INTERNATIONAL STANDARD

ISO 9327-2

First edition
1999-06-15

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

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

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

Partie 2: Aciers non alliés et alliés (Mo, Cr et CrMo) avec caractéristiques spécifiées à température élevée

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

Reference number
ISO 9327-2:1999(E)

Contents

Page

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

© ISO 1999

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed in Switzerland

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 9327-2 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 10, *Steel for pressure purposes*.

This first edition, together with parts 1 and 3 to 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*

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

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

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

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

1 Scope

1.1 This part of ISO 9327 applies to forgings and rolled or forged bars in thicknesses up to 250 mm (partly up to 500 mm) manufactured from the steels listed in Table 1 and to be delivered according to the specifications given in ISO 9327-1.

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 impact properties;
- 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 elevated temperature proof strength values (see C.4 of ISO 9327-1:1998);

d) in Table 4 the estimated average stress rupture properties;

e) in Table 5 the estimated average strength values for 1 % plastic strain.

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 4948-1:1982, *Steels — Classification — Part 1: Classification of steel into unalloyed and alloy steels based on chemical composition.*

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 5.

6 Inspection, testing and conformity of products

See ISO 9327-1.

7 Marking

See ISO 9327-1.

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

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]									Usual reference heat treatment conditions					
	"new"	"old"	C	Si	Mn	P max.	S max.	Al_{total}	Cr	Mo	Others	Thickness of the ruling section [d] t_R	R_e min.	R_m	A min. DIR: x	A min. DIR: y	KV [e] min. DIR: x-y	KV [e] min. DIR: y-x	KV [e] min. DIR: at	Symbol [f]	Austenitizing or solution temperature	Cooling in [g]	Tempering	Cooling in [g]
	Designation [a] in accordance with ISO/TR 4949	ISO 2604-1										mm	N/mm²	N/mm²	%	%	J	J	°C		°C		°C	
1	PH 26	F 9	≤ 0,20	≤ 0,35	0,50 to 1,40	0,035	0,030	≥ 0,020	≤ 0,30	≤ 0,08	Cu ≤ 0,30 [h] Ni ≤ 0,30	≤ 16	265	410 to 530	26	24								
												16 < t_R ≤ 40	255		26	24					890 to 950	a	—	—
												40 < t_R ≤ 60	245		25	23	40	27	0	N or Q + T	880 to 930	o, w	580 to 650	a, f
												60 < t_R ≤ 100	215		24	22								
												100 < t_R ≤ 150	200	390 to 520	24	22								
												150 < t_R ≤ 250	200		23	21								
2	PH 29	F 13	≤ 0,20 [i]	≤ 0,40	0,90 to 1,50	0,035	0,030	≥ 0,020	≤ 0,30	≤ 0,08	Cu ≤ 0,30 [h] Ni ≤ 0,30	≤ 16	290	460 to 580	24	22								
												16 < t_R ≤ 40	285		24	22								
												40 < t_R ≤ 60	280		24	22	40	27	0	N or Q + T	890 to 950	a	—	—
												60 < t_R ≤ 100	255		23	21					880 to 920	o, w	580 to 650	a, f
												100 < t_R ≤ 150	230	440 to 570	23	21								
												150 < t_R ≤ 250	220		22	20								
3	PH 31	F 18	≤ 0,20 [i]	0,10 to 0,50	0,90 to 1,60	0,035	0,030	≥ 0,020	≤ 0,30	≤ 0,08	Cu ≤ 0,30 [h] Ni ≤ 0,30	≤ 16	315	490 to 610	23	21								
												16 < t_R ≤ 40	310		23	21					890 to 950	a	—	—
												40 < t_R ≤ 60	305		23	21	40	27	0	N or Q + T	880 to 920	o, w	580 to 650	a, f
												60 < t_R ≤ 100	280		22	20								
												100 < t_R ≤ 150	255	470 to 600	22	20								
												150 < t_R ≤ 250	245	460 to 590	21	19								
4	16Mo3	F 26	0,12 to 0,20	≤ 0,35	0,40 to 0,90	0,035	0,030	i	≤ 0,30	0,25 to 0,35	Cu ≤ 0,30	≤ 40	270	450 to 600	26	24								
												40 < t_R ≤ 60	260		25	23				N	890 to 950	a	—	—
												60 < t_R ≤ 100	240	430 to 580	24	22	40	27	20	or N + T	890 to 950	a	600 to 650	a, f
												100 < t_R ≤ 250	220	420 to 570	21	19				or Q + T	880 to 920	o, w	600 to 650	a, f
5	20MnMoNi5	—	0,17 to 0,23	≤ 0,40	1,15 to 1,50	0,035	0,030	j	≤0,25	0,45 to 0,60	0,40 to 1,00 Ni, V ≤ 0,03	≤ 150	420	580 to 730	18	16				N + T or Q + T	850 to 925	a, w	620 to 675	a, f
												150 < t_R ≤ 300	390	550 to 700	18	16	50	35	20					
												300 < t_R ≤ 500	360		18	16								
6	14CrMo4-5	F 32	0,08 to 0,18	≤ 0,35	0,40 to 1,00	0,035	0,030	i	0,70 to 1,15	0,40 to 0,60	Cu ≤ 0,30	≤ 40	300	450 to 600	22	20								
												40 < t_R ≤ 60	300		21	19	40	27	20	N + T or Q + T	890 to 950	a, o, w	600 to 650	a, f
												60 < t_R ≤ 100	275	440 to 590	20	18								
												100 < t_R ≤ 250	255	430 to 580	20	18								
7	13CrMo9-10	F 34	0,08 to 0,15 [k]	≤ 0,50	0,40 to 0,70	0,035	0,030	i	2,00 to 2,50	0,90 to 1,10	Cu ≤ 0,30	≤ 60	265	480 to 620	20	18								
												60 < t_R ≤ 100	260	470 to 620	20	18	40	27	20	N + T or Q + T	920 to 980	a, o, w	680 to 750	a, f
												100 < t_R ≤ 150	250	460 to 610	20	18								
												150 < t_R ≤ 300	240	450 to 600	20	18								

