

Specification for

H-section steel arches for use in mines

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Committees responsible for this British Standard

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- Association of British Mining Equipment Companies
- British Coal Corporation
- British Steel Industry
- Health and Safety Executive
- Union of Democratic Mineworkers

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Foreword

This British Standard has been prepared under the direction of the Engineering Sector Board. It was first issued in 1926 and later revised in 1939, 1959, 1966 and 1970. This new edition takes into account further experience that has been gained in the use of steel arch supports in mines.

All dimensions and masses are specified in metric units. Equivalent imperial units are not given and should no longer be used. Use was made of British Coal Specification 114 and the British Coal draft specification for cambered and flat top roadway supports.

Agreement could not be reached on whether the torque tightening requirements for bolts and fasteners should be included and these are not therefore included in the standard.

The decline in the use of semi-circular and double-radiused arches has been reflected in the reduction of specified profiles from the previous edition. The introduction of retreat mining methods since the last revision has led to the creation of a new section for cambered and flat top arches. Because of the many design variations in the joints for cambered and flat top arches, a specification for this type based on performance has been introduced. The 114 × 114 section size referred to in the previous edition has been replaced by a 127 × 114 section of the same mass per unit length and all sections are now given as preferred, rather than specified, sizes and mass per unit lengths. Additionally only a single grade of steel is specified instead of the previous three.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and product surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS EN ISO 9000.

Enquiries as to the availability of third party certification are forwarded by BSI to the Association of Certification bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies requirements for H-section steel arches for use in underground roadways in mines.

This standard applies to semi-circular and double radiused profile arches and cambered and flat-top arches.

This standard excludes H-section steel arches used in roadway junction structures.

In addition to the definitive requirements, this standard also requires the items detailed in **6.1**, **6.2**, **7.1** and **7.5** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

NOTE Dimensions on figures are in millimetres.

2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1

mine

a facility established for extracting coal or other minerals from seams without removal of the overburden and accessed via a shaft or a drift tunnel

3.2

underground roadways

tunnels in mines for access, ventilation and extraction purposes

3.3

H-section steel arch

a structure made from lengths of hot rolled steel H-shaped section, manufactured specifically for the mining industry and used for supporting the sides and roof of underground roadways in mines. It comprises two or more side members or legs and one or more top members or beams or crowns to form a portal frame with an open base. The side members or legs may be splayed out at an angle

3.4

strut

a nominally horizontal structural member used to join adjacent arches to form a continuous structure along the length of the roadway as it is formed

3.5

strut hole

a hole placed centrally along the web of an arch member through which a bolt can be passed for the purpose of attaching struts

3.6

joint

the point at which mating members of an arch are joined during assembly

3.7

joint hole

a hole placed centrally along the web of a member to enable two members to be joined end to end, to form a butt joint by means of fishplates

3.8

fishplate

a plate used to join two members end to end to effect a butt joint. Fishplates are usually fitted in pairs between the flanges on each side of the web and bolted through with, usually, two bolts to each side of the joint. Fishplates can also be curved having the same curvature as the members in order to effect a continuously curved arch

3.9

fishplate holes

holes placed, usually in pairs, centrally along the web of the members to either side of a butt joint, through which bolts can be passed in order to join the members end to end using fishplates

3.10

fish bolts and nuts

bolts and nuts used to connect pairs of fishplates

3.11

cranked fishplate

a fishplate formed at an angle, usually 120° to 135°

3.12

corner brackets and clips

brackets and clips used to join members where the flange of the roof member is positioned to rest on the upper end of a side or leg member. The joint is effected using one or more bolts

3.13 single bolt joints

a type of joint used to join two members at an angle. They usually comprise mating lugs welded to the ends or sides of the members which can be bolted together to effect the joint using a single bolt

3.14 base width

the distance between the inside flanges of the H-section arch measured across the base

3.15 chord length

the distance measured in a straight line between the ends of an H-section member taken from the inside edges

4 Information and requirements to be agreed and to be documented

4.1 The following information to be supplied by the purchaser shall be fully documented. Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) for double radiused arches, the support base width (see 6.2);
- b) for cambered and flat top arches, the beam lengths and support heights (see 7.1).

4.2 The following item to be agreed between the contracting parties which are specified in the clauses referred to shall be fully documented. Both the definitive requirements specified throughout the standard and the following documented item shall be satisfied before a claim of compliance with the standard can be made and verified.

