- From circular or rectangular hollow sections (CHS or RHS) to BS EN 10210:10210 with all-welded construction.

RHS handrail standards may be designed to take conventional tubular handrails or be to be used with RHS handrails. In the latter case the whole assembly is usually prefabricated in suitable lengths for site assembly. Rails may be joined to handrail standards by welding or by bolted inserts.

The use of angles to form both handrails and handrail standards is permissible.

Tubular handrails should have a clearance of approximately 1.5 mm in the handrail standards.

Fixing bases may be flat or palm as shown in Figure 24. Where handrail standards are to be fitted permanently to a concrete floor or stairway, the spigot fixing shown in Figure 3 may be used.

Proprietary fittings may be used provided that their strength and fixing details are adequate for the specified loading.

It is necessary to ensure that platform or stairway members to which the handrail standards are bolted have adequate strength and rigidity to withstand the twisting moment imposed by the handrail standards.

Stanchions should never be mounted from toe plates unless these are substantial structural members. Flat plates are totally inadequate for this purpose.

Figure 3 and Figure 25 illustrate recommended fixings to concrete and steelwork, respectively.

Typical dimensions of handrail standards for horizontal loadings of 0.36kN/m and 0.74 kN/m are given in Tables 3 and 4 as examples of commonly used spacing of standards. However, the designer must be satisfied that stresses and deflections are within permissible limits for the standard, base plate, fixings and supporting structure. Circular and rectangular hollow sections should be to BS EN 10210 or BS EN 10219[62]. Where forged standards are used technical data sufficient to confirm their suitability for the application should be obtained from the supplier. It should be noted that many of the standard two ball type standards available are not compliant with the Work at Height Regulations 2005 unless some sort of infill is provided.

The minimum base width (at right angles to the line of the handrail) and bolt size given for each loading refer to a base with two bolts in line with the handrail. Other types of base give a lower bolt stress. Bolts are assumed to be Grade 8.8.

Table 3 Medium duty handrail standards 0.36 kN/m, minimum base width 65 mm, minimum bolt size 16 mm

Maximum pitch	CHS		RHS		
Mm	mm o.d.	mm thick	mm	mm	mm
1800	48.3	3.2	--	--	--
1500	42.4	3.2	--	--	--
1200	42.4	2.6	--	--	--

Table 4 Heavy duty handrail standards 0.74 kN/m, minimum base width 75 mm, minimum bolt size 20 mm, three or four bolts preferred

Maximum pitch	CHS		RHS		
Mm	mm o.d.	mm thick	mm	mm	mm thick
1800	48.3	4.9*	63.5	38.1	3.2
			50.8	50.8	4.0
1500	48.3	4.0*	-	-	-
1200	48.3	4.9	38.1	38.1	4.0*
1000	48.3	4.0	38.1	38.1	4.0
*Note: * denotes material grade S355JO*					

11.4 Handrails

Tubular handrails should be made from tube to BS EN 10255 Non-alloy steel tubes suitable for welding and threading – or solid bar where environmental, or technical delivery conditions make it necessary.

Tubes should be butt jointed using tubular steel ferrules or proprietary inserts that may be pinned, screwed or dimpled. Aluminium plugs are not approved. Ferrules for heavy-duty handrails should be double length (see Figure 23).

Joints between handrails and steel ferrules should be made with countersunk head pins or plug welds. Joints in continuous handrails should be positioned at points of minimum stress, and not more than 150 mm from the centreline of a stanchion. They should not be placed outboard of end stanchions and neither should they be placed between corner stanchions. Joints should not have any sharp edges or projections (see Figure 22).

It is important that joints should be correctly positioned at points of minimum stress (see Figure 22) and so arranged that the security of an end or corner rail is not dependent on the security of a joint beyond a standard fixing point.

All handrails should be prevented from rotating or moving longitudinally through the handrail standards. This may be ensured by the use of pins, grub screws or by welding. On long runs, there should be a fixing to at least one in every four handrail standards. Any burrs or projections should be removed after pinning or welding, in order to leave the handrail with a smooth finish.

The ends of the handrail should always be secured and their open ends should be bent over to form a continuous return to avoid any risk of catching or injury.

The recommended dimensions for the two examples given in 11.3 are as follows:

- Medium duty (0.36 kN/m): 33.7 mm o.d. x 3.2 mm thick;
- Heavy duty (0.74 kN/m): 33.7 mm o.d. x 3.2 mm or 4 mm thick.

