convenient disposal.

7.3.6 Bleeding off air or gas

Means shall be provided for bleeding off air or gas from the cylinders, without the lift having to travel beyond the normal overtravel.



Conditions for the stress relief of the welding seam:

$$r_1 \geq 0.2 S_1 \text{ and } r_1 \geq 5$$

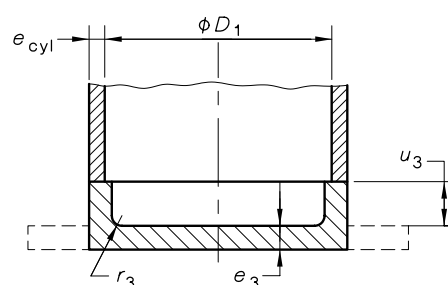
$$u_1 \leq 1.5 S_1$$

$$h_1 \geq u_1 + r_1$$

$$e_1 \geq 0.4 \times D_1 \times \sqrt{\frac{2.3 \times 1.7 p}{R_{p0.2}}} + e_0$$

$$u_1 \geq 1.3 \times \left\{ \frac{D_1}{2} - r_1 \right\} \times \frac{2.3 \times 1.7 \times p}{R_{p0.2}} + e_0$$

(a) Flat end with relieving groove



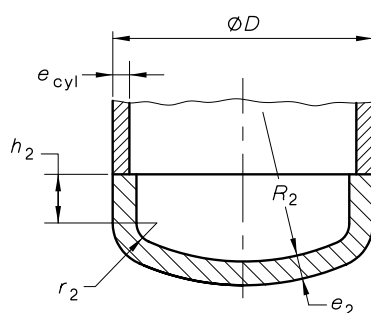
Conditions:

$$u_3 \geq e_3 + r_3$$

$$r_3 \geq \frac{e_{cyl}}{3} \text{ and } r_3 \geq 8$$

$$e_3 \geq 0.4 \times D_1 \times \sqrt{\frac{2.3 \times 1.7 \times p}{R_{p0.2}}} + e_0$$

(b) Flat end with welding flange



Conditions:

$$h_2 \geq 3.0 e_2$$

$$r_2 \geq 0.15 D$$

$$R_2 \geq 0.8 D$$

$$e_2 \geq \frac{2.3 \times 1.7 \times p}{R_{p0.2}} \frac{D}{2} + e_0$$

(c) Concave end

FIGURE 7.3.4.2 CYLINDER ENDS

7.3.7 Cylinder protection

Where a cylinder or part thereof is below ground level, it shall be enclosed in a waterproof caisson of medium density polyethylene (MDPE), concrete, or mild steel. Concrete pipes shall comply with AS 4058. Steel pipes shall comply with BS 3601, BS 3602, BS 3603 or BS 3604, as appropriate. MDPE shall comply with AS 4130.

Caissons of mild steel, concrete or MDPE shall be of the following minimum wall thicknesses and factors of safety (FoS).

- (a) Mild steel 6 mm, FoS 2.
- (b) Concrete 25 mm, FoS 4.
- (c) MDPE type 80 MRS 10 mm, FoS 2 (on base) FoS 4 (on wall).

For applicable minimum thickness for MDPE, see Appendix B.

FoS shall be based on ultimate tensile strength.

The caisson shall extend to not less than 150 mm above the floor of the liftwell and the space between the caisson and the cylinder shall be provided with a detachable cover or covers, to facilitate inspection.

Adequate provisions shall be made to restrain the caisson from floating upwards. The lower end shall be capable of withstanding the hydrostatic pressures that may occur.

The outer surfaces of the cylinder shall be protected against corrosion by a protective coating, as recommended by the manufacturer.

For inspection purposes, the mean space between the cylinder and the caisson shall be not less than 75 mm; i.e., the bore of the caisson shall exceed the outside diameter of any part of the cylinder by not less than 150 mm. The cylinder should be concentric with the caisson. Any part of the cylinder and cylinder assembly shall be clear of the caisson by not less than 25 mm. The space between the cylinder and the caisson shall be left unfilled.

Hydrostatic pressure shall be considered for the purpose of design, and shall be taken from ground level to the bottom of the caisson.

7.3.8 Cylinder restraint

Cylinders supported at the base shall be restrained from lateral movement. Such restraint shall be provided close to the top of the cylinder and the bottom of the cylinder. For centrally located cylinders under the lift car, support means shall be provided close to the head of the cylinder.

7.3.9 Multiple cylinders

If several ram and cylinder units are used to raise the car, they shall be hydraulically connected to ensure pressure equilibrium.

7.3.10 Multiple-axis telescoping cylinders

Where the arrangement is multiple-axis telescoping rams and cylinders, means shall be provided to compensate for any eccentric loading.

7.4 HYDRAULIC LINES

7.4.1 General

7.4.1.1 General

Pipelines and fittings shall be designed for hydraulic application and shall comply with Table 7.4.

7.4.1.2 Length

Any lengths of hydraulic lines shall be as short as possible and the number of joints and fittings shall be kept to the reasonably practicable minimum.

Joints shall not be used in hoses to achieve the required length.