

Specification for

Vessels for use in heating systems —

**Part 2: Tubular heat exchangers and
storage vessels for building and
industrial services**

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Committees responsible for this British Standard

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- British Non-Ferrous Metals Federation
- Chartered Institution of Building Services Engineers
- Copper Development Association
- Health and Safety Executive
- Hevac Association
- Institution of Mechanical Engineers
- Marine Safety Agency
- Waterheater Manufacturers' Association
- Co-opted members

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Foreword

This Part of BS 853 has been prepared by Technical Committee RHE/12. It covers the requirements of vessels with higher duty requirements than BS 853-1, but for which the requirements of BS 5500 are unnecessarily stringent. BS 853 was first published in 1939 and revised in two Parts covering carbon steel and copper in 1960. A second revision was carried out in 1981, when the two Parts were again combined, and this was updated in 1990 to take account of current practice. With the introduction of this Part of BS 853, BS 853:1990 becomes BS 853-1:1996 without any technical changes. No provision has been included for thermal performance tests.

NOTE Information concerning SI units is given in BS 5555 and BS 5775.

WARNING. The use of asbestos is subject to the Control of Asbestos at Work Regulations, 1987 (SI 2115 as amended)[1], and the Health and Safety at Work etc. Act 1974[2]. Attention is drawn to the health hazards arising from asbestos dust. Further information is available in Health and Safety Executive Guidance Note EH/10, *Environmental Hygiene, Asbestos*[3].

This British Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44, 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 Part of BS 853 specifies requirements for the design, methods of construction and testing of tubular heat exchangers and storage vessels for heating, cooling and heat recovery associated with building and industrial services with limiting conditions of 2 N/mm² design pressure, 300 °C maximum and 0 °C minimum temperature using such media as water, steam, thermal oils, glycol mixtures and oil.

In addition to the definitive requirements, this standard also requires the items detailed in clause 4 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

NOTE Attention is drawn to the dangers associated with heating flammable fluids above their flash points.

Three types of heat exchangers are covered by this standard:

- a) fixed tubeplate at each end;
- b) U-tubes (removable tube bundle);
- c) straight tubes with floating head at rear end (removable tube bundle).

2 References

2.1 Normative references

This Part of BS 853 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 page 42. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British 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.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

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

3.1

design pressure

the value of pressure to be employed for calculation

3.2

design temperature

the value of temperature to be employed for calculation

3.3

design stress

the maximum allowable stress for the materials of construction at the design temperature

3.4

purchaser

the organization or individual who buys the heat exchanger for its own use or as an agent for the owner

3.5

inspecting authority

the body or association which checks that the design, materials and construction are in accordance with this standard

3.6

maximum working pressure

the pressure at which the safety relief devices are set to commence operation

3.7

set pressure

the pressure at which the safety relief devices commence to operate

4 Information and requirements to be agreed and to be documented

4.1 Information to be supplied by the purchaser

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) Sufficient details from the data sheet Annex A to enable the manufacturer to offer a heat exchanger suitable for the installation and duty.
- b) Details of any independent inspection requirements.

NOTE The manufacturer is seldom in a position to determine the optimum fouling resistance when calculating the heating surface. The purchaser should therefore, where possible, specify the design fouling resistances for the particular service. When such information is not available the manufacturer should specify the fouling resistances that have been allowed for in the calculations. Typical fouling resistance data are given in Annex B.

4.2 Information to be supplied by the manufacturer

The manufacturer shall provide the purchaser with full information of the heat exchanger or storage vessel offered along with leading dimensions and details of tube bundle withdrawal space where applicable.

NOTE A typical data sheet for a heat exchanger is given in Annex A.

5 Materials

5.1 Selection

Table 1 gives a range of materials which conform to this standard and shall be used for the fabrication of heat exchangers and storage vessels and gives design stress values that shall be used for the scantling design (see clause 8). Where other materials are used the manufacturer shall show that they are comparable with those given in Table 1 and that they have been submitted to equivalent tests and approvals.

Materials for use in the fabrication of heat exchangers and storage vessels specified in this standard shall be either:

- a) selected from Table 1; or
- b) other materials for which the manufacturer shall show that they are comparable with those given in Table 1 and that they have been submitted to equivalent tests and approvals.