For use with RHS handrail standards: 38.1 x 38.1 x 2.6 mm RHS handrail gives a stronger section at lower cost than 33.7 mm o.d. tube. While this may be attractive for long straight rails, corners should be mitred unless a solid bend is used. Fixing to handrail standards is also more complicated than for round tube. Tubing / solid bar and forged standards must be dimensionally matched, chosen not to exceed the permissible stress for the material, and to be within deflection limits.

11.5 Balustrades and panic barriers

Balustrades should be designed for the same loads as handrails with infilling balusters or panels, conforming generally to the requirements of BS 6180.

Panic barriers should be designed for a load of 3.00 kN/m, using circular or rectangular hollow sections with appropriate infilling members.

Various proprietary types of balustrades and barriers are available and are usually designed in short lengths to be bolted together on site.

11.6 Materials and finishes

Materials, such as stainless steel, high duty aluminium alloys, copper, or bronze, may be specified as alternatives to plain carbon steel where superior corrosion resistance, appearance or feel are important. The dimensions of handrails, handrail standards and balustrades made from these materials will depend on the mechanical properties of the material and the condition in which it is used. Where these are offered or specified, supportive stress calculations should be available.

It is recommended that where carbon steel fabricated hollow handrail standards are made, that these should be galvanised after welding to give maximum internal protection against corrosion and to give a superior surface for normal paint systems applied externally. Where corrosion resistance is not an issue, painting or plastic covering may be used.

Handrails on walkways and stairways should be continuous to avoid finger traps. Where bolts are used on handrail connections, they should have dome heads or be countersunk, and to be of the correct length allowing only nominal thread lengths to project through the nut. Handrails should be free of any projection, burrs and any exposed corners rounded off, so as to eliminate any snags.

11.7 Self-closing safety gates

Potentially hazardous areas, such as at the gap in handrails at the head of a ladder or companionway, should be protected by a self-closing gate, which should close gently but securely and should be designed to swing onto the landing (see Figure 27). Hold-open devices should never be fitted. Chains and single lift-up bars should never be used in place of a self-closing safety gate. See Section 6.2 for details.

12 Ladders for access to high structures

Roof ladders are not included within the scope of this Publication, however guidance on roof ladders can be found in BS EN 12951:2004 Prefabricated accessories for roofing – Permanently fixed roof ladders – Product specification and test methods[63].

Access to cranes is also excluded from the scope of this Publication and guidance on this topic can be found in BS EN 13586:2004 + A1:2008 Crane Access[64].

12.1 General

This Section generally follows the requirements of BS 4211 Specification for permanently fixed ladders.

Ladders can be steel ladders with single bar rungs and fixed to high structures including chimneys to provide means of access. Where ladders are used on chimneys, provision of rest platforms may present design problems and a continuous length of ladder may be used. Safety hoops or other approved form of fall arrester (see BS EN 353:2002) should be incorporated if practicable. These ladders should only be used by persons competent to do so, e.g. steeplejacks.

Ladders are often used in relatively short lengths between working platforms, normally up to 6 metres between landings where practicable. Potential users should refer also to BS 3678:1986 Specification for access hooks for hooks for chimneys and other high structures in steel[65] and BS 3572:1986 Specification for access fittings for chimneys and other high structures in concrete or brickwork[66].

Other such ladders are constructed in steel or aluminium and are suitable for general use. They are unsuitable for manholes for sewerage and drainage installations, and in other installations where atmospheric pollution may be anticipated.

Ladders to be fitted within existing vertical columns are not specified separately in the Standard. It may be assumed that the choice of ladder will be based on the presence or otherwise of corrosive conditions. Adequate lighting should be provided to enable a user to climb or descend in safety. Where ladders are to be fitted inside existing columns, rest platforms may be avoided, if they present design problems, provided that safety hoops are fitted. The design of new columns with internal ladders should make provision for rest platforms.

The top two hoops and connecting straps of all possible escape routes on a downward path, as well as the top bar of any safety gate that leads to the ground level, should be finished in 'day-glow' orange. Great care should be taken to ensure that no inappropriate ladders, such as those for maintenance purposes and leading to dead-ends, are identified as escape ladders.

