

PD 6702-1:2009+A1:2019



BSI Standards Publication

Structural use of aluminium

Part 1: Recommendations for the design of aluminium structures to BS EN 1999

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Published by BSI Standards Limited 2019

ISBN 978 0 539 02282 7

ICS 91.080.10

The following BSI references relate to the work on this document:

Committee reference B/525/9

Drafts for comment 18/30382954 DC

Amendments/corrigenda issued since publication

Date	Text affected
31 May 2019	A1: see Foreword

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Foreword

Publishing information

This part of PD 6702 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2009. It was prepared by Subcommittee B/525/9, *Structural use of aluminium*, under the authority of Technical Committee B/525, Building and civil engineering structures. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

PD 6702-1:2009+A1:2019 supersedes PD 6702-1:2009, which is withdrawn.

Relationship with other publications

This Published Document gives guidance on the use of BS EN 1999-1-1 and BS EN 1999-1-3, for the design of aluminium structures in the UK.

Information about this document

BS EN 1999, Parts 1-1, 1-2, 1-3, 1-4 and 1-5 replaced BS 8118-1 after a period of coexistence. The replacement of BS 8118-1 represents substantial change in design practice in the UK. This Published Document aims to ensure that aluminium structures are designed with the same level of assurance of reliability as that implicit in BS 8118-1.

The guidance given in this Published Document consists of non-contradictory complementary information (NCCI) to enable the user to apply BS EN 1999 in a safe and cost-effective manner, with particular reference to the following:

- a) provision in the National Annexes for nationally determined parameters where supporting information is required;
- b) alternative information where options are permitted in BS EN 1999.

This Published Document is likely to be subject to amendment following an update of BS EN 1999-1¹.

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** and **A1**. Minor editorial changes are not tagged.

This publication is not to be regarded as a British Standard.

Presentational conventions

The provisions of this Published Document are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

¹ Currently anticipated to be published in 2020 or 2021.

1 Scope

This part of PD 6702 gives guidance on the use of the following parts of BS EN 1999, *Design of aluminium structures*:

- Part 1-1, *General structural rules*;
- Part 1-3, *Structures susceptible to fatigue*.

It is applicable to the same scope of application as BS EN 1999 unless otherwise stated.

The design information included in this document is applicable only when the recommendations in PD 6705-3 are followed for the execution of the structure.

NOTE This document covers those items identified in the UK National Annexes to BS EN 1999-1-1 and BS EN 1999-1-3 as requiring additional guidance. Further material, not necessarily identified in the relevant National Annex, is also given for information.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[A1] [BS 4395-1](#), *Specification for high strength friction grip bolts and associated nuts and washers for structural engineering – Part 1: General grade*² **[A1]**

BS EN 1090-3, *Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures*

BS EN 1990:2002+A1:2005, *Eurocode – Basis of structural design*

BS EN 1999-1-1:2007, *Eurocode 9: Design of aluminium structures – Part 1-1: General structural rules*

BS EN 1999-1-3:2007, *Eurocode 9: Design of aluminium structures – Part 1-3: Structures susceptible to fatigue*

PD 6705-3, *Structural use of steel and aluminium – Part 3: Recommendations for the execution of aluminium structures to BS EN 1090-3*

3 Terms and definitions

For the purposes of this part of PD 6702, the terms and definitions given in BS EN 1999-1-1 and BS EN 1999-1-3 and the following apply.

3.1 quantified service category

category that characterizes a component or structure (or part thereof), in terms of the circumstances of its use within specified limits of static and cyclic stressing

NOTE See [4.1.1.2](#), [4.1.2](#), [4.1.4](#) and [4.1.5](#).

² BS 4395-1 has been withdrawn.

4 Recommendations for the use of BS EN 1999-1-1

4.1 Reliability differentiation [see BS EN 1999-1-1:2007, 2.1.2(3) and Annex A]

4.1.1 General principles

4.1.1.1 Reliability class

The quality of the work required by BS EN 1090-3 is specified on the basis that the values of partial factor γ_M required by BS EN 1999 provide a safe level of resistance commensurate with Reliability Class 2 (RC2) in BS EN 1990:2002+A1, Annex B. If the design circumstance justifies the use of a higher or lower degree of reliability, the measures specified in BS EN 1990 should be taken in order to make such an adjustment in the design. However, it should be noted that BS EN 1990 recommends that reliability differentiation is not achieved by the adjustment of γ_M (i.e. the quality of the work).