Table 1 also gives design stress values that shall be used for the scantling design.

5.2 Bolting materials

Bolting materials shall be as given in Table 2.

5.3 Filler materials

Filler materials shall be as given in Table 3.

5.4 Forging and fittings

Forging materials and fittings shall be as given in Table 4.

6 Welding procedure and welder approval tests

6.1 General

The welding shall conform to approved welding procedures in accordance with 6.2 and welder approval tests shall be in accordance with 6.3.

The preparation of welding procedures, the approval of welders, testing and the maintenance of records shall be the responsibility of the manufacturer.

6.2 Approval of procedure

Approval testing of welding procedures for steel shall be conducted, recorded and reported in accordance with BS EN 288-3:1992.

Approval testing of welding procedures for copper shall use the methods of testing welds given in BS 4206. The copper test piece shall be subject to visual examination, penetrant testing and destructive tests. The number of test specimens shall be as given in Table 5. The welding procedures shall be certified to BS 853-1 using relevant documentation and records conforming to BS EN 288.

Each welding procedure test and the accompanying test results shall be recorded as "Welding Procedure Approval Records" in accordance with Annex A of BS EN 288-3:1992.

Each welding procedure test shall be documented to include all items in accordance with clause 4 of BS EN 288-2:1992.

An approved welding procedure test shall only require reapproval when any changes are made which conform to BS EN 288-3:1992.

6.3 Welder approval

Approval testing of welders for steel shall be conducted, recorded and reported in accordance with Annex B of BS EN 287-1:1992.

Approval testing of welders for copper shall use the methods of testing welds in accordance with BS 4206. The copper test piece shall be subject to visual examination and destructive tests, augmented by penetrant testing if necessary. The number of test specimens shall be as given in Table 6.

Welder approval shall be certified to BS 853-1 using relevant documentation and records in accordance with BS EN 287-1:1992.

A welder's approval to weld to a particular procedure shall remain valid unless there are changes in the procedure in accordance with clause 8 of BS EN 288-3:1992.

Table 1 — Materials for the construction of heat exchangers (with design stress values *f*)

Material	British Standard designation	Relevant note(s)	Design stress values (<i>f</i>) for metal (see note 1)								
			Design temperature not exceeding:								
			50 °C	100 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
			N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²
Shells and branches:											
carbon steel plate	BS 1501 151 or 161 grade 430A or B		108	108	108	108	108	104	100	93	91
carbon steel tube	BS 3601 320.ERW 360.ERW.S (A106B)	11	80	80	80	80	78	73	69	65	62
	430.ERW.S		90	90	90	90	89	83	77	73	69
	BS 3602 360.ERW.S		108	108	108	108	106	99	92	87	82
	430.ERW.S		90	90	90	90	90	90	89	83	78
			108	108	108	108	108	102	96	91	87
stainless steel plate, sheet and strip	BS 1501 Part 3. 304S11 (A240.304L) 304S31	11	114	102	89	85	81	78	76	74	72
	(A240.304) 316S11.S13	11	122	109	95	91	87	84	82	80	78
	(A240.316L) 316S31.S33	11	120	107	95	91	88	85	82	80	79
	(A240.316)	11	128	114	102	98	94	91	89	87	85
stainless steel tube	BS 3605 304S11										
	(A312.TP304L) 304S31	11	114	102	89	85	81	78	76	74	72
	(A312 TP304) 316S11.S13	11	122	109	95	91	87	84	82	80	78
	(A312 TP316L) 316 S31.S33	11	120	107	95	91	88	85	82	80	79
	(A312 TP316)	11	128	114	102	98	94	91	89	87	85

Table 1 — Materials for the construction of heat exchangers (with design stress values f)

