INTERNATIONAL STANDARD

ISO 9327-4

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Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions —

Part 4:
Weldable fine grain steels with high proof strength

Pièces forgées et barres laminées ou forgées en acier pour appareils à pression — Conditions techniques de livraison —

Partie 4: Aciers soudables à grain fin à limite conventionnelle d'élasticité élevée

Reference number
ISO 9327-4:1999(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

International Standard ISO 9327-4 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 10, *Steel for pressure purposes*.

This first edition, together with parts 1 to 3 and 5 of ISO 9327, cancels and replaces ISO 2604-1:1975.

ISO 9327 consists of the following parts, under the general title *Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions*:

— *Part 1: General requirements*

— *Part 2: Non-alloy and alloy (Mo, Cr and CrMo) steels with specified elevated temperature properties*

— *Part 3: Nickel steels with specified low temperature properties*

— *Part 4: Weldable fine grain steels with high proof strength*

— *Part 5: Stainless steels*

Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions —

Part 4:
Weldable fine grain steels with high proof strength

1 Scope

1.1 This part of ISO 9327 applies to forgings and rolled or forged bars in thicknesses up to 250 mm manufactured from fine grain steels (see NOTE) given in Table 1 and to be delivered according to the specifications given in ISO 9327-1.

The steels are classified into

— room temperature grades (P...),

— elevated temperature grades (PH...),

— low temperature grades (PL...),

— low and elevated temperature grades (PLH...).

NOTE Fine grain steels are here understood as steels with grain size 6 or finer according to the grain size charts in ISO 643.

1.2 This part of ISO 9327 covers the following data:

a) In Table 1 the limits for

   — the chemical composition according to the cast analysis;

   — the tensile properties at room temperature;

   — the indications on the usual heat treatment condition at the time of delivery;

b) in Table 2 the permissible product analysis tolerances on the limiting values given for the cast analysis;

c) in Table 3 the minimum impact energy values;

d) in Table 4 the minimum elevated temperature proof strength values.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 9327. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 9327 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 148:1983, *Steel — Charpy impact test (V-notch).*

ISO 4948-2:1981, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*.

ISO/TR 4949:1989, *Steel names based on letter symbols.*

ISO 9327-1, *Steel forgings and rolled or forged bars for pressure purposes — Technical delivery conditions — Part 1: General requirements*.

ISO/TR 15461:1997, *Steel forgings — Testing frequency, sampling conditions and test methods for mechanical tests.*

3 Terms and definitions

For the purposes of this part of ISO 9327, the terms and definitions given in ISO 9327-1 apply.

4 Ordering

See ISO 9327-1.

5 Requirements

See ISO 9327-1 and Tables 1 to 4.

6 Inspection, testing and conformity of products

See ISO 9327-1.

7 Marking

See ISO 9327-1.

Table 1 — Chemical composition (cast analysis), room temperature mechanical properties and heat treatment conditions

Line No.	Steel type		Chemical composition [b] % by mass														Mechanical properties at room temperature [c]					Heat treatment			
	«new»	«old»	C max.	Si	Mn[d]	P max.	S max.	Al_{tot} min.[e]	Cr max.	Cu max.	Mo max.	N max.	Nb max.[e]	Ni max.	Ti max.[e]	V max.[e]	Thickness of the ruling section [f] t_R	R_e	R_m	A min. DIR: x	A min. DIR: y	Usual reference heat treatment conditions: Symbol [g]	Austenizing or solution temperature	Cooling in[h]	Tempering
	designation [a]																								
	ISO/TR 4949	ISO 2604-1															mm	N/mm²	N/mm²	%	%		°C		°C
1	P 28, PH 28	—	0,18	0,10 to 0,40	0,50 to 1,40	0,035	0,030	0,020 i	0,30 j	0,30 j	0,08 j	0,020	0,05 k	0,30	0,03 k	0,05 k	⩽ 16	285	390 to 510	26	24	N	880 to 960	a	—
																	16 < t_R ⩽ 35	285							
	PL 28	—	0,16			0,025	0,020										35 < t_R ⩽ 50	275				Q+T	860 to 940	o, w	560 to 700
																	50 < t_R ⩽ 70	265							
																	70 < t_R ⩽ 100	245	370 to 510	25	23				
																	100 < t_R ⩽ 250	225		24	22				
2	P 35, PH 35	—	0,20	0,10 to 0,50	0,90 to 1,70	0,035	0,030	0,020 i	0,30 j	0,30 j	0,08 j	0,020	0,05 l	0,30 m	0,03 l, n	0,10 l	⩽ 16	355	490 to 610	24	22	N	880 to 960	a	—
																	16 < t_R ⩽ 35	355							
	PL 35, PLH 35	—	0,18			0,025	0,020										35 < t_R ⩽ 50	345				Q+T	860 to 940	o, w	560 to 700
																	50 < t_R ⩽ 70	325							
																	70 < t_R ⩽ 100	315	470 to 610	23	21				
																	100 < t_R ⩽ 250	295		22	20				
3	P 42, PH 42	—	0,20	0,10 to 0,60	1,00 to 1,70	0,035	0,030	0,020 i	0,30	0,30 o	0,10	0,020	0,05 p	1,00	0,20 p	0,20 p	⩽ 16	420	540 to 680	21	19	N	880 to 960	a	—
																	16 < t_R ⩽ 35	410							
	PL 42, PLH 42	—				0,025	0,020										35 < t_R ⩽ 50	400				Q+T	860 to 940	o, w	560 to 700
																	50 < t_R ⩽ 70	380							
																	70 < t_R ⩽ 100	365	510 to 670	20	18				
																	100 < t_R ⩽ 250	345		19	17				