12.2 Materials

12.2.1 General

Materials should be either low carbon steel complying with BS EN 10025-2[67] grade S275 galvanised sheet, or aluminium alloy complying with the following Table 5.

Table 5 Aluminium alloys

Form	Alloys
Extruded sections	6063 (HE9), 6082 (HE30), 6063 A 1200 (E1C) and 6061 (HE20),
Sheet and strip	1200 (S1C), 3103 (NS3), 5154A (NS5), 5251 (NS4) and 6082 (HS30), complying with BS EN 485[68]
Drawn tube	6063 (HT9) and 6082 (HT30), complying with BS EN 573[69]
Longitudinally welded tube	5251 (NJ4), complying with BS EN 1592[70]

12.2.2 Connections

Connection between components shall be by proven durable means selected to withstand the specified or calculated load. Traditional means are threaded fasteners or welding. Where these are used they shall be in accordance with the appropriate British Standard.

12.3 Stiles

12.3.1 Steel

Steel stiles should be of flat bar of minimum section 65 mm x 10 mm.

12.3.2 Materials other than Steel and ladder Loading

Where materials other than steel are used, the stiles shall be designed to resist the forces due to two persons each weighing 100 kg in transit on a 6 m section of ladder as fixed unless flights in excess of 6 m are used when the distance between supports should be used. Deflection in any direction shall not exceed 2 mm.

12.3.3 Width between stiles

The width between inside faces of the stiles should be between 400 mm and 450 mm. The stiles should be parallel and straight to within a tolerance of ± 10 mm in any 3 m length.

12.3.4 Stile Extensions

In order to permit users to safely access the top of the structure or any landing, the stiles should extend upwards, at the same angle as the ladder, or a similar upright provided, to a minimum height of 1000 mm above the surface or platform level. Such upward extensions shall not encroach on the clear width of the platform passageway and shall not deflect by more than 10 mm when subjected to a side (horizontal) load of 1.0 kN.

12.3.5 Jointing of stiles

If it is necessary for stiles to be in more than one length, they should be joined by a means which exposes no edges likely to scratch or cut, and which maintains the stiles in good alignment and structural continuity.

The EEMUA preference is for stiles to be joined using fish plates which are welded, riveted or bolted to the inside of the stiles, such that the finished joint

complies with the previous paragraph. Bolts or rivets shall be 12 mm diameter low carbon steel, or 10 mm diameter high tensile steel of grade S. Not less than two shall be used at each side of a joint. An alternative method is for the fishplate to be welded to one stile and bolted to the mating one.

Bolts or rivets shall be finished in one of the following ways:

- Hot galvanised to BS EN ISO 1461:2009[71];
- Sheradised to BS 4921:2002 Class 2[72];
- Cadmium coated and passivated to BS EN ISO 2082:2008[73];
- Zinc coated and passivated to BS EN ISO 2081:2008[74].

12.3.6 Stile Fixing

Stiles shall be fixed to the supporting structure by means of connectors or brackets designed to resist the applied loads, and to restrict stile movement at the fixing to no more than 5 mm. The method of attachment will depend upon the type of supporting structure. A minimum pull out resistance should be 0.5 kN.

Connectors shall be of sufficient length to give toe clearance of at least 150 mm behind the rungs (230 mm is preferable as shown in Figure 15C), and positioned to give side clearance at openings of between 150 and 230 mm (see Figure 15A and Figure 17).

12.4 Rungs

12.4.1 Spacing

Rungs should be uniformly spaced, throughout the entire length of the ladder, at centres between 225 mm minimum and 255 mm maximum.

The top rung should be the same height as the associated platform which may be extended either to replace the top rung or to ensure that the gap between the top rung and the platform does not exceed 75 mm.

12.4.2 Fixing to stiles

Rungs should be rigidly fixed to the stiles and should not rotate. If they protrude through the stiles, the protrusion should be minimal and smoothly finished.

12.4.3 Loading

Rungs shall be of a section capable of supporting a mass of 150 Kg spread over 100 mm at the centre of the rung, with a rung deflection of less than 2 mm.

12.4.4 Rung Material

As for normal fixed ladders (see Chapter 6), rungs in mild steel should be made from round section bar of 20 to 50 mm diameter.

Where aluminium alloys are used, extruded hollow section tubular rungs with anti-slip longitudinal ridges or a textured surface present an attractive alternative to plain round bars. Sections other than completely circular may be used for

alloy rungs, such as square with heavily radiused corners, provided that the flat face is parallel to the floor.