Material	British Standard designation		Relevant note(s)	Design stress values (f) for metal (see note 1)								
				Design temperature not exceeding:								
				50 °C	100 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
				N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²
copper plate	BS 2875	C106-0		48	46	34	26	18	—	—	—	—
copper sheet	BS 2870	C106-0		48	46	34	26	18	—	—	—	—
copper tubes	BS 2871	Part 2. C106-0		41	40	34	26	18	—	—	—	—
90/10 CuNi plate	BS 2875	CN102-0		97	92	89	63	60	58	54	49	44
90/10 CuNi sheet	BS 2870	CN102-0		97	92	89	63	60	58	54	49	44
90/10 CuNi tube	BS 2871	Part 2. CN102-0		75	73	71	63	60	58	54	49	44
70/30 CuNi plate	BS 2875	CN107-0		117	109	105	76	75	73	72	71	70
70/30 CuNi sheet	BS 2870	CN107-0		117	109	105	76	75	73	72	71	70
70/30 CuNi tube	BS 2871	Part 2. CN107-0		93	87	84	76	75	73	72	71	70
Bars and sections (for welding):												
carbon steel	BS 1502	151 or 161		108	108	108	108	108	104	100	93	91
stainless steel	BS 1502	304S11		114	102	89	85	81	78	76	74	72
		304S31		122	109	95	91	87	84	82	80	78
		316S11.S13		120	107	95	91	88	85	82	80	79
		316S31.S33		128	114	102	98	94	91	89	87	85
copper	BS 2874	C106-0		41	40	34	26	18	—	—	—	—
Tubeplates:												
carbon steel	BS 1501	151 or 161 grade 430A or B		108	108	108	108	108	104	100	93	91
stainless steel	BS 1501	Part 3. 304S11 (A240.304L)	11	114	102	89	85	81	78	76	74	72
		304S31 (A240.304)	11	122	109	95	91	87	84	82	80	78
		316S11.S13 (A240.316L)	11	120	107	95	91	88	85	82	80	79
		316S31.S33 (A240.316)	11	128	114	102	98	94	91	89	87	85

Table 1 — Materials for the construction of heat exchangers (with design stress values *f*)

Material	British Standard designation		Relevant note(s)	Design stress values (f) for metal (see note 1)								
				Design temperature not exceeding:								
				50 °C	100 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
			N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	
70/30 brass	BS 2875	CZ105-0		72	71	69	54	25	15	—	—	—
aluminium bronze	BS 2875	CA105-0		180	175	174	103	94	87	77	71	63
90/10 CuNi	BS 2875	CN102-0		97	92	89	63	60	58	54	49	44
70/30 CuNi	BS 2875	CN107-0		117	109	105	76	75	73	72	71	—
aluminium brass	BS 2875	CZ110-0		72	71	69	54	25	15	—	—	—
naval brass	BS 2875	CZ112-0		117	108	105	55	17	—	—	—	—
60/40 brass	BS 2875	CZ123-0		93	93	92	55	17	—	—	—	—
Tubes:												
carbon steel	BS 3059	Part 1. 320	10	80	80	80	80	78	73	69	65	62
	BS 3059	Part 2. 360		90	90	90	90	90	90	89	83	78
	BS 3606	320		80	80	80	80	78	73	69	65	62
	BS 3606	400		100	100	100	100	98	93	88	82	77
stainless steel	BS 3059	Part 2. 304S51										
		(A213.TP304)		122	109	95	91	87	84	82	80	78
		316S51.S52										
		(A213.TP316)		128	114	102	98	94	91	89	87	85
	BS 3606	304S11										
		(A213 TP304L)	11	114	102	89	85	81	78	76	74	72
		304S31	11	122	109	95	91	87	84	82	80	78
		316S11.S13										
		(A213 TP316L)	11	120	107	95	91	88	85	82	80	79
		316 S31.S33		128	114	102	98	94	91	89	87	
	copper	BS 2871	Part 3. C106-0		41	40	34	26	18	—	—	—
	aluminium bronze	BS 2871	CA102-0		85	82	80	67	44	31	16	—
90/10 CuNi	BS 2871	CN102-0		75	73	71	63	60	58	54	49	44
70/30 CuNi	BS 2871	CN107-0		93	87	84	76	75	73	72	71	70
aluminium brass	BS 2871	CZ110-0	6	87	83	83	54	25	15	—	—	—
70/30 arsenical brass	BS 2871	CZ105-0	6	70	69	67	57	25	15	—	—	—

Table 1 — Materials for the construction of heat exchangers (with design stress values f)