For all H-section members, the requirement, if any, for strut holes (see 6.1, 6.2 and 7.5).

5 Common requirements

5.1 General

Clauses 5.2 to 5.6 shall apply to all arches and members covered in clause 6 and clause 7 unless otherwise stated.

5.2 Material

The properties of the steel shall conform with Table 1 and shall be tested in accordance with Annex A.

Table 1 — Steel properties

Chemical composition	
Carbon	0.25 % max.
Sulfur	0.060 % max.
Phosphorus	0.060 % max.
Nitrogen	0.010 % max.
Manganese	1.60 % max.
Silicon	0.50 % max.
Mechanical properties	
Tensile strength	430 – 580 N/mm ²
Elongation	22 % min.

NOTE An example of such a steel is grade Fe 430 B of BS EN 10025.

5.3 Cross-section profile

The arch as rolled cross-section profile shall be in accordance with the provisions for joists with tapered flanges as specified in BS 4-1 and be subject to the following additional tolerances on dimensions as indicated in Figure 1:

- a) thickness of flanges $T \pm 2.5$ %;
- b) out of squareness of flanges ($P \pm P1$) 2 mm maximum.

NOTE The preferred cross-section dimensions and masses per unit length are given in Table 2.

Table 2 — Preferred sections

Section size mm	Mass per unit length kg/m
89 × 89	19.35
102 × 102	23.07
127 × 114	26.79
127 × 114	29.76
152 × 127	37.20

5.4 Strut holes

The requirement for strut holes in the members shall be by agreement between the supplier and purchaser (see 4.2). Where it is agreed that there shall be strut holes in the member they shall have a diameter of 25 mm $\pm$ 2 mm and their centres shall be within 2 mm of the centre line of the member section.

5.5 Fishplates

5.5.1 Material

Steel shall conform with 5.2.

5.5.2 Material testing

Fishplates made from any material other than in 5.2, or by any other method than that of 5.2, the joints made shall be type tested in accordance with Annex B.

5.5.3 Fishplate cross-section

Hot rolled and pressed steel fishplate cross-sections shall be in accordance with Figure 2 to Figure 4 as appropriate.

5.5.4 Fishplate holes

Fishplate holes shall be dimensioned and positioned in accordance with Figure 2 to Figure 4 as appropriate.

5.5.5 Fish bolts and nuts

Fish bolts shall have square heads and necks, and shall be of sufficient length to be used with a full hexagon nut which, when tightened down, shall leave 2 mm of bolt protruding. Bolts and nuts shall conform to Figure 5 and also strength grade designation 4.6 and all other requirements shall be in accordance with BS 4190. Threads shall be coarse pitch series in accordance with BS 3643.

5.5.6 Fishplated joints

Fishplated joints shall conform to Figure 2 to Figure 4 as appropriate.

5.6 Welding

All welding shall be compatible with the design and materials of construction and conform to BS 5135.

6 Semi-circular and double radiused arches

6.1 Semi-circular arches

Semi-circular arches shall be of a semi-circular profile with parallel legs, or splayed legs inclined at between 6° and $6^\circ 4'$ to the vertical, and shall conform to the parameters specified in Table 3 and illustrated in Figure 6. They shall have joints positioned by reference to a) the number of members per arch, b) the crown angle and c) the chord length, all as specified in Table 3 and illustrated in Figure 6.

The requirement for strut holes in the semi-circular arch shall be by agreement between the supplier and purchaser (see 4.2). Where it is agreed that there shall be strut holes in the arch they shall be in accordance with 5.4 and shall be positioned by reference to Figure 7 to Figure 42 and Table 3. The holes shall be positioned along the centre line of the arch within the following tolerances:

strut hole centre to adjacent	
strut hole centre	$\pm 12 \text{ mm};$
strut hole centre to joint end	$\pm 2.5 \text{ mm}.$

Semi-circular arches of the refuge hole type shall be in accordance with Figure 43.

6.2 Double radiused arches

Double radiused arches shall be of a double radiused profile with parallel legs or splayed legs inclined at between 6° and $6^\circ 45'$ to the vertical as illustrated in Figure 44. They shall have a base width within $\pm 25 \text{ mm}$ of that specified by the purchaser [see 4.1 a)].

