INTERNATIONAL STANDARD

ISO 10684

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Fasteners — Hot dip galvanized coatings

Éléments de fixation — Revêtements de galvanisation à chaud

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 10684 was prepared by Technical Committee ISO/TC 2, *Fasteners*, Subcommittee SC 1, *Mechanical properties of fasteners*.

Fasteners — Hot dip galvanized coatings

1 Scope

This International Standard specifies material, process, dimensional and some performance requirements for hot dip spun galvanized coatings applied to coarse threaded steel fasteners from M8 up to and including M64 and for property classes up to and including 10.9 for bolts, screws and studs and 12 for nuts. It is not recommended to hot dip galvanize threaded fasteners in diameters smaller than M8 and/or with pitches below 1,25 mm.

NOTE Attention is drawn to the fact that the proof loads and stresses under proof load of oversize tapped nuts with threads M8 and M10 and the ultimate tensile loads and proof loads of undersize threaded bolts and screws with threads M8 and M10 are reduced as compared to the values specified in ISO 898-2 and ISO 898-1 respectively and are specified in Annex A.

It primarily concerns the spun hot dip galvanizing of threaded steel fasteners, but it may also be applied to other threaded steel parts.

The specifications given in this International Standard may also be applied to non-threaded steel parts such as washers.

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.

ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs*

ISO 898-2, *Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread*

ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*

ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for general purpose external and internal screw threads — Medium quality*

ISO 965-3, *ISO general purpose metric screw threads — Tolerances — Part 3: Deviations for constructional screw threads*

ISO 965-4, *ISO general purpose metric screw threads — Tolerances — Part 4: Limits of sizes for hot-dip galvanized external screw threads to mate with internal screw threads tapped with tolerance position H or G after galvanizing*

ISO 965-5, *ISO general purpose metric screw threads — Tolerances — Part 5: Limits of sizes for internal screw threads to mate with hot-dip galvanized external screw threads with maximum size of tolerance position h before galvanizing*

ISO 1460, *Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area*

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 8991, *Designation system for fasteners*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064 (in particular, the definitions of significant surface, measuring area, local thickness, minimum local thickness and average thickness) and the following apply.

3.1
batch
quantity of identical parts cleaned, pickled, fluxed and galvanized together at one time in a galvanizing basket

3.2
production lot
batches of parts originating from the same manufacturing lot, processed continuously through cleaning, pickling, fluxing, dipping in molten zinc and spun in a centrifuge without any change in temperature and concentration of the constituents of the process

3.3
batch average thickness
calculated average thickness of a coating as if it was uniformly distributed over the surface of the parts of the batch

3.4
baking
process of heating parts for a definite time at a given temperature in order to minimize the risk of hydrogen embrittlement

3.5
stress relief
process of heating parts for a definite time at a given temperature in order to relieve stress induced by work hardening

3.6
hot dip galvanizing of fasteners
process whereby steel fasteners are zinc coated by immersion in a bath of molten zinc, resulting in the formation of a zinc-iron alloy coating or a zinc-iron alloy coating plus a zinc coating at the surface of the fastener

NOTE This process involves the removal of excess zinc by spinning the parts in a centrifuge or by an equivalent method.

4 Materials

4.1 Raw material of parts

4.1.1 Chemical composition

Materials as included in ISO 898-1 and ISO 898-2 are suitable for hot dip galvanizing except if the total content of phosphorus and silicon is between 0,03 % and 0,13 %, in which case high temperature galvanizing (530 °C to 560 °C) is recommended.

4.1.2 Surface condition

The surface of the fastener, before immersion in the molten zinc, shall be clean and free from all contaminants that would adversely effect the galvanizing.

4.2 Zinc

The zinc used for this process shall be in accordance with ISO 1461.

5 Hot dip galvanizing procedures and precautions

5.1 Stress relief

Fasteners subjected to severe work hardening may require stress relief before acid cleaning and hot dip galvanizing.

