
**Mechanical properties of fasteners
made of carbon steel and alloy steel —
Part 3:
Flat washers with specified property
classes**

iTeh STANDARD PREVIEW
*Caractéristiques mécaniques des fixations en acier au carbone et en
acier allié —
(standards.iteh.ai)
Partie 3: Rondelles de forme plane de classes de qualité spécifiées*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html. (standards.iteh.ai)

This document was prepared by Technical Committee ISO/TC 2, *Fasteners*.

A list of all parts in the ISO 898 series can be found on the ISO website. www.iso.org/iso/898-3-2018

Introduction

ISO 898 consists of the following parts, under the general title “*Mechanical properties of fasteners made of carbon steel and alloy steel*”:

- *Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*
- *Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread*
- *Part 5: Set screws and similar threaded fasteners with specified hardness classes — Coarse thread and fine pitch thread*
- *Part 7: Torsional test and minimum torques for bolts and screws with nominal diameters 1 mm to 10 mm*

This document in the ISO 898 series provides a single point of reference for flat washers, in order to standardize market expectations for users, distributors and manufacturers.

This document only deals with flat washers made of carbon steel or alloy steel.

Washers made of stainless steel are not addressed in this document due to their different characteristics and test methods.

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Mechanical properties of fasteners made of carbon steel and alloy steel —

Part 3: Flat washers with specified property classes

1 Scope

This document specifies mechanical and physical properties of flat washers, designed to be used in bolted joints in combination with bolts, screws, studs and nuts with a specified property class in accordance with ISO 898-1 and ISO 898-2.

NOTE 1 These types of washers can also be used with other fasteners such as screws forming their own mating thread.

Washers that conform to the requirements of this document are evaluated at an ambient temperature range of 10 °C to 35 °C. They might not retain the specified mechanical and physical properties at elevated temperatures and/or lower temperatures.

NOTE 2 Washers conforming to the requirements of this document are used in applications ranging from -50 °C to +150 °C. Users are advised to consult an experienced fastener expert for temperatures outside this range and up to a maximum temperature of +300 °C when determining appropriate choices, or for critical applications.

This document is applicable to the following flat captive and non-captive washers made of carbon steel or alloy steel, with thickness from 0,2 mm to 12 mm:

- plain washers (with or without knurls, ribs or chamfers);
- square washers;
- square hole washers;
- shaped plates.

It does not specify requirements for the following properties:

- corrosion resistance;
- weldability.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1891-4, *Fasteners — Terminology — Part 4: Controls, inspection, delivery, acceptance and quality*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 10644, *Screw and washer assemblies made of steel with plain washers — Washer hardness classes 200 HV and 300 HV*

ISO 10669, *Plain washers for tapping screw and washer assemblies — Normal and large series — Product grade A*

ISO 10673, *Plain washers for screw and washer assemblies — Small, normal and large series — Product grade A*

ISO 10684, *Fasteners — Hot dip galvanized coatings*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Symbols

For the purposes of this document, the following symbols apply.

d_1 clearance hole, mm

d_2 outside diameter, mm

F force, N

G depth of the complete decarburization, mm

r radius of the supporting part and pressure part for the ductility test, mm

t nominal thickness of flat washer, mm

t_{eff} effective thickness of the material measured on the washer, mm

α angle of the supporting part and pressure part for the ductility test, °

5 Designation system for property classes of washers and combination with property classes of bolts, screws, studs and nuts

The symbol for property classes of washers is composed of two parts:

- the number to the left is the minimum Vickers hardness value in accordance with [Table 3](#);
- the letters HV to the right represent Vickers hardness.

EXAMPLE A steel flat washer with a minimum Vickers hardness of 200 according to [Table 3](#) has the property class designation 200HV.

The designation system of this document may be applied for sizes outside its scope (e.g. for washers with thickness $t > 12$ mm) provided all applicable requirements in accordance with [Tables 2](#) and [3](#) are met.

Although a great number of property classes is specified in this document, this does not mean that all property classes are appropriate for all washers and/or for all bolts/nuts/washers assemblies. The combination of property classes for flat washers with bolts, screws, studs and nuts is specified in [Table 1](#).

Table 1 — Combination of property classes of flat washers (e.g. plain washers) with property classes of bolts, screws, studs and nuts

Threaded fasteners in accordance with ISO 898-1 and ISO 898-2		Mating property classes for flat washers			
Property classes		100HV	200HV ^a	300HV ^a	380HV ^{b,c}
Bolts, screws and studs	Regular and high nuts				
4.6, 4.8, 5.6, 5.8	5	RC ^e	e	e	e
6.8	6	d,e	RC ^e	e	e
8.8	8	f	RC ^e	e	e
9.8, 10.9	10	f	d, e	RC ^e	e
12.9, 12.9	12	f	f	d,e	RC ^e

Key
RC = recommended combination.

^a Only 200HV and 300HV property classes are standardized for captive washers in bolts and washers assemblies; they shall be in accordance with ISO 10644 or ISO 10673.

^b Property class 380HV is currently not included in existing ISO product standards; if required, the use of this property class shall be agreed between the purchaser and the supplier.

^c The design of the bolted joint with a washer with property class 380HV shall prevent bending effect and tensile stress in the washer, especially with regard to slotted and enlarged holes.

^d RC represents the optimal combination; however, other combinations marked with footnote ^d may also be used provided joint design and/or installation conditions are checked.

^e The combinations above the stepped thick line can be used for bolted joints.

^f The combinations under the stepped thick line (grey zone) shall not be used.