NOTE Preferred forms are given in Table 4.

Table 3 — Semi-circular arch forms

Arch diameter (i.e. radius × 2)	Arch height	Arch base width	Number of members per arch	Crown angle	Chord lengths given with the largest section		Strut hole positioning (where appropriate) figure number	Preferred cross-sections for arch forms (as indicated by ×)			
					Crown member	Side member		89 mm × 89 mm	102 mm × 102 mm	127 mm × 114 mm	152 mm × 127 mm
± 25 mm	± 25 mm	± 25 mm			± 25 mm	± 25 mm					
mm	mm	mm			mm	mm					
1 000	1 800	1 000	2	—	—	1 979	—		×		
1 829	1 829	1 829	2	—	—	2 165	—	×			
2 134	2 134	2 134	2	—	—	2 506	—	×	×		
2 440	2 135	2 665	2	—	—	2 640	7	×	×		
2 440	2 440	2 745	2	—	—	2 910	—	×	×		
2 745	2 135	2 935	2	—	—	2 700	—	×	×		
2 745	2 440	3 010	2	—	—	2 990	—	×	×		
3 050	2 438	3 050	2	—	—	3 016	—	×	×		
3 050	2 440	3 275	2	—	—	3 080	8	×	×		
3 050	2 745	3 355	2	—	—	3 330	—	×	×		
3 355	2 440	3 545	2	—	—	3 130	—	×	×		
3 355	2 745	3 620	2	—	—	3 400	—	×	×		
3 660	2 440	3 810	2	—	—	3 260	8	×	×	×	
3 660	3 050	3 960	2	—	—	3 800	9	×	×	×	
4 265	3 050	4 495	2	—	—	3 950	10	×	×	×	
3 050	2 745	3 355	3	90°	2 300	2 440	11		×		
3 355	2 440	3 545	3	83°	2 370	2 200	12		×		
3 660	2 440	3 810	3	77°	2 440	2 280	13		×	×	
3 660	2 745	3 885	3	90°	2 620	2 470	14		×	×	
3 660	3 050	3 960	3	84°	2 770	2 690	15		×	×	
3 960	3 050	4 230	3	83°	2 780	2 750	16			×	
4 265	2 745	4 420	3	77°	2 810	2 540	17			×	
4 265	3 050	4 495	3	77°	2 850	2 860	18 and 19	×		×	×
4 265	3 355	4 570	3	77°	2 810	3 140	20 and 21			×	
4 265	3 660	4 650	3	90°	3 200	3 220	22 and 23			×	
4 570	3 050	4 765	3	84°	2 990	2 810	24			×	
4 570	3 355	4 840	3	84°	3 260	3 010	24			×	×
4 570	3 660	4 915	3	84°	3 260	3 310	24 and 25			×	×
4 875	3 200	5 065	3	80°	3 330	2 910	26 and 27				×
4 875	3 355	5 105	3	80°	3 330	3 050	28 and 29			×	×
4 875	3 660	5 180	3	80°	3 330	3 350	30 and 31			×	×
5 180	3 960	5 525	3	80°	3 530	3 640	32 and 33				×
5 485	3 810	5 755	3	80°	3 720	3 470	34 and 35			×	×
5 485	4 265	5 865	3	90°	4 090	3 700	36 and 37			×	×
6 095	4 875	6 555	3	84°	4 280	4 370	38 and 39			×	×
4 875	3 660	5 180	4	2 × 60°	2 × 2 550	2 540	40			×	
5 180	3 960	5 525	4	2 × 60°	2 × 2 710	2 780	41				×
6 705	5 485	7 240	4	2 × 60°	2 × 3 510	3 940	42				×

Table 4 — Preferred double radiused 3-piece arch forms (in 127 mm × 114 mm and 152 mm × 127 mm H-section)

Major radius nominal mm	Minor radii nominal mm	Arch height nominal mm
3 355	1 830	3 660 ± 25
4 875	1 830	2 895 ± 25
4 875	1 830	3 200 ± 25
4 875	1 830	3 505 ± 25
4 875	1 830	3 810 ± 25

The requirement for strut holes in the double radiused arches shall be by agreement between the supplier and purchaser (see 4.2). Where it is agreed that there shall be strut holes in the arch they shall be in accordance with 5.4 and shall be positioned such that the distance between adjacent strut holes is between 0.46 m and 1.2 m.