Material	British Standard designation		Relevant note(s)	Design stress values (f) for metal (see note 1)								
				Design temperature not exceeding:								
				50 °C	100 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
				N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²
special 70/30 arsenical brass	BS 2871	CZ126-0	6	77	72	71	54	25	15	—	—	—
Castings:												
carbon steel	BS 1504	161-430A		107	97	88	86	83	82	81	77	73
grey cast iron	BS 1452	grade 180	7, 8 and 9	16	16	16	16	16	—	—	—	—
	BS 1452	grade 220	7, 8 and 9	19	19	19	19	19	—	—	—	—
spheroidal or nodular graphite cast iron	BS 2789	SNG 24/17		60	60	60	60	60	60	—	—	—
			—	—	—	—	—	—	—	—	—	—
admiralty gunmetal	BS 1400	G1	2	55	55	55	52	49	46	25	—	—
lead ed gunmetal	BS 1400	LG2	3	64	61	58	47	45	43	34	22	—
lead ed gunmetal	BS 1400	LG4	3	59	59	59	56	51	—	—	—	—
naval brass	BS 1400	SCB4	4 and 5	—	—	—	—	—	—	—	—	—
brass for brazable castings	BS 1400	SCB6	4	30	30	20	—	—	—	—	—	—
NOTE 1 Linear interpolation may be used to determine the appropriate design stress value when the design metal temperature lies between two temperatures.												
NOTE 2 May be welded only if the lead content is less than 0.5 %.												
NOTE 3 Cannot be welded but may be brazed.												
NOTE 4 Not suitable for operating temperatures greater than 150 °C.												
NOTE 5 Suitable for non-pressure parts only.												
NOTE 6 If these materials are to be screwed they should be ordered in the “M” instead of the “O” condition												
NOTE 7 Grey cast iron is not suitable for design pressures in excess of 1.03 N/mm ² or for temperatures exceeding 220 °C, at which temperature the values of <i>f</i> at 200 °C should be used.												
NOTE 8 Refer to Figure 3 of BS 1452:1990 for estimated thicknesses of cast iron greater than 30 mm. The design stress used should be 10 % of the tensile stress for the grade of material selected and thickness required.												
NOTE 9 Iron castings that are subjected to the working pressure should have the number and grade of the relevant British Standard cast upon them so that the maximum operating pressure and temperature for which they are suitable may be assessed at any time.												
NOTE 10 Where necessary tubes should be ordered to special tolerances, so that the maximum diametral clearances specified in 10.1.4 are not exceeded.												
NOTE 11 Acceptable ASTM materials shown in brackets.												

Table 2 — Bolting materials (see note 1)

Material	British Standard designation	Diameter	Design temperature, ° not exceeding:				
			50 °C	100 °C	150 °C	200 °C	250 °C
		mm	N/mm ²	N/mm ²	N/mm ²	N/mm ²	N/mm ²
Carbon steel	BS 3692 Grade 8.8	≤ 68	192	174	156	139	129
1 % chromium molybdenum steel	BS 4882 Grade B7	≤ 63	193	181	174	167	158
Stainless steel	BS 4882 Grade B8 (304)	All	126	106	97	89	83
	BS 4882 Grade B8M (316)	All	129	109	101	94	87

NOTE 1 Linear interpolation may be used to determine the appropriate design stress when the design temperature lies between two temperatures

NOTE 2 The grade of the bolt material used should be specified on a separate and easily seen plate attached to the heat exchanger or storage vessel.

NOTE 3 Nuts used with high tensile steel bolts or studs shall have a specific minimum ultimate tensile strength which is not more than 77 N/mm² lower than that of the bolts or studs.