4.1.1.2 Service category

Different structural types and/or different parts of the same structure could be subjected to significant differences in static and/or A_1 cyclic A_1 stressing. As the quality of the work necessary to provide a consistent value of γ_M across such a wide potential range of conditions can vary considerably, there would be a severe economic penalty if one quality level was specified which gave a safe degree of reliability for all the conditions permitted by BS EN 1999.

A major factor in the determination of the quality requirements is the degree of cyclic loading which the structural components need to resist. BS EN 1999-1-3 does not provide normative fatigue design data. However, recommended rules for such data are given in [Clause 5](#) of this document. Furthermore, [Clause 5](#) provides a quantitative method for differentiating the required quality level according to seven levels of service category (F12 through to F63). These are a refinement of the two service categories (SC1 and SC2) used in BS EN 1090-3, which are based on an unquantified differentiation between the static limits state rules in BS EN 1999-1-1 and the informative fatigue design data in BS EN 1999-1-3. The National Annex to BS EN 1999-1-3 does not recommend the latter for UK use.

A range of quantified service categories, designated F12, F20, F25, F31, F40, F50 and F63, is provided (see [4.1.4](#)) which enables a safe, but economical, quality level to be specified for the full range of conditions. The method of specifying the appropriate quantified service category on drawings is given in [4.1.5](#).

NOTE This system has been adapted using the principles already applied in structural design and execution standards for metal structures, including ISO 10721-1 and ISO 10721-2.

4.1.1.3 Execution class

The execution class provides a means of varying the degree of assurance that the work meets the relevant quality requirements of BS EN 1090-3. The assurance is only provided by the documentation required under the contract.

4.1.2 Default service category and execution class

In order to simplify the administration of contracts where BS EN 1090-3 is specified, the choice of quantified service categories and execution classes has been selected so that the majority of structural aluminium generally falls into one category and class, namely:

- quantified service category F20;
- Execution Class 2 (EXC2).

These are the default category and class and are deemed to apply unless other categories or classes are specifically prescribed. It should be noted that it is an important design responsibility to specify any parts of the structure which need a service category of F25 or above.

A1 Where EXC2 is selected, it is recommended that Design Supervision Level 2 (DSL2) or 3 (DSL3) of BS EN 1990 is employed for selection of the party responsible for the design check and that Inspection Level 2 (IL2) of BS EN 1990 is employed for selection of the party responsible for the inspection of the work (see BS EN 1990:2002+A1, Annex B). **A1**

4.1.3 Choice of execution class

4.1.3.1 Use of Execution Class 1 (EXC1)

A1 EXC1 is not recommended for general use, however it may be considered for simple constructions when the consequences of failure are low and the workmanship requirements are readily achievable.

It is essential that EXC1 is not used for structures with regular human occupancy or where structural failure would be likely to directly or indirectly result in human injury or death.

In assessing the economic, social or environmental consequences of failure, account should be taken of the likely number of constructions based on the same design which might be placed on the market.

As a guide to the construction features which might be suitable for EXC1, subject to information given in this subclause, the restrictions given in [Table 1](#) are recommended. **A1**

Table 1 — Restrictions on construction features for use with EXC1 **A1** where the consequences of failure are known to be low **A1**

Feature	Recommended restrictions
Type of structure	Single storey buildings with span <10 m carrying roof only, not cranes Masts, fences and similar structures <5 m high Architectural features etc. Other minor structural works (e.g. screens, panelling, supports for lightweight services)
Quantified service category	F12 and F20 only
Type of product	Open section extrusions Sheeting Plate Simple single cell extrusions
Materials	3 000, 5 000 and 6 000 series only
Joining methods	Non-preloaded bolts Proprietary fasteners (e.g. blind rivets) A1 Shop fillet welding only (≤ 15 mm thick parent metal only) A1

NOTE It is anticipated that EXC1 would be suitable for small workshops fabricating light weight simple forms of construction, where quality requirements are easily met by personnel with basic training and conditions require relatively limited assurance measures.

Where EXC1 is specified, it is essential that this is indicated in the project specification and/or on the drawings (see [4.1.5](#)).

4.1.3.2 Use of Execution Class 2 (EXC2)

It is anticipated that EXC2 (which is the default class, see [4.1.2](#)) would be appropriate for the majority of structural aluminium applications.

It is recommended that DSL2 or DSL3 and IL2 of BS EN 1990 are employed for this class (see [4.1.2](#)).