6.3 Joints

All arches specified in 6.1 and 6.2 shall be jointed with fishplates in accordance with 5.5 and fish bolts shall be in accordance with Table 5.

The joint holes shall be in accordance with Figure 45.

Table 5 — Fish bolts (see Figure 5)

	Arch section mm	Diameter × length mm	Square neck		Length of thread <i>I</i> mm
			Width across flats <i>G</i> mm	Neck length <i>H</i> mm	
In-web fishplated joints	89 × 89	M20 × 90	19.16/20.84	10	40
	102 × 102	M20 × 90	19.16/20.84	10	40
	127 × 114	M20 × 110	19.16/20.84	10	40
	152 × 127	M20 × 110	19.16/20.84	10	40
Wrap round fishplated joints: conventional arch settings	102 × 102	M20 × 70	19.16/20.84	10	40
	127 × 114	M20 × 70	19.16/20.84	10	40
	152 × 127	M20 × 70	19.16/20.84	10	40
Wrap round fishplated joints: whole arch settings	102 × 102	M20 × 90	19.16/20.84	10	40
	127 × 114	M20 × 90	19.16/20.84	10	40
	152 × 127	M20 × 90	19.16/20.84	10	40

7 Cambered and flat top arches

7.1 General

Cambered and flat top arches shall be of three piece construction as shown in Figure 46 to Figure 51 as appropriate and shall have beam lengths and arch heights to within ± 50 mm of those specified by the purchaser [see 4.1 b)].

NOTE Preferred sizes for beam length and arch height are given in Table 6.

Table 6 — Preferred beam lengths and arch heights

Beam length mm	Arch height mm
3 000	1 800
3 300	1 950
3 600	2 100
3 800	2 250
3 900	2 400
4 200	2 550
4 500	2 700
4 800	2 850
^a	3 000
^a	3 150
^a	3 300
^a No preferred data are available.	

7.2 Cambered top arches

Cambered top arches shall be of one of the basic profiles illustrated in Figure 46 and Figure 47.

Beam, leg and joint combinations shall be selected such that leg inclination is within the range 4° to 10° to the vertical.

7.3 Flat top arches

When using single bolt joints as the jointing system, flat top arches shall be of one of the basic profiles illustrated in Figure 48 to Figure 51.

When using fishplates as the jointing system, flat top arches shall be of one of the basic profiles illustrated in Figure 48 and Figure 49.

When using corner brackets or clips as the jointing system, flat top arches shall be of one of the basic profiles illustrated in Figure 50 and Figure 51.

7.4 Joints

7.4.1 General

The beam member shall be connected to the upright members of the arch by one of the following jointing methods:

- single bolt;
- corner brackets and clips;
- cranked fishplates.

Where cranked fishplates are used as the jointing method:

- they shall be in accordance with 5.5 (except that 5.5.3 and 5.5.4 shall not apply); and
- joint holes and fishplate holes shall be dimensioned and positioned in accordance with Figure 52 and Figure 53.

All jointing systems shall be permanently and legibly marked with the manufacturer's identification symbol.

All fixing bolts, except for those used with cranked fishplates, shall be in accordance with BS 4190 and/or BS 3692.

Fixing bolts for cranked fishplates shall be in accordance with 5.5.5.