Table 3 — Filler and brazing materials

Material	British Standard designation	Relevant note(s)
Filler rods, wires and fluxes or welding: for manual metal-arc welding of carbon steel for submerged arc welding of carbon steel for TIG and MIG welding of carbon steel for TIG and MIG welding of copper for gas welding of copper for manual metal-arc welding of stainless steel for submerged arc welding of stainless steel for TIG and MIG welding of stainless steel	BS EN 499 BS 4165 BS EN 440 BS EN 440 BS 1453 C1 BS 2926 BS 5465 BS EN 440	
Brazing filler metals: copper-phosphorus silver	BS 1845 CP1, CP2 or CP4 BS 1845 AG1 to AG18	1 1
Filler alloys for attaching steel non-pressure parts (e.g. support brackets) to copper shells: for bronze welding for flame brazing for soft soldering (tin content exceeding 33 %)	BS 1453 C2, C4, C5 or C6 BS 1845 CZ3 to CZ8 BS EN 29453	2

NOTE 1 For brazed seams exposed to aggressive water, which could give rise to dezincification or other forms of selective attack, brazing alloys in accordance with BS 1845 CP1 or CP2 should be used. For brazed seams which are not subject to such forms of attack, brazing alloys in accordance with BS 1845 AG1 to AG7 may be used.

NOTE 2 Soft solders may be used only for the external attachment of brackets and similar fittings and may only be applied to parts not in contact with either the heated or the heating medium in the heat exchanger. The operating temperature for soft solder should not exceed 150 °C.

Table 4 — Forgings and hot pressing stock

Material	British Standard designation
Carbon steel	BS 1503 BS 1640-1 and BS 1640-3 BS 1945 BS 1740-1 BS 3799
Stainless steel	BS 1503 BS 1640-2 and BS 1640-4 BS 3799
Copper	BS 2872 C106
Naval brass	BS 2872 CZ112
Aluminium bronze	BS 2872 CA 104
Steel pipe fittings (for screwed connections)	BS 1740

Table 5 — Number of test specimens required for procedure approval for copper

Test specimen	Butt joint in plate of thickness		Butt joint in pipe of thickness		Fillet weld in plate
	less than 10 mm	10 mm and over	less than 10 mm	10 mm and over	
Macro examination	1	1	2	2	2
Transverse tensile	1	1	1	1	1
Root bend	2	0	2	—	—
Face bend	1	0	1	—	—
Side bend	0	2	—	2	—
Fillet weld fracture (for test piece with only single side weld)	0	0	—	—	3

NOTE When more than one specimen of a particular type is required the specimens shall be taken as far apart as possible with one specimen for macro-examination taken from that part of the joint considered to have been welded in the most difficult welding position or from a stop/start position.

Table 6 — Number of test specimens required for welder approval for copper

Test specimen	Butt joint in plate of thickness		For fillet weld in plate
	less than 10 mm	10 mm and over	
Macro examination	2	2	2
Root bend	1	—	—
Face bend	1	—	—
Side bend	—	2	—
Fillet weld fracture (for test piece with only single side weld)	—	—	3

NOTE When more than one specimen of a particular type is required the specimens shall be taken as far apart as possible with one specimen for macro-examination taken from that part of the joint considered to have been welded in the most difficult welding position or from a stop/start position.

(Organization's symbol or logo)	Welder approval test certificate	Test record
Manufacturer's name	Welder's name and identity no.	Issue no.

Declaration

I, the undersigned, declare that welder named above has been regularly and satisfactorily employed on work covered by this certificate during the six month preceding the date of my signature.

Date	Personal signature	Position or title

Figure 1 — Welder's history sheet

6.3.1 Reapproval of welder

For the purpose of this standard a welder's approval shall remain valid provided that it can be shown, as signified at intervals of 6 months by a senior responsible person in the firm that employs the welder, that the welder has, subsequent to the test, been employed with reasonable continuity on work within the extent of his approval and has continued to produce satisfactory welds as verified by traceable records by the type of production work. Reapproval shall be required if any of the following apply.

- The welder is to be employed on work outside the extent of his current approval.
- The welder changes his employer without the transfer of his test records.
- Six months or more have elapsed since the welder was engaged in welding on work within the extent of his approval.

NOTE Subject to the agreement of the inspecting authority, a complete reapproval test may be waived provided the first production weld by the welder is supplemented with a non-destructive test for steel and a bend test for copper.

- There is some specific reason to question the welder's ability.

Proof of the welder's continued use of the approved procedure shall be the maintenance of a welder's history sheet such as that shown in Figure 1.

7 Design pressure and design temperature

NOTE In establishing the design pressure and the design temperature it is necessary to take into account all conditions of service, including start-up, shut-down and cleaning.