For screws forming their own mating thread and screws for soft material (e.g. plastic, wood ...), combination with washer property classes shall be determined based on the intended application.

6 Materials

[Table 2](#) specifies limits for the chemical composition of carbon steel and alloy steel for the different property classes of washers. The chemical composition shall be assessed in accordance with the relevant International Standards.

NOTE Alloy steel includes spring steel and alloy spring steel that can also be used for flat washers.

For washers that are to be hot dip galvanized, the additional material requirements specified in ISO 10684 apply.

Washers may be supplied in non-heat treated condition if to be quenched and tempered as part of an assembly. In these cases, in accordance with ISO 10644, the chemical composition for washers shall be specified by agreement between the purchaser and the supplier.

When tapping screw assemblies require case hardening in accordance with ISO 10669, the carbon content of washers shall not exceed 0,12 %.

Each manufacturing lot of washers shall be manufactured from one single cast of raw material.

Table 2 — Chemical composition of steels

Property class	Material and process		Chemical composition limits (cast analysis, %) ^{a,b,c}					Minimum tempering temperature ^{b,c} °C
	Material	Process	C min.	C max.	P max.	S max.	B ^d max.	
100HV	Steel	Hot/cold rolled	Material selection shall be at the manufacturer's discretion, provided that the requirements of Table 3 are fulfilled.					NA
200HV ^e	Steel	Hot/cold rolled or quenched and tempered	Material selection shall be at the manufacturer's discretion, provided that the requirements of Table 3 are fulfilled.					NA
300HV ^f	Carbon steel ^g	Quenched and tempered	0,17	0,80	0,035	0,035	0,003	425
	Alloy steel ^h		0,14	1,30	0,035	0,035	0,003	425
380HV ^{f,i}	Carbon steel ^g	Quenched and tempered	0,40	0,80	0,035	0,035	0,003	425
	Alloy steel ^h		0,20	1,30	0,035	0,035	0,003	380

Key

NA = not applicable.

^a In case of dispute, the product analysis applies.

^b For captive washers, see ISO 10644 or ISO 10673. Chemical composition and minimum tempering temperature shall be agreed between the purchaser and the supplier at the time of the order.

^c For special applications (e.g. washers to be hot dip galvanized), chemical composition and minimum tempering temperature shall be agreed between the purchaser and the supplier at the time of the order.

^d Boron content shall be 0,003 % maximum, but it may be up to 0,005 % provided that non-effective boron is controlled by the addition of titanium and/or aluminium.

^e Property class 200HV washers can be manufactured using raw material having the right mechanical property or by quenching and tempering washers after manufacturing. Process choice is at manufacturer's discretion provided that the requirements of [Table 3](#) are fulfilled.

^f There shall be a sufficient hardenability to ensure a structure consisting of approximately 90 % martensite in the core section in the "as-hardened" condition before tempering.

^g Carbon steel can contain additives, e.g. chromium, manganese, nickel, etc.

^h Alloy steel shall contain at least one of the following elements in the minimum quantity given: chromium 0,30 %, manganese 0,20 %, nickel 0,30 %, vanadium 0,10 %, molybdenum 0,08 % and boron 0,000 8 %. Where elements are specified in combinations, the limit value to be applied for steel class determination is 70 % of the sum of the individual minimum values specified above for the elements concerned.

ⁱ For hydrogen embrittlement consideration, see future ISO/TR 20491.

7 Mechanical and physical properties

The washers of the specified property classes shall, at ambient temperature, meet all the applicable mechanical and physical properties in accordance with [Table 3](#), regardless of which tests are performed during manufacturing or final inspection.

[Clause 8](#) specifies the applicability of test methods and the reference test methods for verifying that washers fulfil the properties in accordance with [Table 3](#).

For property class 380HV, ductility test in accordance with [Annex A](#) shall be applied when specifically required by the customer at the time of the order.

Table 3 — Mechanical and physical properties

Property class		100HV	200HV	300HV	380HV ^a
Vickers hardness, HV	min.	100	200	300	380
	max.	200 ^b	300	370	450
Rockwell hardness, HRC	min.	—	—	30	39
	max.	—	—	39	45
Partial decarburization, HV 0,3	max.	—	—	c	30 ^d
Depth of the complete decarburization, <i>G</i>	max.	—	—	c	2 % of t_{eff} or 0,02 mm ^e
Carburization, HV 0,3	max.	—	—	c	30 ^f
Reduction of hardness after retempering, HV 10	max.	—	—	20	20

^a Property class 380HV is currently not included in existing ISO product standards; if required, the use of this property class shall be agreed between the purchaser and the supplier.

^b Exceeding the maximum hardness up to 250 HV shall not be cause of rejection.

^c For knurled or ribbed washers, the limits specified for property class 380HV shall apply.

^d Hardness at 0,1 mm from the bearing surface shall not be more than 30 Vickers units below the measured hardness on a transverse radial section through the washer in accordance with 8.2.3.

^e The lowest value applies.

^f Hardness at 0,1 mm from the bearing surface shall not be more than 30 Vickers units above the measured hardness on a transverse radial section through the washer in accordance with 8.3.

8 Test methods

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8.1 Hardness test

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8.1.1 General

The purpose of this test is to determine:

- that the hardness of the washer fulfils the requirement of minimum and maximum values specified in Table 3;
- that, for quenched and tempered washers, the required material conditions have been achieved in accordance with Table 2.

This test applies to washers for all property classes.

Washers shall be tested in the as-received condition, except captive washers which will be quenched and tempered after assembly.

Hardness shall be determined either on a suitable surface or on a transverse radial section through the washer, in accordance with Table 4.