7.4.2 Joint assembly testing

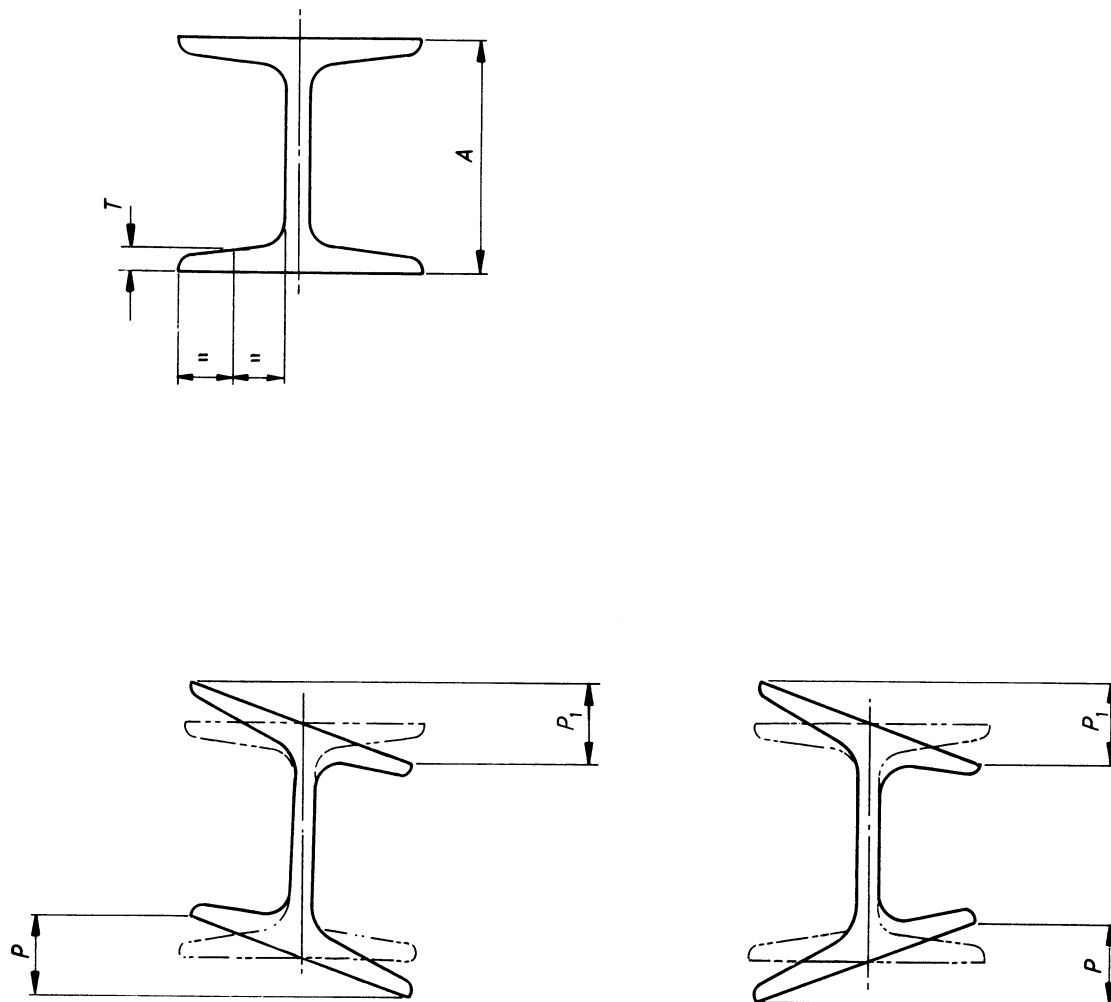
Joint assemblies shall be type tested in accordance with test procedures described in Annex B.

NOTE The object of mechanical testing is to determine the comparative bend and shear strengths of joint assemblies in the three bending modes of open, closure and lateral as shown in Figure B.1 to Figure B.4.

The mode of deformation of the joint under test is significant and shall not allow the members to become detached in an abrupt manner.

7.5 Strut holes

The requirement for strut holes in the cambered and flat top arches shall be by agreement between the supplier and purchaser (see 4.2). Where it is agreed that there shall be strut holes in the arch they shall be in accordance with 5.4 and shall be positioned to ensure that a strut is located within 0.4 m of the beam and legs interface in both beam and legs and such that the distance between adjacent strut holes is between 0.46 m and 1.2 m.



