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

Part 3: Flat washers with specified property classes

Caractéristiques mécaniques des fixations en acier au carbone et en acier allié —

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

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.

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.

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]
	Material	Process	C min.	C max.	P max.	S max.	B[d] max.	°C
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, G	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

8.1 Hardness test

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.

Table 4 — Hardness tests

Property class	For routine inspection	In case of dispute
100HV	Bearing surface 8.1.2	Bearing surface 8.1.2
200HV[a]		
300HV		Hardness in the transverse section 8.1.3
380HV		

[a] When washers of property class 200HV are quenched and tempered at the request of the customer at the time of the order, hardness in the transverse section is the reference test in case of dispute.

8.1.2 Hardness test on the washer bearing surface

8.1.2.1 General

Hardness shall be determined using the Vickers or Rockwell hardness test:

— the Vickers hardness test shall be carried out in accordance with ISO 6507-1;

— the Rockwell hardness test shall be carried out in accordance with ISO 6508-1.

8.1.2.2 Test force for Vickers hardness test

The choice of the test force for the Vickers hardness test depends on the washer property class and thickness.

The test force, *F*, should be selected according to Figure 1 and Formula (1):

$$F = \frac{t_{\text{eff}} \times \text{HV}}{0{,}39} \tag{1}$$

Dimensions in mm

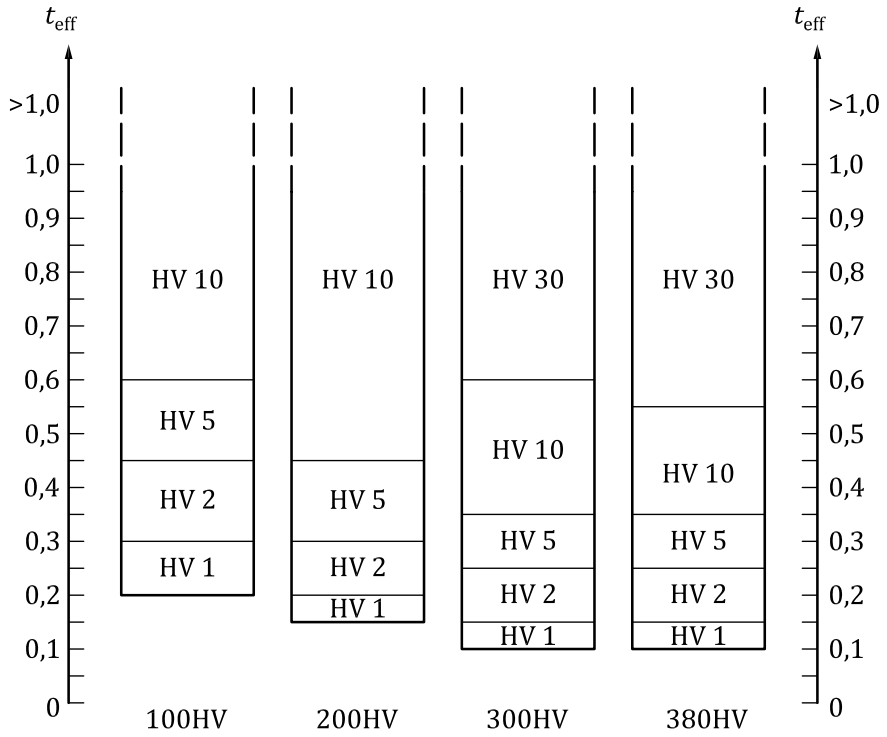


Figure 1 — Test force for Vickers hardness test on the bearing surface, as a function of the property class and thickness of the washer

EXAMPLE A washer with a thickness of 0,3 mm and property class 300HV is tested with a test force of HV 5.

8.1.2.3 Test force for Rockwell hardness test

The choice of the test force for the Rockwell hardness test depends on the washer property class and thickness.

The test force should be selected according to Figure 2.

When no appropriate Rockwell test force can be found, the Vickers hardness test shall apply.