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

© ISO

Table 1 — *(concluded)*

Line No.	Steel type		Chemical composition [b] % by mass									Mechanical properties at room temperature [c]									Usual reference heat treatment conditions				
	"new"	"old"	C	Si	Mn	P max.	S max.	Al_{total}	Cr	Mo	Others	Thickness of the ruling section [d] t_R	R_e min.	R_m	A min. DIR: x	A min. DIR: y	KV [e] min. DIR: x-y	KV [e] min. DIR: y-x	KV [e] min. DIR: at	Symbol [f]	Austenitizing or solution temperature	Cooling in [g]	Tempering	Cooling in [g]
	Designation [a] in accordance with ISO/TR 4949	ISO 2604-1										mm	N/mm²	N/mm²	%	%	J	J	°C		°C		°C	
8	X12CrMo5-1	F 37	0,08 to 0,15	≤ 0,50	0,30 to 0,60	0,035	0,030	i	4,00 to 6,00	0,45 to 0,65		≤ 150	175	430 to 580	20	18	—	—	—	A	850 to 880	f	—	—
9	X20CrMoV12-1	F 40	0,17 to 0,23	≤ 0,40	0,30 to 1,00	0,035	0,030	≤ 0,025	10,00 to 12,50	0,80 to 1,20	0,30 to 1,00 Ni 0,20 to 0,35 V	≤ 100	500	700 to 850	16	14	39	27	20	N + T or Q + T	1 020 to 1 070	a, o, w	730 to 780	
												$100 < t_R \leq 200$	500	700 to 850	16	14	31	27	20					
												$200 < t_R \leq 300$	500	700 to 850	14	14	27	24	20					

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 4948-2 the steels in lines 1 to 3 are non-alloy quality steels, the steels in lines 4 to 9 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 the 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 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.

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

f N = normalized (austenitizing with subsequent cooling in air);

T = tempered;

Q = quenched;

A = annealed (austenitizing with subsequent furnace cooling).