5.2 Cleaning and pickling

Parts shall be cleaned. During the cleaning process, hydrogen could be absorbed into the steel. The hydrogen may not effuse completely in the galvanizing bath and consequently, may lead to brittle failure. Unless otherwise agreed, parts heat treated or work hardened to a hardness of $\geqslant$ 320 HV shall be cleaned using an inhibited acid, alkaline or mechanical process. Immersion time in the inhibited acid depends on the as-received surface condition and should be of minimum duration.

NOTE An inhibited acid is an acid to which a suitable inhibitor has been added to reduce corrosive attack on the steel and absorption of hydrogen.

5.3 Baking

If baking is carried out, it shall be carried out prior to surface activation.

5.4 Fluxing

Parts shall be surface activated, and dried if necessary.

5.5 Hot dip galvanizing

Normal temperature galvanizing is carried out at a bath temperature of 455 °C to 480 °C. High temperature galvanizing is used to produce a smoother and thinner coating and is carried out at a bath temperature of 530 °C to 560 °C. The finish obtained using the high temperature process is dull. In order to avoid micro-cracks, bolts, screws and studs of property class 10.9 in sizes M27 and above, shall not be high temperature galvanized.

Galvanizing shall not be carried out at bath temperatures between 480 °C and 530 °C.

5.6 Spinning and quenching

Parts shall be spun immediately following removal from the galvanizing bath and quenched in water or air cooled depending on size consideration.

5.7 Special requirements for nuts

Nut threads and other internal threads shall be tapped after hot dip galvanizing. Retapping shall not be permitted.

5.8 Post-treatment

Most galvanized parts do not require any post treatment. When required by the purchaser, treatments such as chromating or phosphating may be applied to reduce the possibility of wet storage staining (white corrosion) or to assist subsequent painting.

6 Requirements on thread tolerances and additional marking

6.1 General

Dimensional limits for ISO metric screw threads M10 to M64 before and after coating are specified in ISO 965-1 to ISO 965-5. All other dimensions and tolerances of fasteners apply before hot dip galvanizing. Dimensional limits for internal and external screw threads M8 with thread tolerances 6AX and 6AZ for internal threads and 6az for external threads are specified in Annex B.

NOTE It is not possible to check the thread tolerance of a hot dip galvanized part by stripping the coating and gauging the thread thereafter, since some steel is dissolved from the part during the galvanizing process.

6.2 Requirements and precautions in assembling hot dip galvanized threaded fasteners

6.2.1 General

This clause applies only to parts with thread tolerances in accordance with ISO 965-1 to ISO 965-5 and with marking according to the marking requirements for fasteners as given in ISO 898-1 and ISO 898-2. The marking specified in 6.2.2 and 6.2.3 shall be carried out in addition to the marking according to ISO 898-1 and ISO 898-2.

The application of zinc coating by the hot dip process results in the deposition of a heavy coating thickness of zinc (always in excess of 40 µm). Hence, it is necessary to manufacture screw threads to special limits in order to accommodate such heavy coatings.

There are two different methods provided for, which give the necessary fundamental deviations (clearances) for the zinc layer applied to fasteners by hot dip galvanizing.

The first method (see 6.2.2) consists of using nuts tapped oversize to tolerance class 6AZ or 6AX after coating, to mate with bolts or screws manufactured with screw threads to tolerance position g or h before coating.

The second method (see 6.2.3) consists of using bolts or screws manufactured with threads undersized to tolerance class 6az before coating, to mate with nuts tapped to tolerance position H or G after coating.

Nuts tapped oversize (marked with Z or X) shall never be mated with bolts or screws with undersized threads (marked with U), because such combinations create a high probability of thread stripping.

Assembling hot dip galvanized nuts tapped to tolerance position H or G after coating with hot dip galvanized bolts or screws manufactured with threads to tolerance position g or h before coating results in thread interference.