Refer to ISO 18265 for conversion between Rockwell scales and Vickers scales.

Dimensions in mm

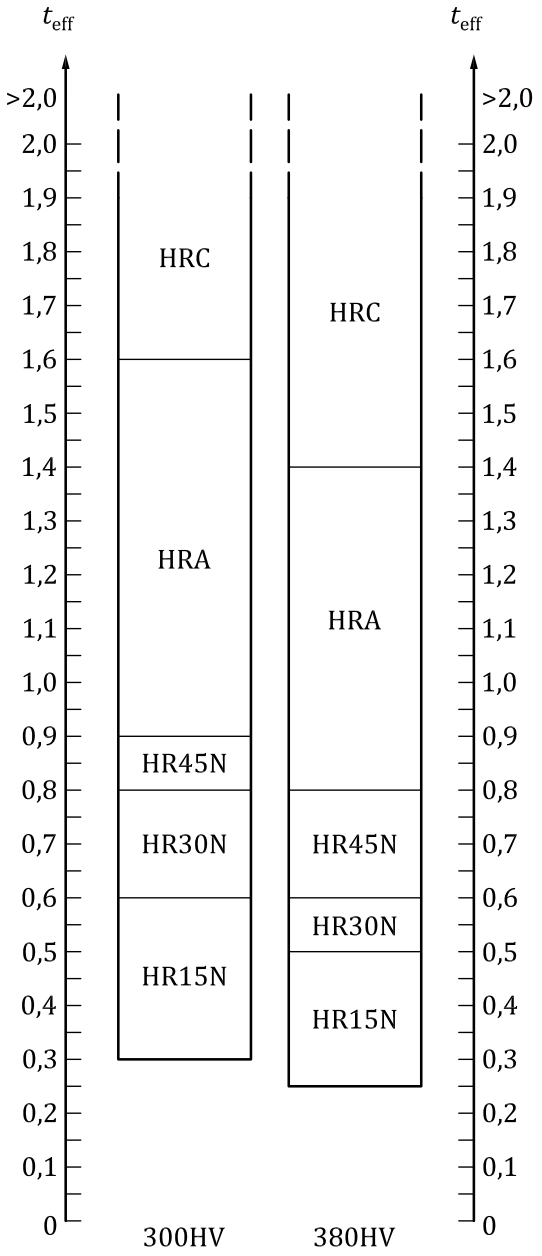


Figure 2 — Test force for Rockwell hardness test on the bearing surface, as a function of the property class and thickness of the washer

EXAMPLE A washer with a thickness of 0,5 mm and property class 380HV is tested with a test force of 294 (HR30N).

8.1.2.4 Test procedure

The hardness shall be determined in the mid-position of the bearing surface after removal of any coating or scale and after suitable preparation of the washer.

For hot dip galvanized washers, the transition layer shall be completely removed.

The hardness value shall be the mean of at least three readings on the same washer, when the size of the washer allows them.

8.1.2.5 Requirements for washers with property classes 100HV and 200HV

For routine inspection, the hardness determined on the washer bearing surface in accordance with 8.1.2 shall be within the range specified in Table 3.

In case of dispute, the Vickers hardness test shall be carried out on the washer bearing surface with the test force specified in Figure 1; however, for washers with a thickness $t_{eff} \leq 0{,}5$ mm, a lower test force may be used but it shall not be less than HV 1.

8.1.2.6 Requirements for washers with property class 300HV and 380HV

For routine inspection, the hardness determined on the washer bearing surface, in accordance with 8.1.2, shall be within the range specified in Table 3.

In case of dispute, hardness determined on a transverse radial section in accordance with 8.1.3 shall apply.