It is recommended that sections, such as angle iron, T iron, U section or other non-round shapes are not used.

12.5 Hoops and fall arrest systems

Hoops and straps should follow the general design criteria given in Clause 6.8.

On silos, the minimum steel section for the hoops and straps may be reduced to 30 mm x 5 mm.

Five vertical straps should be fitted internally to brace the hoops. One of these shall be fitted at the centre to support the back of a person using the ladder. The others are to be spaced equidistant between the centre back of the hoop and the ladder stiles with a gap of no more than 300 mm between them.

Alternatively a permanent fall arrest system as detailed in BS EN 353 may be incorporated.

12.6 Platforms

12.6.1 Spacing or height between platforms

The maximum distance between platforms should be 6 m wherever it is reasonably practicable.

12.6.2 Rest platforms

It is recommended that rest platforms should have a minimum dimension of 850 mm x 850 mm. They should be fitted with a guardrail at 1100 mm above platform level and should have an intermediate rail. A 150 mm high toe rail should also be provided to restrain the foot and to prevent items of equipment falling off the platform and injuring persons who may be below.

12.6.3 Work platforms

Where these are provided they should be sized to suit the work activity taking into consideration the number of people using it and any equipment and tools needed and shall have a slip resistant finish. Guardrails and toe plates, as above, are to be provided.

12.6.4 Obstructions at head of ladder

Where dwarf walls, parapets, copings or other obstructions could interfere with a direct exit from or approach to the ladder, at the level where access is required, the ladder shall be extended to give a platform spanning the obstruction. Minimum dimensions of platform shall be 600 mm wide x 840 mm deep.

12.6.5 Ladder line

The line of a ladder should be broken at landings in order to limit the free fall distance of any one using it.

12.7 Finish

12.7.1 General

Construction shall be carried out in a manner that ensures no sharp ends, or edges that could cut the user or hinder access.

12.7.2 Protection

The choice of finish to provide corrosion protection should be made taking into consideration environmental factors, e.g. coastal locations.

Where steel parts are hot dip galvanised, possible embrittlement of some materials after cold forming should be considered.

Aluminium components in non-aggressive atmospheres need have no additional protection. However anodising (BS EN ISO 7599:2010) [75], electroplated nickel or electroplated nickel and chromium (BS EN ISO 1456:2009) [76] may be used to provide additional protection.

13 Inspection and maintenance

It is important that a through life maintenance regime is established, implemented and maintained to ensure that access installations remain safe. Factors which could influence the safety of the installations are considered below.

13.1 Inadequate initial design/ installation

Although it is not required that new Standards are applied retrospectively to existing plant there is a requirement to ensure that installations do not present an unacceptable risk to personnel. All access installations should be the subject of a one-off inspection and appraisal by personnel competent to do so. A programme for the rectification of any deficiencies found should then be implemented as soon as practicable and interim control measures applied as required.

During this one-off inspection the load path of the access components should be established, where it is not obvious, to ensure that the inspection is fully comprehensive. This information should be used in the preparation of the regular inspections recommended in Section 13.2.

It is also recommended that a review of scaffold usage, particularly long term use, is performed to determine whether there is a safety and/or economic case for installing permanent access.

13.2 Deterioration and physical damage

Installations should be regularly inspected by competent personnel to ensure that they are still fit for purpose. The following should be included for consideration when preparing the inspection schedule:

- Condition of corrosion protection;
- Security of components, e.g. no missing or loose bolts, flooring clips, connections to other equipment/structures;
- Satisfactory operation of safety gates: ease of use and self-closing function and security of attachments;
- Physical damage to components;
- Functionality of lighting systems and emergency lighting on escape routes;
- Condition of warning signs;
- Integrity of fixings into concrete (this may need removal of surface concrete around fixing to check the extent of any corrosion).

The frequency of the inspections should be determined from a risk assessment taking account of all relevant factors, including:

- Condition of plant;
- Frequency and type of use;
- Environment;
- Vulnerability to corrosion and physical damage;
- Known requirement for removal of components for maintenance activities.

The inspections should be included with other programmes where practicable, e.g. Safety Walk Downs, routine civil assets inspections. It is recommended that inspection intervals do not exceed six months.