6.2.2 Nuts tapped oversize to tolerance class 6AZ or 6AX after coating

Oversize tapping of nuts and internal threads to tolerance class 6AZ or 6AX in accordance with ISO 965-5 is required after hot dip galvanizing when the mating bolts or screws or external threads are manufactured to tolerance position g or h in accordance with ISO 965-1 to ISO 965-3 before hot dip galvanizing.

Nuts tapped oversize shall be marked with the letter Z immediately after the property class mark in case of tolerance class 6AZ or with the letter X in case of tolerance class 6AX. See example in Figure 1.

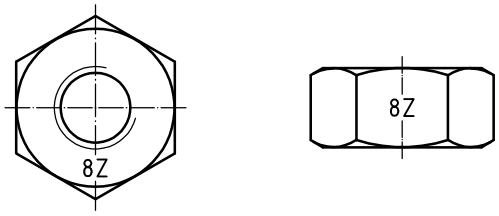


Figure 1 — Example of marking of hot dip galvanized nuts tapped oversize to tolerance position 6AZ after coating

In order to reduce the risk of interference on assembly of threads with hot dip galvanized coatings, the coating thickness on the mating bolts or screws or external threads advisably should not exceed one quarter of the minimum clearance of the thread combination. These values are given in Table 1 for information.

Table 1 — Fundamental deviations and upper limits of coating thicknesses for assemblies with nuts tapped oversize

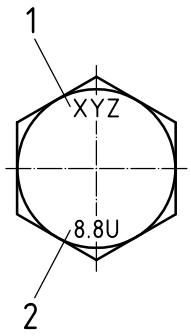
Pitch	Nominal thread diameter	Fundamental deviation				Minimum clearance and maximum coating thickness for thread combinations (for information)							
		Internal thread		External thread		AZ/h		AZ/g		AX/h		AX/g	
P	d	AZ	AX	h	g	Minimum clearance	Maximum coating thickness	Minimum clearance	Maximum coating thickness	Minimum clearance	Maximum coating thickness	Minimum clearance	Maximum coating thickness
mm	mm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm
1,25	8	+ 325[a]	+ 255[a]	0	− 28	325	81	353	88	255	64	283	71
1,5	10	+ 330	+ 310	0	− 32	330	83	362	91	310	78	342	86
1,75	12	+ 335	+ 365	0	− 34	335	84	369	92	365	91	399	100
2	16 (14)	+ 340	+ 420	0	− 38	340	85	378	95	420	105	458	115
2,5	20 (18,22)	+ 350	+ 530	0	− 42	350	88	392	98	530	133	572	143
3	24 (27)	+ 360	+ 640	0	− 48	360	90	408	102	640	160	688	172
3,5	30 (33)	+ 370	+ 750	0	− 53	370	93	423	106	750	188	803	201
4	36 (39)	+ 380	+ 860	0	− 60	380	95	440	110	860	215	920	230
4,5	42 (45)	+ 390	+ 970	0	− 63	390	98	453	113	970	243	1 033	258
5	48 (52)	+ 400	+ 1 080	0	− 71	400	100	471	118	1 080	270	1 151	288
5,5	56 (60)	+ 410	+ 1 190	0	− 75	410	103	485	121	1 190	398	1 265	316
6	64	+ 420	+ 1 300	0	− 80	420	105	500	125	1 300	325	1 380	345

[a] The fundamental deviations for AZ and AX are calculated according to the formulae given in ISO 965-5 on the basis of the thread dimensions specified in Annex B.

6.2.3 Bolts and screws with threads undersized to tolerance class 6az before coating

Undersize threading of bolts, screws and external threads to tolerance class 6az in accordance with ISO 965-4 is required before hot dip galvanizing, when the mating nuts or internal threads have tolerance position G or H in accordance with ISO 965-1 to ISO 965-3 after hot dip galvanizing.

Bolts and screws with undersized threads shall be marked with the letter U immediately after the property class mark. See example in Figure 2.