8.1.3 Hardness determined on a transverse radial section through the washer

8.1.3.1 General

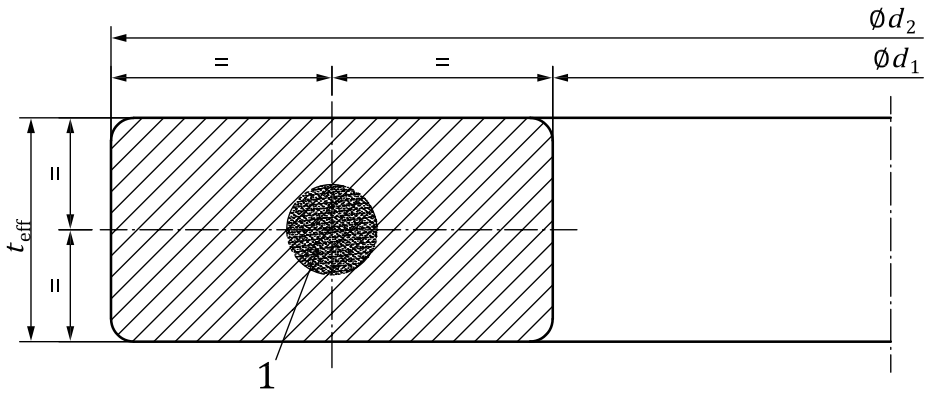
Hardness shall be determined using the Vickers hardness test in accordance with ISO 6507-1.

This test applies to quenched and tempered washers.

8.1.3.2 Test procedure

A radial section through the hole axis shall be taken, and the surface shall be suitably prepared. The test specimen shall be embedded in a plastic mount or, alternatively, in a clamp. After mounting, the surface shall be ground and polished in accordance with good metallographic practice.

Hardness readings shall be performed with Vickers hardness test in the middle of the radial section as specified in Figure 3. The hardness value shall be the mean of at least three readings on the same washer, when the size of the washer allows them.



Key

1 area for readings (radius of $0{,}25 t_{eff}$)

Figure 3 — Area for hardness readings

8.1.3.3 Requirements

The hardness shall be within the range specified in Table 3.

In addition, if a difference greater than 30 Vickers units is shown, it shall be verified that the requirement of approximately 90 % content of martensite has been achieved in accordance with Table 2.

8.2 Decarburization test

8.2.1 General

The purpose of the decarburization test is to detect if the bearing surfaces of knurled or ribbed washers of property class 300HV and of all washers of property class 380HV are decarburized and to determine the depth of the decarburized zone.

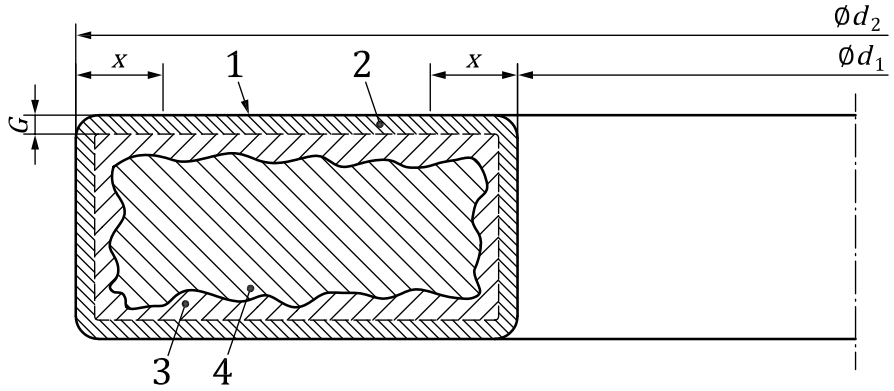
Zones of decarburization are shown in Figure 4.

Decarburization of the bearing surfaces shall be determined using the following methods:

— microscopic method, for the determination of the depth of complete decarburized zones; and

— hardness method, for the detection of partial decarburization by micro-hardness.

Bearing surface means the ring surface which excludes the distance $x = 0{,}1\ (d_2 - d_1)$ from the edge of the clearance hole and outer edge (only 60 % of the width in accordance with Figure 4).