Out of squareness of flanges $P + P_1$

Figure 1 — Tolerances on cross-section

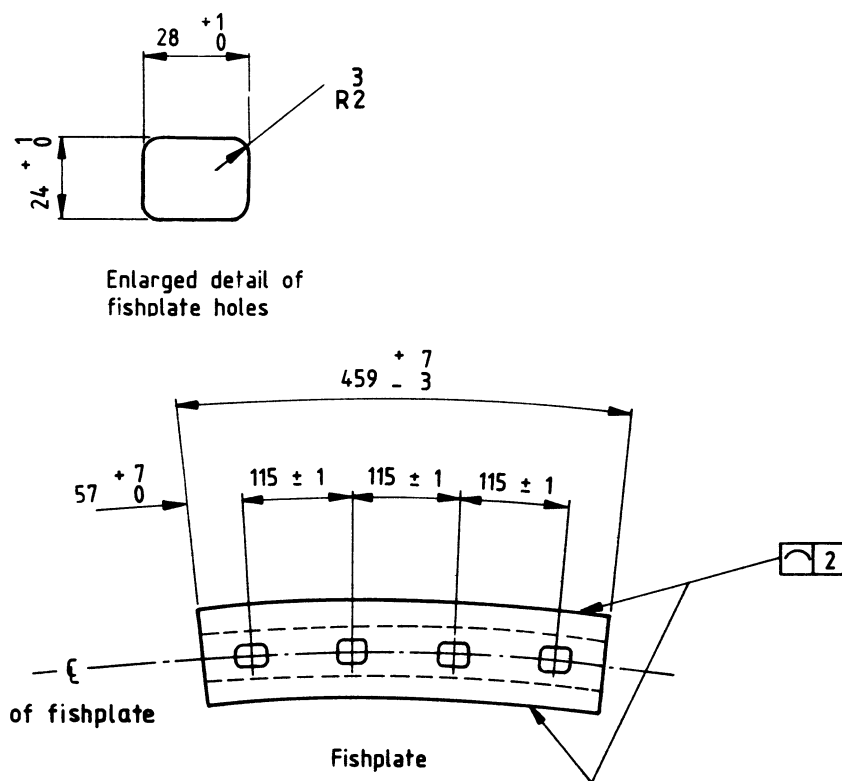
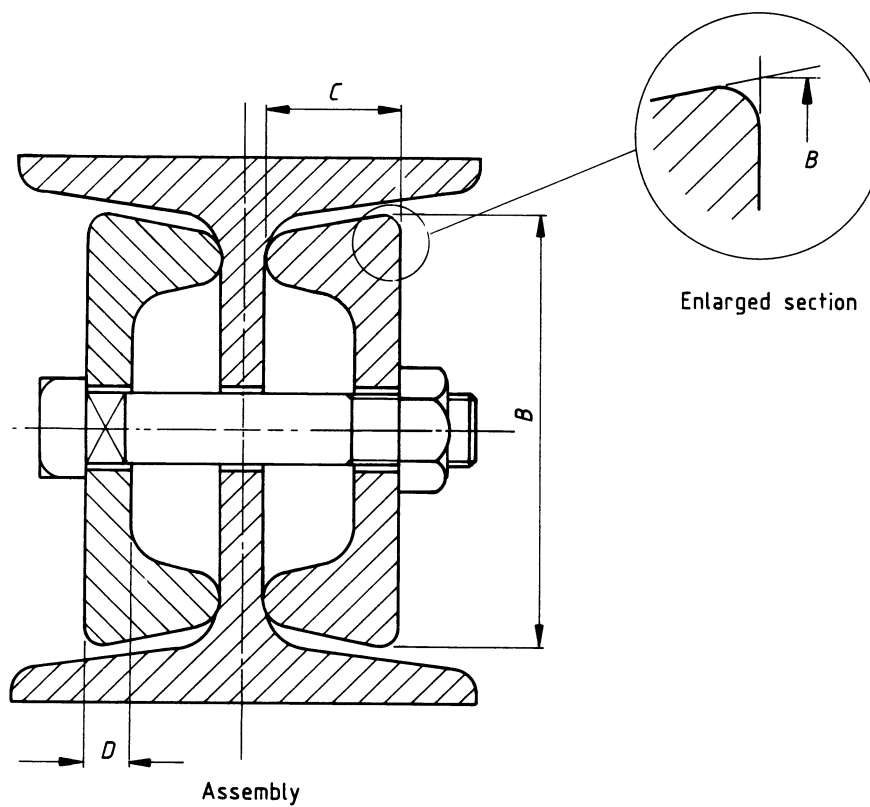


Figure 2 — Rolled steel in-web fish plated joint



Section	$B \begin{smallmatrix} 0 \\ -2 \end{smallmatrix}$	$C \pm 1$	$D \begin{smallmatrix} +2 \\ 0 \end{smallmatrix}$
89 × 89	67	25	12.7
102 × 102	78	30	12.7
127 × 114	101	35	12.7
152 × 127	122	35	12.7

Figure 2 — Rolled steel in-web fish plated joint (concluded)