Key

1 manufacturer's identification mark

2 property class and additional marking

Figure 2 — Example of marking of hot dip galvanized bolts and screws with threads undersized to tolerance class 6az before coating

In order to reduce the risk of interference on assembly of threads with hot dip galvanized coatings, the coating thickness advisably should not exceed one quarter of the minimum clearance of the thread combination. These values are given in Table 2 for information.

Table 2 — Fundamental deviations and upper limits of coating thicknesses for assemblies with bolts and screws with undersized threads

Pitch	Nominal thread diameter	Fundamental deviation			Minimum clearance and maximum coating thickness for thread combinations (for information)			
		External thread	Internal thread		az/H		az/G	
P	d	az	H	G	Minimum clearance	Maximum coating thickness	Minimum clearance	Maximum coating thickness
mm	mm	µm	µm	µm	µm	µm	µm	µm
1,25	8	− 325[a]	0	+ 28	325	81	353	88
1,5	10	− 330	0	+ 32	330	83	362	91
1,75	12	− 335	0	+ 34	335	84	369	92
2	16 (14)	− 340	0	+ 38	340	85	378	95
2,5	20 (18, 22)	− 350	0	+ 42	350	88	392	98
3	24 (27)	− 360	0	+ 48	360	90	408	102
3,5	30 (33)	− 370	0	+ 53	370	93	423	106
4	36 (39)	− 380	0	+ 60	380	95	440	110
4,5	42 (45)	− 390	0	+ 63	390	98	453	113
5	48 (52)	− 400	0	+ 71	400	100	471	118
5,5	56 (60)	− 410	0	+ 75	410	103	485	121
6	64	− 420	0	+ 80	420	105	500	125

[a] The fundamental deviation for az is calculated according to the formula given in ISO 965-4 on the basis of the thread dimensions specified in Annex B.

6.3 Special requirements for marking when supplying fasteners in sealed containers

If hot dip galvanized bolts or screws and mating nuts are packed together and supplied in the manufacturer's sealed container, the additional marking of the bolts, screws or nuts as described in 6.2.2 and 6.2.3 is not mandatory. The label on each sealed container shall indicate the additional marking as required in 6.2.2 and 6.2.3.

Additional marking of products or labelling of containers as described in 6.2.2 and 6.2.3 is not mandatory for fasteners with a special marking related to a product standard which specifies the thread tolerance for hot dip galvanized bolts, screws, studs or nuts and, therefore, does not allow the manufacturer to choose the thread tolerance.

7 Mechanical properties of nuts tapped oversize and undersize threaded bolts, screws and studs

For bolts, screws, studs and nuts $\geqslant$ M12, the requirements of ISO 898-1 and ISO 898-2 shall be met after hot dip galvanizing. For the sizes M8 and M10, proof loads and stresses under proof loads for nuts and ultimate tensile loads and proof loads for bolts, screws and studs are specified in Annex A.

8 Coating requirements

8.1 Appearance of zinc coating

The hot dip galvanized parts shall be free from uncoated areas, blisters, flux deposits, black spots, dross inclusions and other defects that would impair the intended use of the parts. Dull appearance shall not constitute grounds for rejecting parts.

8.2 Considerations for hot dip galvanized washers

Hot dip galvanized washers tend to bond to each other and suitable acceptance criteria should be agreed upon at the time of ordering.

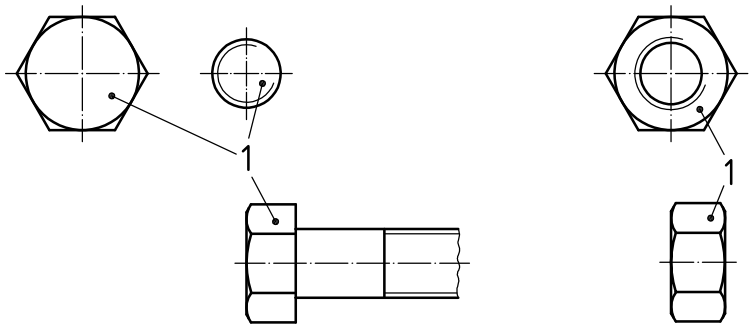
8.3 Zinc coating thickness

The local coating thickness shall be a minimum of 40 µm and the batch average coating thickness shall be a minimum of 50 µm. The measurement of the local coating thickness shall be made on measuring areas as shown in Figure 3.