Key

1 bearing surface
2 complete decarburization
3 partial decarburization
4 basis metal
x excluded areas for the decarburization test

Figure 4 — Zones of decarburization

8.2.2 Microscopic method

8.2.2.1 Preparation of test specimen

Washers shall be tested in the as-received condition after removal of coating, if any.

The test specimen shall be taken as a radial section through the hole axis. The test specimen shall be embedded in a plastic mount or, alternatively, in a clamp. After mounting, the surface shall be ground and polished in accordance with good metallographic practice.

NOTE Etching in a 3 % nital solution (concentrated nitric acid in ethanol) is usually suitable for showing changes in microstructure caused by decarburization.

8.2.2.2 Test procedure

The test specimen shall be placed under a microscope. Unless otherwise agreed, a 100 × magnification shall be used for examination.

When the microscope is of a type with a ground glass screen, the extent of decarburization can be measured directly with a scale. When an eyepiece is used for measurement, it should be of an appropriate type, containing a cross-hair or scale.

8.2.2.3 Requirement

The maximum depth of complete decarburization *G*, if any, shall meet the requirements specified in Table 3.

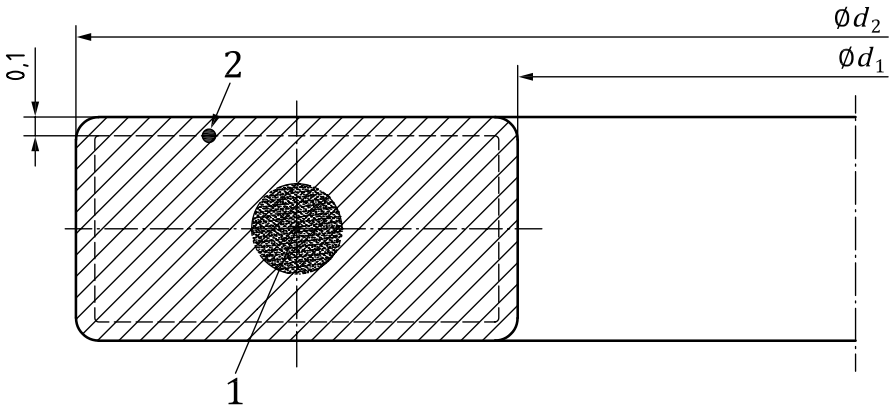
8.2.3 Hardness method

8.2.3.1 Preparation of test specimen

This test applies to washers with minimum thickness of 0,4 mm included. The test specimen shall be prepared in accordance with 8.2.2.1, but etching is not necessary.

8.2.3.2 Test procedure

The Vickers hardness shall be determined at points 1 and 2 in accordance with Figure 5. The test force shall be 2,942 N (Vickers hardness test HV 0,3).



No decarburization when HV(2) ≥ HV(1) – 30
No carburization when HV(2) ≤ HV(1) + 30

Key

1 HV(1) measurement point of hardness located at the centre of the cross-section through the washer
2 HV(2) measurement hardness point at 0,1 mm from the bearing surface

Figure 5 — Hardness determination for decarburization and carburization tests

8.2.3.3 Requirements

The Vickers hardness value at point 2, HV(2) in Figure 5, shall be greater than or equal to the Vickers hardness at point 1, HV(1) in Figure 5, minus 30 Vickers units.

NOTE Complete decarburization up to the maximum specified in Table 3 cannot be detected by the hardness measurement method.

8.3 Carburization test

8.3.1 General

The purpose of the carburization test is to detect if the bearing surfaces of the washers are carburized during the heat treatment.

Carburization shall be detected by hardness test on a radial section through the hole axis.

This test applies to knurled or ribbed washers with property class 300HV and to all washers of property class 380HV, but only to those washers with a minimum thickness of 0,4 mm.

8.3.2 Test procedure

The test specimen shall be prepared in accordance with 8.2.2.1, but etching is not necessary.

The Vickers hardness shall be determined at points 1 and 2 in accordance with Figure 5. The test force shall be 2,942 N (Vickers hardness test HV 0,3).