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

h The sum of Cr+Cu+Mo+Ni shall not exceed 0,70 %.

i When Option C.5 in ISO 9327-1:1999 – mandatory minimum elevated temperature proof strength values – is ordered, the carbon content of steel PH 29 shall be 0,14 % to 0,20 % and that of steel PH 31 0,15 % to 0,20 %.

j Though the aluminium content is not specified, it shall be given in the document.

k For product thicknesses < 60 mm the lower limit may by agreement be reduced to 0,06 % C; for thicknesses > 15 mm the upper limit may, by agreement, be increased to 0,17 % C.

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

© ISO

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	⩽ 0,23	± 0,03
Si	⩽0,50	± 0,05
Mn	⩽ 1,60	± 0,10
P	⩽ 0,035	+ 0,005
S	⩽ 0,030	+ 0,005
Al	⩾ 0,025	± 0,005
Cr	< 10,00	± 0,10
	⩾ 10,00 ⩽ 12,50	± 0,15
Cu	⩽ 0,30	+ 0,05
Ni	⩽ 1,00	± 0,03
Mo	⩽ 0,60	± 0,03
	> 0,60 ⩽ 1,20	± 0,05
V	⩽ 0,35	± 0,03

[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.

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

Table 3 — Minimum 0,2% proof strength ($R_{p0,2}$) values at elevated temperature for steels according to Table 1[a]

Steel type	Reference heat treatment section[b]	Thickness of the ruling section[c] t_R	$R_{p0,2}$ min. N/mm² Temperature °C									
			150	200	250	300	350	400	450	500	550	600
PH 26	N or Q+T	$t_R \leqslant 16$	216	194	171	152	141	134	130	—	—	—
		$16 < t_R \leqslant 40$	213	192	171	152	141	134	130	—	—	—
		$40 < t_R \leqslant 60$	204	188	171	152	141	134	130	—	—	—
		$60 < t_R \leqslant 100$	204	188	171	152	141	134	130	—	—	—
		$100 < t_R \leqslant 150$	197	182	166	147	136	129	125	—	—	—
		$150 < t_R \leqslant 250$	197	182	166	147	136	129	125	—	—	—
PH 29	N or Q+T	$\leqslant 16$	247	223	198	177	167	158	153	—	—	—
		$16 < t_R \leqslant 40$	242	220	198	177	167	158	153	—	—	—
		$40 < t_R \leqslant 60$	236	217	198	177	167	158	153	—	—	—
		$60 < t_R \leqslant 100$	236	217	198	177	167	158	153	—	—	—
		$100 < t_R \leqslant 150$	223	205	187	167	157	148	144	—	—	—
		$150 < t_R \leqslant 250$	213	195	177	157	147	138	134	—	—	—
PH 31	N or Q+T	$t_R \leqslant 16$	265	240	213	192	182	173	168	—	—	—
		$16 < t_R \leqslant 40$	260	237	213	192	182	173	168	—	—	—
		$40 < t_R \leqslant 60$	256	234	213	192	182	173	168	—	—	—
		$60 < t_R \leqslant 100$	256	234	213	192	182	173	168	—	—	—
		$100 < t_R \leqslant 150$	243	222	203	182	172	163	158	—	—	—
		$150 < t_R \leqslant 250$	233	212	193	172	162	153	148	—	—	—
16Mo3	N or N+T or Q+T	$\leqslant 60$	237	224	205	173	159	155	150	145	—	—
		$60 < t_R \leqslant 100$	225	212	195	162	147	143	137	132	—	—
		$100 < t_R \leqslant 250$	219	207	189	156	140	135	130	125	—	—
20MnMoNi5	Q+T	$\leqslant 300$	—	360	—	350	343	—	—	—	—	—
		$300 < t_R \leqslant 500$	—	350	—	330	314	—	—	—	—	—
14CrMo4-5	N+T or Q+T	$\leqslant 60$	240	230	218	94	181	176	172	167	160	155
		$60 < t_R \leqslant 100$	230	220	208	183	169	164	160	156	150	146
		$100 < t_R \leqslant 250$	220	210	200	172	158	153	150	146	140	136
13CrMo9-10	N+T or Q+T	$\leqslant 60$	241	233	224	219	212	207	194	180	160	137
		$60 < t_R \leqslant 100$	229	221	212	207	201	196	183	170	151	130
		$100 < t_R \leqslant 150$	217	209	200	195	190	185	172	160	142	124
		$150 < t_R \leqslant 300$	205	197	188	183	179	174	161	150	133	118
12CrMo20-5	A	$\leqslant 60$		118	116	115	114	113	111	—	—	—
X20CrMoV12-1	N+T or Q+T	$\leqslant 300$	390	362	340	328	322	316	302	280	—	—