Measurement of the local coating thickness shall be conducted by the magnetic method in accordance with ISO 2178 on every production lot. To calculate the local coating thickness, a minimum of five readings shall be taken and averaged. In case the geometry does not permit five readings, five samples shall be used to establish the readings to be averaged. In case of dispute, the gravimetric method in accordance with ISO 1460 shall be used. For the calculation of the batch average coating thickness, the surface area of the fastener can be evaluated according to Annex D.

8.4 Adhesion of zinc coating

The zinc coating shall adhere tenaciously to the surface of the base metal. The method for testing the adherence is specified in Annex E.



Key

1 measuring area

Figure 3 — Measuring area for local coating thickness measurement on fasteners

9 Lubrication

To enhance tightening behaviour of the assembly, the nuts or the bolts or the screws should be lubricated.

10 Ordering requirements

When ordering fasteners to be coated in accordance with this International Standard, the following information shall be supplied to the coater:

a) reference to this International Standard and the coating designation (see Clause 11);

b) the material of the part, the manufacturing lot number and the condition of the part, e.g. heat treatment, hardness or other properties, which may be affected by the coating process;

c) whether a special coating thickness is required;

d) additional tests, if required;

e) additional treatments such as lubrication, chromating, etc., as required.

11 Designation

Fasteners shall be designated according to the appropriate product standards. The designation of the surface coating shall be added to the product designation according to the specification of ISO 8991 using the symbol tZn for the hot dip galvanized coating.

Example 1 refers to a bolt/nut combination as described in 6.2.2 using nuts tapped oversize.

Example 2 refers to a bolt/nut combination as described in 6.2.3 using bolts or screws with undersized threads.

EXAMPLE 1 A hexagon nut in accordance with ISO 4032, size M12, property class 8, hot dip galvanized and tapped oversize to thread tolerance class 6AZ is designated as follows:

Hexagon nut ISO 4032 - M12 - 8Z - tZn

NOTE 8Z is substituted by 8X in case of thread tolerance class 6AX.

The mating hexagon head bolt in accordance with ISO 4014 size M12 × 80, property class 8.8, thread tolerance class 6g and hot dip galvanized is designated as follows:

Hexagon head bolt ISO 4014 - M12 × 80 - 8.8 - tZn

EXAMPLE 2 A hexagon head bolt in accordance with ISO 4014, size M12 × 80, property class 8.8, thread tolerance class 6az and hot dip galvanized is designated as follows:

Hexagon head bolt ISO 4014 - M12 × 80 - 8.8U - tZn

The mating hexagon nut in accordance with ISO 4032, size M12, property class 8, hot dip galvanized and tapped to thread tolerance class 6H is designated as follows:

Hexagon nut ISO 4032 - M12 - 8 - tZn

Annex A
(normative)

Special requirements for bolts, screws and nuts with thread sizes M8 and M10

A.1 General

For M8 and M10 ultimate tensile loads and proof loads lower than those specified in ISO 898-1 and ISO 898-2 are specified in this annex taking into account the relatively large fundamental deviations according to 6.2.2 and 6.2.3.

For nuts tapped oversize, the reduced overlap of thread M8 and M10 significantly reduces the proof load values as compared with those given in ISO 898-2.

For bolts and screws with undersized threads, the stress areas for M8 and M10 are significantly smaller than the stress areas given in ISO 898-1.

A.2 Minimum proof loads for hexagon nuts tapped oversize to tolerance class 6AZ or 6AX after coating

According to 6.2.2 nuts may be tapped oversize to tolerance class 6AZ or 6AX in accordance with ISO 965-5 and Annex B. For thread sizes M8 and M10 tolerance class 6AZ gives the largest fundamental deviation. Consequently, for thread sizes M8 and M10 the fundamental deviations for tolerance class 6AZ are used to establish the proof loads as given in Table A.1. Stresses under proof load are given in Table A.2.