8.3.3 Requirements

The Vickers hardness value at point 2, HV(2) in Figure 5, shall be less than or equal to the value at point 1, HV(1) in Figure 5, plus 30 Vickers units. An increase of more than 30 Vickers units indicates carburization.

In addition to this requirement, the hardness on the washer bearing surface shall not exceed 370 HV 0,3 for property class 300HV, and 450 HV 0,3 for property class 380HV as specified in Table 3.

8.4 Retempering test

8.4.1 General

The purpose of this test is to check that the minimum tempering temperature has been achieved during the heat treatment process.

This test applies to washers with property classes 300HV and 380HV.

This test shall be performed only in case of dispute.

8.4.2 Test procedure

The Vickers hardness shall be determined in accordance with 8.1.3 by taking three readings in point 1 of Figure 3.

The washer shall be retempered by holding it for 30 min at a part temperature of 10 °C less than the minimum tempering temperature specified in Table 2. After retempering, the Vickers hardness shall be determined by taking three new readings on the same washer and in the same area as for the first determination.

8.4.3 Requirements

The average of the three hardness readings taken before and after retempering shall be compared. The reduction of hardness after retempering, if any, shall be less than 20 Vickers units.

9 Marking

9.1 General

Washers manufactured to the requirements of this document shall be designated in accordance with the property class as specified in Clause 5, only if all relevant requirements of this document are met.

9.2 Marking of washers

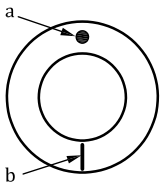
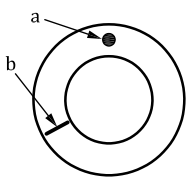
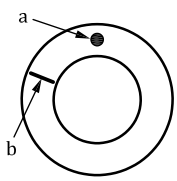
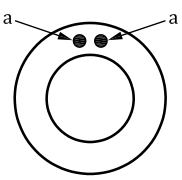
Washers can be marked at the discretion of the manufacturer, or if agreed between the purchaser and the supplier at the time of the order; in this case, marking shall include the manufacturer's identification mark and the property class.

A distributor who distributes washers that are marked with their own identification mark shall be considered to be the manufacturer.

Embossed marking shall not be used for washers. Indented marking is usually not recommended, because it could alter the torque/clamp force relationship of the bolt/nut assembly, or could create a stress concentration point which can initiate cracking. However, marking may be made by other processes resulting in durable identification, such as laser marking.

When property class marking is present, it shall be in accordance with Table 5 and consists either of the property class itself, the property class symbol or the clock face system.

Table 5 — Clock face system for marking washers

Property class	100HV	200HV	300HV	380HV
Property class symbol	100	200	300	380
Clock face system				

NOTE The dash is positioned in order to indicate the recommended combination (RC) specified in Table 1 for the relevant mating property class of bolts and nuts (e.g. washers of property class 300HV are designed to be mated with bolts of property class 10.9 and nuts of property class 10, therefore the dash for 300HV is placed at the 10 o'clock position).

[a] The 12 o'clock position (reference point) shall be marked with either the manufacturer's identification mark or by a reference point.

[b] The property class shall be marked with a dash. Its length and depth are at the manufacturer's discretion.

9.3 Marking of packages

All packages for washers within the scope of this document and for all property classes shall be marked (e.g. through labelling). The marking shall include the manufacturer's and/or distributor's identification and the property class as specified in Clause 5, as well as the manufacturing lot number as defined in ISO 1891-4.

Annex A
(normative)

Ductility test for washers of property class 380HV

A.1 General

The purpose of the ductility test is to determine that washers have not become brittle during the manufacturing process.

This test applies when specifically required by the customer at the time of the order.

This test applies to finished washers, and after coating if any.