4.1.3.3 Use of Execution Class 3 (EXC3)

EXC3 is suitable for complex constructions where the consequences of failure are exceptionally high and workmanship requirements are particularly critical.

It is anticipated that the use of EXC3 would be limited to designs where unusual circumstances exist, which require a higher degree of assurance than usual. Typical examples are where:

- novel forms of construction are being used;
- conditions are close to, or beyond, the limits of previous experience;
- quality levels are generally expected to be difficult to achieve;
- the designer considers that the measures recommended in BS EN 1990:2002+A1, Annex B, are insufficient on their own to cover a case where a particularly high target reliability is necessary.

It is recommended that Design Supervision Level 3 (DSL3) and Inspection Level 3 (IL3) of BS EN 1990 are employed for this class.

4.1.3.4 Use of Execution Class 4 (EXC4)

The execution requirements for EXC4 in BS EN 1090-3 are identical to those for EXC3, apart from the use of lock nuts and certain differences in the degree of the welding co-ordinator's knowledge. It is recommended that EXC4 is only used in place of EXC3 where additional quality or assurance requirements outside the scope of BS EN 1090-3 are needed.

4.1.4 Determination of quantified service category

The quantified service category is dependent on the orientation and intensity of the static and cyclic stressing at a cross-section of a member or in a joint. The stresses used to calculate the quantified service category should be determined using the design methods specified in the relevant part of BS EN 1999. The quantified service categories are defined in [Table 2](#).

The procedure for determining the appropriate quantified service categories in the structure is as follows.

- a) If no fatigue check is required, it should be assumed that F20 applies throughout.
- b) If a fatigue check is required, a detail category of 20-3, 2 should be ascribed to all details. A fatigue check to BS EN 1999-1-3 and this document should be carried out using that detail category and nominal (or modified nominal, where relevant) stress ranges. If all parts pass this check, F20 applies to the whole structure and no further action is required.
- c) If any details fail the check in b), the check on the failed details should be repeated assuming a detail category of 25-3, 2 applies to them. If they pass this check, these details should be identified as F25 (see [4.1.5](#)).
- d) If any parts fail the check in c), the procedure should be repeated using assumed detail categories 31-3, 2, 40-3, 2 etc., as necessary until all parts pass.

Table 2 — Performance criteria for designation of quantified service category

Level of service stresses		Quantified service category designation	Static utilization factor U ^{A)}		Minimum required value of reference fatigue strength $\Delta\sigma_c$ ^{B)} N/mm ²
Static	Fatigue				
Reduced	Very low	F12	Tension	$U \leq 0,6$	$\Delta\sigma_c \leq 12$
			Shear	$U \leq 0,8$	$\Delta\sigma_c \leq 12$
			Compression	$U \leq 0,8$	$\Delta\sigma_c \leq 12$
Full	Low	F20		$U \leq 1,0$	$\Delta\sigma_c \leq 20$
Full	Significant	F25		$U \leq 1,0$	$20 < \Delta\sigma_c \leq 25$
		F31		$U \leq 1,0$	$25 < \Delta\sigma_c \leq 31$
		F40		$U \leq 1,0$	$31 < \Delta\sigma_c \leq 40$
		F50		$U \leq 1,0$	$40 < \Delta\sigma_c \leq 50$
		F63		$U \leq 1,0$	$50 < \Delta\sigma_c \leq 63$

^{A)} The static utilization factor, U, is the ratio of the ultimate limit state (ULS) design action on the member cross-section or joint divided by its design resistance. Where the resistance depends on an interaction formula for more than one stress mode, the U value is equal to the interaction formula sum divided by the permissible limit. This applies to all static failure modes at the joint or member in question.

^{B)} The minimum required value of $\Delta\sigma_c$ is the lowest value for which the damage $D_L \leq 1$ for safe life design (see 4.1.4). The fatigue service category depends on the direction of stress fluctuation.

4.1.5 Designation of quantified service category on drawings

4.1.5.1 General

Where no quantified service category is designated on a drawing, F20 should be deemed to apply to all work described on that drawing.