All other mechanical property requirements as given in ISO 898-2 are valid.

For test methods, see ISO 898-2.

Table A.1 — Proof loads for nuts with threads of tolerance classes 6AZ and 6AX

Thread	Pitch of thread	Nominal stress area of standard test mandrel	Property class				
			5	6	8	9	10
			Marking				
(d)	P	A_S	5Z/5X	6Z/6X	8Z/8X	9Z/9X	10Z/10X
			Proof load N				
	mm	mm^2					
M8	1,25	36,6	17 300	20 000	25 500	27 600	30 600
M10	1,5	58,0	28 600	33 000	42 200	45 600	50 400

Table A.2 — Stresses under proof load for nuts with threads of tolerance classes 6AZ and 6AX

Thread (d)	Property class				
	5	6	8	9	10
	Marking				
	5Z/5X	6Z/6X	8Z/8X	9Z/9X	10Z/10X
	Stress under proof load N/mm^2				
M8	473	546	698	754	835
M10	493	569	728	786	870

A.3 Minimum ultimate tensile loads and proof loads for bolts and screws with threads undersized to tolerance class 6az before coating

According to 6.2.3 bolts, screws and external threads have to be threaded undersize to tolerance class 6az in accordance with ISO 965-4 and Annex B. For thread sizes M8 and M10 tolerance class 6az gives large fundamental deviations and this reduces the stress area. Consequently, for thread sizes M8 and M10, the ultimate tensile loads and proof loads are reduced. For principles of calculation, see Annex C. The reduced values are given in Tables A.3 and A.4.

All other mechanical property requirements as given in ISO 898-1 are valid.

For test methods, see ISO 898-1.

Table A.3 — Minimum ultimate tensile loads for bolts and screws with threads of tolerance class 6az

Thread (d)	**Stress area** A_{saz} mm^2	**Property class**			
		4.6	**5.6**	**8.8**	**10.9**
		Marking			
		4.6U	**5.6U**	**8.8U**	**10.9U**
		Minimum ultimate tensile load ($A_{saz} \times R_{m,\,min}$) N			
M8	33,2	13 300	16 600	26 600	34 500
M10	53,6	21 400	26 800	42 900	55 700

Table A.4 — Proof loads for bolts and screws with threads of tolerance class 6az

Thread (d)	**Stress area** A_{saz} mm^2	**Property class**			
		4.6	**5.6**	**8.8**	**10.9**
		Marking			
		4.6U	**5.6U**	**8.8U**	**10.9U**
		Proof load ($A_{saz} \times S_p$) N			
M8	33,2	7 470	9 300	19 300	27 600
M10	53,6	12 100	15 000	31 100	44 500

Annex B
(normative)

Limits of sizes for hot dip galvanized internal and external screw thread M8

B.1 General

For thread size M8 this annex gives information on screw thread limits for

a) internal screw threads tapped oversize to tolerance class 6AZ and 6AX;

b) external screw threads undersize threaded to tolerance class 6az.

B.2 Limits of sizes — Internal screw thread M8

The internal screw thread limits for M8 for tolerance class 6AZ and 6AX are specified in Table B.1.

Tolerance quality: medium

Thread engagement group: normal

Tolerance classes: 6AZ and 6AX

Table B.1 — Internal screw thread limits for tolerance classes 6AZ and 6AX

Dimensions in millimetres

Thread	Length of thread engagement		Tolerance class	Major diameter [a]	Pitch diameter [a]		Minor diameter [b]	
				D	D_2		D_1	
	over	up to and including		min.[c]	max.	min.	max.	min.
M8	4	12	6AZ	8,325	7,673	7,513	7,237	6,972
			6AX	8,255	7,603	7,443	7,167	6,902

[a] Dimensions apply to internal screw threads after galvanizing and tapping oversize.