A.2 Test procedure

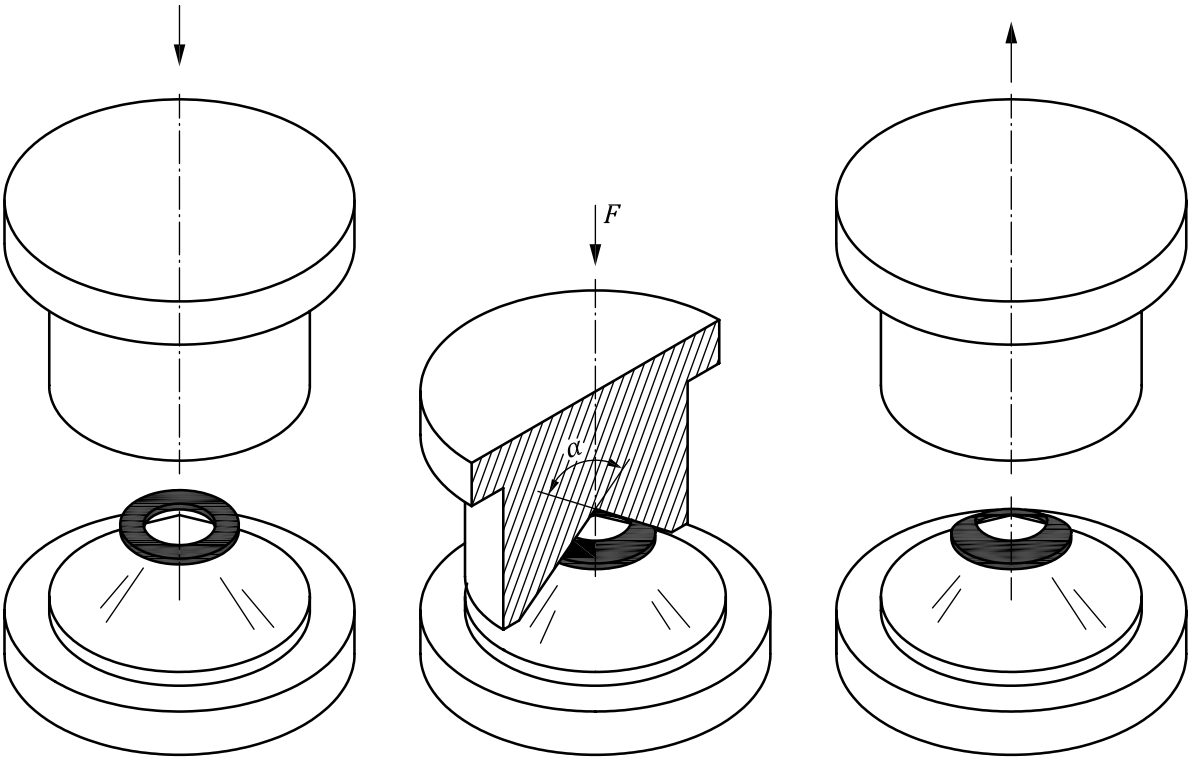
The test is carried out using a supporting part and a pressure part with an angle α depending on the thickness of washers. The supporting and pressure parts shall have a hardness of 60 HRC minimum and their surfaces shall be ground.

For round concentric washers, the contact surface of the supporting and pressure parts shall have a conical shape in accordance with Figure A.1.

For all other washers (e.g. square, rectangular), the surfaces shall have a V-shape in accordance with Figure A.2.