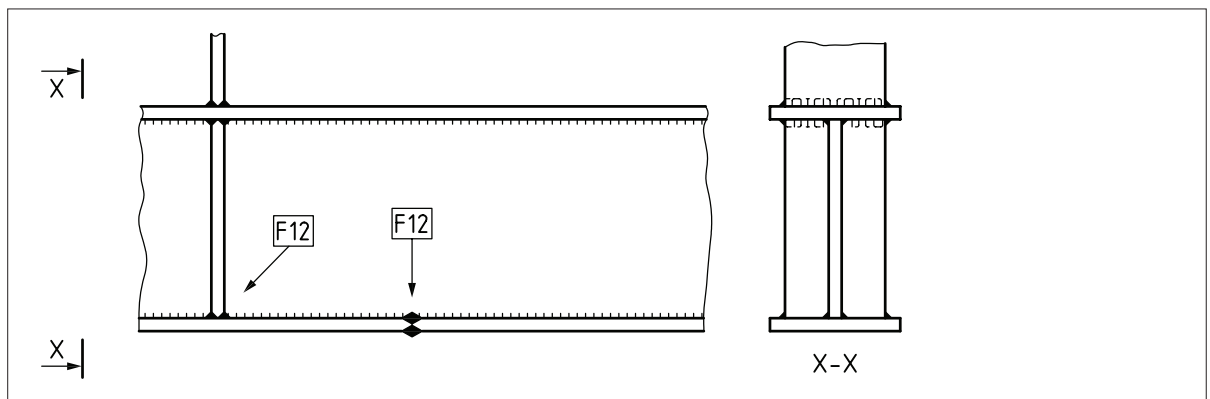
Where a service category is designated for a joint or member, it should apply to the full extent of the joint or member, unless otherwise noted.

4.1.5.2 Quantified service category F12 (reduced static)

Where the reduced static service category (i.e. F12) applies to all structural items on a drawing, it should be stated in a general note.

NOTE The use of F12 as a general category is unlikely to apply except in designs where consideration of stiffness/deflection, as opposed to strength, is an overriding factor throughout the design.

Where this service category applies to selected parts of a structure, each joint concerned should be identified individually as shown in [Figure 1](#).

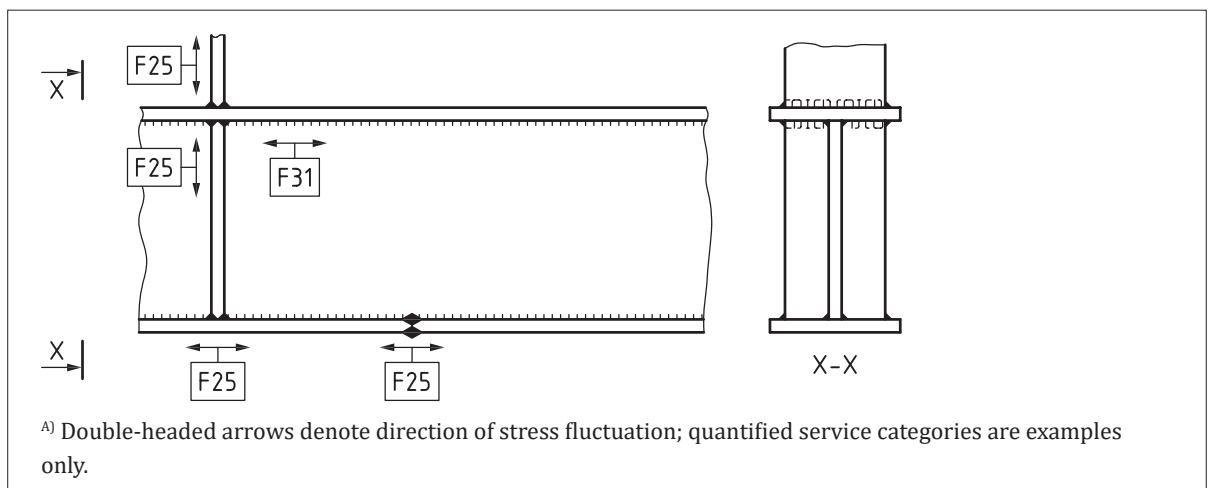
Figure 1 — Method of designation of quantified service category F12 on drawings

4.1.5.3 Quantified service categories F25 and above (significant fatigue)

The quantified service categories should be designated on all joints where the default quantified service category F20 is inadequate (see [Table 2](#)). The method of designation should show the direction of stress fluctuation and the quantified service category as shown in [Figure 2](#).

The use of a general note covering all items on a drawing, based on the joint with the highest service category, should be avoided, as this is likely to result in unnecessary inspection and repair. However, if a significant number of details in a distinct part of a structure require a quantified service category of F25 (or even F31), it might be justifiable to designate that category for the entire part by means of a general note.

NOTE There might be applications where more than one fatigue service category is required for an individual joint, depending on the directions of stressing. If so, the service category needs to be indicated for each direction.