7.1 Design pressure (data sheet item 26)

7.1.1 Shell side design pressure

The shell side design pressure shall be not less than the set pressure of the safety valve mounted on or adjacent to the shell (see clause 11) and in no case less than two-thirds of the hydraulic test pressure.

7.1.2 Tube side design pressure

The tube side design pressure shall be not less than the highest pressure which can be reached in the tubes under all service conditions and in no case less than two-thirds of the hydraulic test pressure.

Protection against excess pressure shall be given to both the tube side and shell side of the heat exchanger in accordance with clause 11.

NOTE It is recommended that when the shell or the tube side is subject to vacuum, that side should be designed for full negative pressure of 0.1 N/mm^2 ($1 \text{ bar}^{1)}$ unless a vacuum breaker valve or similar device is provided, in which case a lower design pressure may be used.

7.2 Design temperature (data sheet item 26)

For parts in contact with one fluid only, the design temperature shall be taken as the maximum fluid temperature in contact with each part. For parts subject to two different fluid temperatures, the design temperature shall be taken as either the actual temperature under operating conditions or the higher fluid temperature in contact with the part.

NOTE In establishing the actual metal temperatures due consideration needs to be given to such factors as the relative heat transfer coefficients of the two fluids contacting the part and the relative heat transfer area of the two sides of the part in contact with the fluids.

8 Scantling design

8.1 General

The thickness and construction of the components of shell, channel and tubeplate assemblies shall conform to 8.3 to 8.8 and, where appropriate, shall include the corrosion allowance in accordance with 8.2.

8.2 Corrosion allowance

8.2.1 Pressure parts

8.2.1.1 Unprotected carbon steel pressure parts

All unprotected carbon steel pressure parts shall have a corrosion allowance of 1 mm unless a different allowance is specified.

8.2.1.2 Unprotected cast iron pressure parts

All unprotected cast iron pressure parts shall have a corrosion allowance of 1 mm.

8.2.2 Tubes

If no corrosion allowance is specified by the purchaser the manufacturer shall either:

- a) select a material which is suitable for the service conditions without a corrosion allowance; or
- b) include a corrosion allowance suitable for the material selected and the service conditions.

8.2.3 Internal covers

Internal covers shall have corrosion allowance on both sides.

8.2.4 Tubeplates

Tubeplates shall have corrosion allowance on both sides.

8.2.5 Grooved tubeplates and external covers

Where the plates are grooved the depth of the pass-partition groove shall be considered available for corrosion allowance.

8.2.6 End flanges

Corrosion allowance shall not be applied to the mating faces of flanges.

8.2.7 Non-pressure parts

Non-pressure parts such as tie rods, spacers, baffles and support plates shall have no corrosion allowance.

8.2.8 Floating head backing devices

Floating head backing devices and internal bolting shall have no corrosion allowance.

8.2.9 Copper and stainless steel components

Copper, copper alloys and stainless steel components shall have no corrosion allowance unless it is definitely specified.

8.3 Shell and shell ends (data sheet item 30 and 31)

8.3.1 Cylindrical shells

8.3.1.1 Calculated shell thickness

The calculated thickness of a cylindrical shell subject to pressure on its internal surface shall be calculated from the following equations.

$$t_c = \frac{PD_i}{2fJ - P} + c \quad (1)$$

or

$$t_c = \frac{PD_o}{2fJ + P} + c \quad (2)$$

where

- t_c is the calculated thickness (in mm);
- P is the design pressure (in N/mm^2);
- D_i is the internal diameter of the shell without corrosion allowance (in mm);
- D_o is the external diameter of the shell without corrosion allowance (in mm);
- f is the design stress value for the shell material from Table 1 (in N/mm^2);
- J is the joint factor, which has the following value:
 - a) for seamless shells $J = 1.0$
 - b) for shells with butt-welded longitudinal seams:
 - $J = 0.7$ for carbon steel and stainless steel
 - $J = 0.8$ for copper
- c is the corrosion allowance (in mm).

¹⁾ $1 \text{ bar} = 0.1 \text{ N/mm}^2 = 0.1 \text{ MPa} = 10.2 \text{ m head}$.