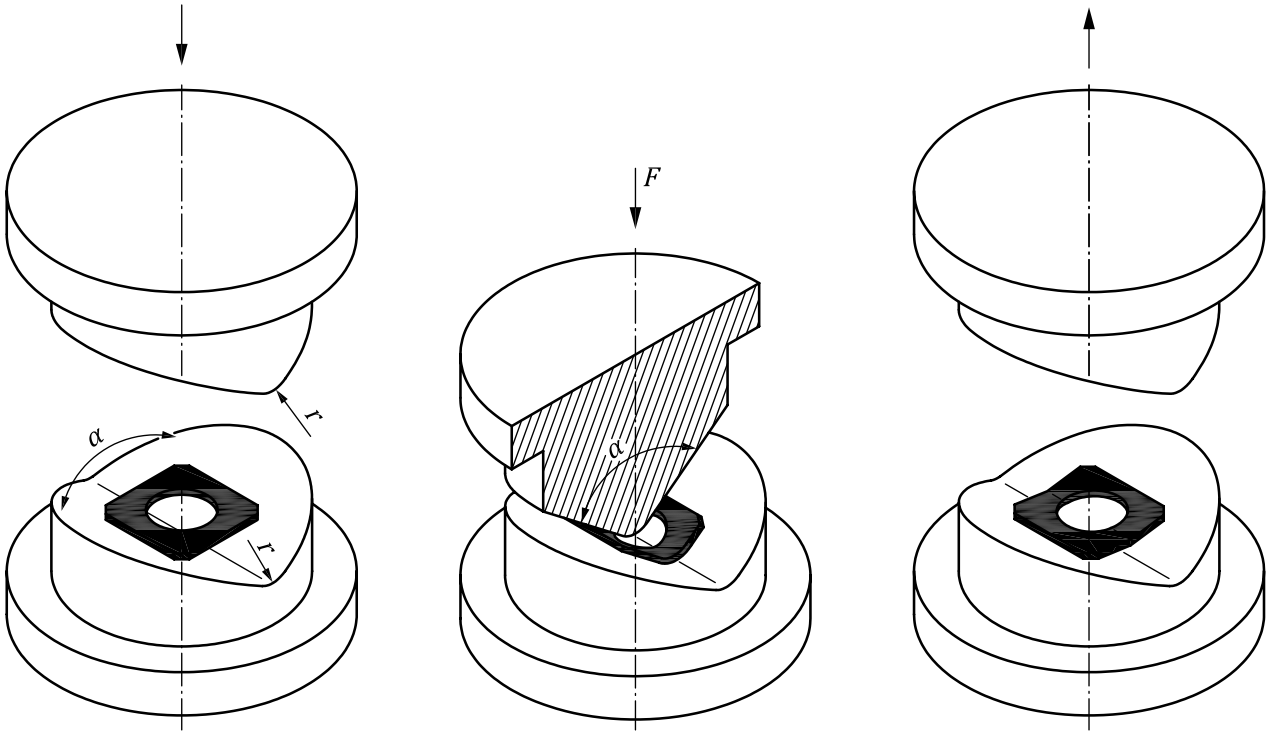
The washer to be tested shall be placed in the test device as specified in Figure A.1 or Figure A.2. For captive washer, it shall be disassembled from the bolt or nut before testing.

The axis of the supporting and pressure parts and the axis of the washer shall remain aligned before and during the test.



For washer thickness $t < 4$ mm, $\alpha = 120°$; for washer thickness $t \geq 4$ mm, $\alpha = 160°$.

Figure A.1 — Example of conical shape testing device for washers with concentric round inside and outside diameters



For washer thickness $t < 4$ mm, $\alpha = 120°$ and $r = 4$ mm; for washer thickness $t \geq 4$ mm, $\alpha = 160°$ and $r = 8$ mm.

Figure A.2 — Example of V-shape testing device for washers with other shapes

An axial test force shall be steadily applied until the surfaces of the supporting and pressure parts are in full contact with the bearing surfaces of the washer. After 2 min, the test force shall be released.

A.3 Requirements

The tested washer shall not be fractured.

Failure occurs when the washer breaks entirely. In case of doubt, the washer shall be cut on the opposite side of the fracture: the fact that the washer breaks in two single parts means that fracture occurred during the test.

Bibliography

[1] ISO 898-1, *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*

[2] ISO 898-2, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread*

[3] ISO 18265, *Metallic materials — Conversion of hardness values*

[4] ISO/TR 20491[1)], *Fasteners — Fundamentals of hydrogen embrittlement in steel fasteners*

1) Under preparation.

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