[b] Dimensions apply to internal screw threads before galvanizing or after galvanizing and removal of zinc fragments.

[c] Refers to the imaginary co-axial cylinder through the points where the requirement with regard to straightness of flank ceases.

B.3 Limits of sizes — External screw thread M8

The external screw thread limits for M8 for tolerance class 6az are specified in Table B.2.

Tolerance quality: medium

Thread engagement group: normal

Tolerance class: 6az

The actual root contour shall not at any point transgress the basic profile.

For hot-dip galvanized screw threads, the tolerances apply to the parts before galvanizing. After galvanizing, the actual thread profile shall not in any point transgress the maximum material limits for tolerance position h and is intended to mate with internal screw threads of tolerance position H or G only.

Table B.2 — External screw thread limits for tolerance class 6az

Dimensions in millimetres

Thread	**Length of thread engagement**		**Major diameter**		**Pitch diameter**		**Minor diameter** (for stress calculation)	**Root radius**
			d		d_2		d_3	
	over	up to and including	max.	min.	max.	min.	max.	min.
M8	4	12	7,675	7,463	6,863	6,745	6,142	0,156

Annex C
(informative)

Calculation of minimum ultimate tensile loads and proof loads for bolts and screws M8 and M10 with threads undersized to tolerance class 6az

The minimum ultimate tensile loads given in Table A.3 and the minimum proof loads given in Table A.4 have been calculated using the minimum tensile strength, R_m, and the stress under proof load, S_p, as specified in ISO 898-1. These values are multiplied by the stress area, A_{saz}, derived from the thread diameters for M10 in accordance with ISO 965-4 and for M8 in accordance with Annex B and the following formula:

$$A_{saz} = \frac{\pi}{4}\left(\frac{d_2 + d_3}{2}\right)^2$$

where

d_2 is the maximum pitch diameter of the thread;

d_3 is the maximum minor diameter of the thread.

Annex D
(informative)

Surface areas of bolts, screws and nuts

D.1 General

This annex gives guidance for the evaluation of the surface areas of bolts, screws and nuts which are needed for the determination of the batch average thickness according to 8.3.

NOTE The surface areas given in Tables D.1 and D.2 apply only if agreed upon between the parties concerned.

D.2 Bolts and screws

To obtain the total surface area of a bolt or screw, the following parameter values are necessary (see Figure D.1):

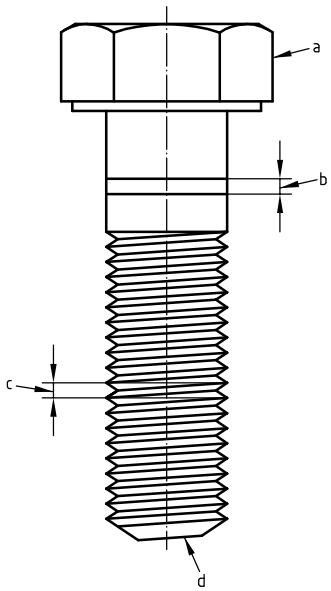
— the surface area, A_1, of a length of 1 mm of the threaded shank of the bolt or screw;

— the surface area, A_2, of a length of 1 mm of the unthreaded shank of the bolt or screw;

— the surface area, A_3, of the head (including surface of the end face).

The total surface areas, A, is then calculated as follows:

$$A = A_1 \times \text{thread length} + A_2 \times \text{shank length} + A_3$$



a Total surface area of the head including surface area of the end face, see[d].

b Surface area of the shank of 1 mm length.

c Surface area of the threaded part of 1 mm length.

d Surface area of the end face is included in the surface area of the head (A_3).

Figure D.1 — Surface area

If the thread is cut, the unthreaded shank will be approximately equal to the basic major diameter (nominal diameter). If the thread is rolled, the unthreaded shank will be approximately equal to either the pitch diameter (reduced shank) or the basic major diameter (full shank).