Table 1 (*concluded*)

Line No.	Steel type		Chemical composition [b] % by mass														Mechanical properties at room temperature [c]					Heat treatment			
	«new»	«old»	C max.	Si	Mn [d]	P max.	S max.	Al_{tot} min. [e]	Cr max.	Cu max.	Mo max.	N max.	Nb max. [e]	Ni max.	Ti max. [e]	V max. [e]	Thickness of the ruling section [f] t_R mm	R_e N/mm²	R_m N/mm²	A min. DIR: x %	A min. DIR: y %	Usual reference heat treatment conditions: Symbol [g]	Austenizing or solution temperature °C	Cooling in [h]	Tempering °C
	designation [a]																								
	ISO/TR 4949	ISO 2604-1																							
4	P 46, PH 46	—	0,20 q	0,10 to 0,60	1,00 to 1,70	0,035	0,030	0,020 i	0,30	0,030 o	0,10	0,020 q	0,05 p	1,00	0,20 p	0,20 p	⩽ 16	460	570 to 720 [r]	19	17	N	880 to 960	a	—
																	16 < t_R ⩽ 35	450							
																	35 < t_R ⩽ 50	440				Q + T	860 to 940	o, w	560 to 700
																	50 < t_R ⩽ 70	420							
	PL 46, PLH 46	—				0,025	0,020										70 < t_R ⩽ 100	400	520 to 710	19	17				
																	100 < t_R ⩽ 250	385		18	16				

a All data on designations in this part of ISO 9327 are to be regarded as preliminary (see NOTE 2 of 4.1 in ISO 9327-1:1999). According to ISO 4948 the steels in lines 1 and 2 are non-alloy quality steels, the steels in lines 3 and 4 alloy special steels.

b See 5.2.1.1 of ISO 9327-1:1999.

c R_e is the yield strength (where a yield phenomenon occurs either the upper yield strength R_{eH} or the 0,2 % proof strength shall be recorded);
R_m is the tensile strength;
A is the percentage elongation after fracture on gauge length;
L_o is gauge length = 5,65 $\sqrt{S_o}$;
KV is the Charpy V-notch impact energy.
DIR:x, DIR:x-y, DIR:y and DIR:y-x are the directions of the test piece in relation to the main direction of grain flow. For detailed explanations see Table 5 and Figures 9 and 10 of ISO/TR 15461:1997.

d For product thicknesses ⩽ 6 mm, the minimum Mn content may be reduced by 0,2 %.

e Grain refining elements (Al, Nb, Ti, V) shall be added to the steel singly or in combination such that the fine grain structure as mentioned in the NOTE in 1.1 and the properties specified in this part of ISO 9327 are met.

f The thickness ranges given here apply for the as heat-treated thickness of ruling sections with rectangular cross-section, a width to thickness ratio of ⩾ 2 and a length to thickness ratio of ⩾ 4. For ruling sections of other shapes the equivalent thickness shall be determined according to annex A of ISO 9327-1:1999, or be agreed upon at the time of enquiry and order.

NOTE The designer should observe that because of machining allowances, the as heat-treated thickness of the ruling section is normally greater than the finished size.

g N = normalized (austenitizing with subsequent cooling in air);
T = tempered;
Q = quenched;

h a = air; o = oil; w = water; f = furnace.

i The Al content of ⩾ 0,020 % is valid if Al only is added.

j The sum of Cr+Cu+Mo shall not exceed 0,45 %.

k The sum of Nb+Ti+V shall not exceed 0,05 %.

l The sum of Nb+Ti+V shall not exceed 0,12 %.

m A maximum of 0,85 % Ni applies if added as an alloying element.

n For special cold forming applications a maximum of 0,08 % Ti may be added.

o A maximum of 0,70 % Cu applies if added as an alloying element.

p The sum of Nb+Ti+V shall not exceed 0,22 %.

q By agreement the maximum carbon content may be increased to 0,22 % and the maximum nitrogen content to 0,030 % provided that the level of the elements Cr, Cu, Mo and Ni not exceed the maximum levels specified for P 35.

r For thicknesses ⩽ 16 mm an upper limit of 730 N/mm² shall be tolerated.