Figure 2 — Method of designation of quantified service categories F25 and above on drawings^{A)}

4.2 Use of other wrought alloys [see BS EN 1999-1-1:2007, 3.2.1(1)]

[A1] To enable designs of existing structures to be assessed to BS EN 1999 which contain materials produced prior to the adoption of European material standards, the aluminium alloys listed in [Table 3](#) and [Table 4](#) should be used. The existing use of these alloys should be accepted by the designer and the values for minimum 0,2% tensile proof stress and minimum tensile strength given in the tables should be applied when calculating the design resistance of the relevant material. The values in BS EN 1999-1-1:2007+A2:2013, Table 3.2a, Table 3.2b and Table 3.2c, should not be used in such circumstances. **[A1]**

 Text deleted. 

NOTE The information in these tables might also be useful when assessing existing structures conforming to BS EN 1999.

Table 3 — Mechanical properties of original British Standard heat-treatable alloys

Alloy	Condition	Product	Thickness range		Minimum 0,2% tensile proof stress	Minimum tensile strength	Elongation (see Note)		Related British Standard
			>	≤	(see Note)	(see Note)	5.65√S ₀	50 mm	
			mm	mm	N/mm ²	N/mm ²	%	%	
6061	T6	Extrusions ^{A)}	—	150	240	280	8	7	BS 1474
		Drawn tube	—	6,0	240	295	7 ^{B)}	7 ^{B)}	BS 1471
			6,0	10	255	295	9 ^{B)}	9 ^{B)}	
6063	T4	Extrusions	—	150	70	130	16	14	BS 1474
		Drawn tubes	—	10	100	155	15 ^{B)}	15 ^{B)}	BS 1471
		Forgings	—	150	85	140	16	—	BS 1472
	T5	Extrusions	—	25	110	150	8	7	BS 1474
	T6	Extrusions	—	150	160	185	8	7	BS 1474
		Drawn tube	—	10	180	200	8 ^{B)}	8 ^{B)}	BS 1471
		Forgings	—	150	160	185	10	—	BS 1472
	T4	Extrusions	—	150	120	190	16	14	BS 1474
		Sheet	0,2	3,0	120	200	—	15	BS 1470
		Pile	3,0	25	115	200	12	15	BS 1470
		Drawn tube	—	6,0	115	215	12 ^{B)}	12 ^{B)}	BS 1471
			6,0	10	115	215	14 ^{B)}	14 ^{B)}	
		Forgings	—	150	120	185	16	—	BS 1472
	T6	Extrusions	—	20	255	295	8	7	BS 1474
			20	150	270	310	8	—	
		Sheet	0,2	3,0	255	295	—	8	BS 1474
		Plate	3,0	25	240	295	8	8	BS 1470
		Drawn tube	—	6,0	255	310	7 ^{B)}	7 ^{B)}	BS 1471
			6,0	10	240	310	9 ^{B)}	9 ^{B)}	
		Forgings	—	120	255	295	8	—	BS 1472
7020	T4	Extrusions	—	25	190	300	10	12	BS 4300/15
		Sheet and Plate		25	170	280	10	12	BS 4300/14
	T6	Extrusions	—	25	280	340	8	10	BS 4300/15
		Sheet and Plate		25	270	320	8	10	BS 4300/14

Table 3 (continued)

Alloy	Condition	Product	Thickness range		Minimum 0,2% tensile proof stress	Minimum tensile strength	Elongation (see Note)		Related British Standard
			>	≤	(see Note)	(see Note)	$5,65\sqrt{S_0}$	50 mm	
			mm	mm	N/mm ²	N/mm ²	%	%	
LM25	TB7	Sand cast	—	—	80 to 100	160 ^{C)}	2,5	—	BS 1490
		Chill cast	—	—	90 to 110	230 ^{C)}	5	—	
	TF	Sand cast	—	—	200 to 250	230 ^{C)}	—	—	
		Chill cast	—	—	220 to 260	280 ^{C)}	2	—	

^{A)} Extrusion refers to bars, extruded round tubes and sections.

^{B)} Elongation on $5,65\sqrt{S_0}$ for tubes with wall thickness of 3 mm and thinner, and on 50 mm for tubes with thicker walls.

^{C)} Minimum value specified in BS 1490.

NOTE Minimum value specified in BS 1470, BS 1471, BS 1472, BS 1474 and BS 4300/14 and BS 4300/15.