Table D.1 gives values for the surface areas A_1, A_2 and A_3 for different shanks and hexagon head.

Table D.1 — Surface areas of bolts and screws

Surface areas in square millimetres

Thread size (coarse thread)	**Surface area per millimetre length**			**Surface area of head, A_3**
	Threaded shank, A_1 (coarse thread)	Unthreaded shank, A_2		Hexagon head
		Full shank	Reduced shank (coarse thread)	
M8	38,48	25,15	22,43	541,3
M10	48,31	31,42	28,17	905,8
M12	58,14	37,63	33,98	1 151
M14	67,97	43,99	39,45	1 523
M16	78,69	50,27	45,67	1 830
M18	87,63	56,54	50,88	2 385
NOTE For the time being, values for bolts and screws with sizes > M18 or with fine pitch thread are not available and should be calculated as appropriate.				

D.3 Nuts

Table D.2 gives the surface areas of hexagon nut style 1.

NOTE When evaluating the surface area of a hot dip galvanized nut, the surface area of the thread is not taken into consideration since the nut is tapped after hot dip galvanizing.

Table D.2 — Surface areas of hexagon nuts style 1

Surface areas in square millimetres

Thread size	Surface area A
M8	536
M10	892
M12	1 169
M14	1 522
M16	1 877
M18	2 424
NOTE For the time being values for nuts with sizes > M18 and nuts of style 2 are not available and should be calculated as appropriate.	

Annex E
(normative)

Adherence of hot-dip galvanized coating

To determine the adherence of the zinc coating to the surface of the base metal, use the point of a stout knife. Cut or prise, with the application of considerable pressure, in a manner tending to remove a portion of the coating.

The adherence shall be considered inadequate if the coating flakes off in the form of a layer or skin so as to expose the base metal in advance of the knife point.

Testing shall not be done at edges or corners (points of lowest coating adherence) to determine adherence of coating.

Likewise, the removal of small particles of the coating by paring or whittling shall not constitute failure and therefore not be grounds for rejection.

Annex F
(informative)

Strength of hot dip galvanized bolt or screw and nut assemblies

Bolts, screws and nuts modified by either undersizing of the bolt or screw thread as required by ISO 965-4 or oversize tapping of the nut thread in accordance with ISO 965-5, if manufactured to the full range of dimensional and mechanical property tolerances, may not achieve the expected assembly strength when combined with the specified mating component.

The reduction in assembly strength is due to the reduction in shear strength of the modified threads; refer to the work of Alexander[1)] on the strength of screw threads.

The following proposals indicate methods by which the full assembly strength of a 6g/6H thread tolerance combination may be achieved, when modified thread combinations are used.

a) Bolts and screws manufactured with thread tolerance class 6az in accordance with ISO 965-4

The bolts or screws should not be manufactured to the minimum tensile strength, R_m, specified in ISO 898-1.

Care should be taken with bolts and screws of property class 8.8 not to exceed the maximum hardness of property class 8.8, because of the risk of hydrogen embrittlement.

b) Nuts manufactured with thread tolerance class 6AZ in accordance with ISO 965-5

To achieve full assembly strength with nuts tapped oversize to thread tolerance class 6AZ two options may be considered:

1) Fit the bolts and screws with nuts of one property class higher, i.e. bolt or screw of property class 8.8 with nut of property class 10, etc.

2) Fit the bolts and screws with nuts of the same property class but of style 2 nut height instead of style 1.

c) Nuts manufactured with thread tolerance class 6AX in accordance with ISO 965-5

For diameters greater than M10 in order to achieve the full assembly strength of nuts tapped oversize to thread tolerance class 6AX, nuts of an even higher property class than those used with thread tolerance class 6AZ should be used. In some countries, where this thread tolerance class is generally used, the national standards require the use of nuts of two property classes higher.

1) E.M. ALEXANDER, *Analysis and design of threaded assemblies,* SAE Transactions, Section 3 — Volume 86.

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