Table 2 — Permissible product analysis tolerances on the limiting values given in Table 1 for the cast analysis

Element	Specified limits, cast analysis % by mass	Permissible tolerance[a] % by mass
C	⩽ 0,20	+ 0,03
Si	⩽0,60	± 0,05
Mn	⩽ 1,70	± 0,10
P	⩽ 0,035	+ 0,005
S	⩽ 0,030	+ 0,005
Al	⩾ 0,020	− 0,005
Cr	< 0,30	+ 0,05
Cu	⩽ 0,50 > 0,50 ⩽ 0,70	+ 0,05 + 0,07
Mo	⩽ 0,10	+ 0,05
N	⩽ 0,020	+ 0,002
Nb	⩽ 0,05	+ 0,005
Ni	⩽ 1,00	+ 0,05
Ti	⩽ 0,20	+ 0,02
V	⩽ 0,20	+ 0,02
Cr+Cu+Mo	⩽ 0,45	+ 0,05
Nb+Ti+V	⩽ 0,22	+ 0,02

[a] The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified, the deviations are positive only. The values are valid only if the samples were selected according to C.5 of ISO 9327-1:1999.

Table 3 — Impact properties

Steel type	Reference heat treatment [a]	Thickness of the ruling section [b]	Impact energy [c] KV J min.									
			DIR:x-y [d]					DIR:y-x [d]				
			Temperature, °C									
		t_R mm	20	0	– 20	– 40	– 50	20	0	– 20	– 40	– 50
P xx PH xx	N or Q+T	⩽ 250	55	47	40	—	—	31	27	20	—	—
PL xx PLH xx			63	55	47	35	27	38	33	27	20	16

a N = normalized; Q = quenched; T = tempered;.

b See Table 1, footnote f.

c Average of three tests. One of the three individual values may be below the specified minimum average value, provided that it is not less than 70 % of the value. The values apply to standard 10 mm × 10 mm Charpy V-notch impact test pieces (see ISO 148).

d DIR: x-y } Direction of the test piece in relation to the main direction of grain flow.
DIR: y-x } For detailed explanations see Table 5 and Figures 9 and 10 of ISO/TR 15461:1997.

Table 4 — Minimum 0,2 % proof strength ($R_{p0,2}$) values at elevated temperatures [a]

Line No.	Steel type	Reference heat treatment [b]	Thickness of the ruling section [c] t_R mm	$R_{p0,2}$ N/mm² min. Temperature, °C 150	200	250	300	350	400
1	PH 28 PLH 28	N Q + T	$\leqslant 35$	226	196	177	157	137	118
			$35 < t_R \leqslant 70$	216					
			$70 < t_R \leqslant 100$	206	186	167	137	118	98
			$150 < t_R \leqslant 250$	186	167	147	118	98	78
2	PH 35 PLH 35	N Q + T	$\leqslant 35$	284	245	226	216	196	167
			$35 < t_R \leqslant 70$	275					
			$70 < t_R \leqslant 100$	255	235	216	196	177	147
			$150 < t_R \leqslant 250$	235	216	196	177	157	127
3	PH 42 PLH 42	N Q + T	$\leqslant 35$	343	304	275	265	235	206
			$35 < t_R \leqslant 70$	333					
			$70 < t_R \leqslant 100$	314	294	265	245	216	186
			$150 < t_R \leqslant 250$	294	275	245	226	196	167
4	PH 46 PLH 46	N Q + T	$\leqslant 35$	373	333	314	294	265	235
			$35 < t_R \leqslant 70$	363					
			$70 < t_R \leqslant 100$	343	324	294	275	245	216
			$150 < t_R \leqslant 250$	324	304	275	255	226	196

NOTE All values are provisional and are subject to revision when more data become available.

a See C.4 of ISO 9327-1:1999.

b N = normalized; Q = quenched; T = tempered.

c See Table 1, footnote f.

Bibliography

[1] ISO 643:1983, *Steels — Micrographic determination of the ferritic or austenitic grain size.*

[2] ISO 2604-1:1975[1)], *Steel products for pressure purposes — Quality requirements — Part 1: Forgings.*

1) To be replaced by ISO 9327 parts 1 to 5.

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