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

[b] A = annealed; N = normalized; Q = quenched; T = tempered. For temperatures and cooling conditions see Table 1.

[c] See Table 1, footnote d.

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

Table 4 — Stress rupture properties at elevated temperatures for steels according to Table 1

Steel type	Heat treatment[a]	Rupture time	Estimated average stresses for rupture[b] N/mm² — Temperature, °C																							
		h	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600
PH 26	N or Q+T	10 000	213	197	181	166	151	138	125	112	100	89	78	67	57										
		30 000	192	176	161	147	133	120	107	95	84	73	63	52	42										
		50 000	183	167	152	138	125	112	100	88	77	66	56*	45*	35*										
		100 000	171*	155*	141*	127*	114*	102*	90*	78*	67*	57*	47*	36*											
		150 000	164*	149*	134*	121*	108*	96*	84*	73*	62*	52*	41*	29*											
		200 000	159*	144*	130*	116*	104*	92*	80*	69*	58*	48*	37*	23*											
		250 000	155*	140*	126*	113*	101*	89*	77*	66*	55*	45*	34*												
PH 29 PH 31	N or Q+T	10 000	291	266	243	221	200	180	161	143	126	110	96	84	74										
		30 000	262	237	214	192	171	151	132	115	99	86	74	65	57										
		50 000	248	223	200	177	156	136	118	102	87	75	65	57	50										
		100 000	227	203	179	157	136	117	100	85	73	63	55	(47)	(41)										
		150 000	215	190	167	144	124	105	89	76	65	56	(49)	(42)	(34)										
		200 000	206*	181*	157*	135*	115*	97*	82*	70*	60*	52*	(44)*	(37)*											
		250 000	199*	174*	150*	128*	108*	91*	77*	66*	56*	(48)*	(41)*	(32)*											
16Mo3	N or N+T or Q+T	10 000								298	273	247	222	196	171	147	125	102							
		30 000								273	244	216	187	159	134	113	93	76							
		50 000								260	229	200	172	144	119	99	80	66							
		100 000								239*	208*	178*	148	123	101	81	66	53*							
		150 000								226*	197*	168*	139*	114*	91*	74*	60*	48*							
		200 000								217*	188*	159*	130*	105*	84*	69*	55*	45*							
		250 000								210*	180*	151*	124*	100*	80*	65*	52*	(42)*							
14CrMo4-5	N+T or Q+T	10 000								(407)	(371)	(338)	304	273	239	209	179	154	129	109	91	76	64	53	44
		30 000								(371)	(336)	(301)	267	233	200	169	140	116	96	79	66	54	44	36	(29)
		50 000								(339)	(307)	(273)	239	207	177	149	124	101	82	68	55	45			
		100 000								(326)	(286)	(247)	210	177	146	121	99	81	67	54	43	35			
		150 000								(312)	(270)	(210)	194*	161*	132*	108*	87*	71	57	46	38	(31)			
		200 000								(298)	(255)	(197)	180*	148*	122*	99*	79*	64*	52*	42*	34*	(28)*			
		250 000								(292)	(247)	(186)	170*	139*	114*	91*	74*	59*	48*	39*	32*	(26)*			

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

© ISO

Table 4 — *(concluded)*

Steel type	Heat treatment[a]	Rupture time	Estimated average stresses for rupture[b] N/mm² Temperature, °C																						
		h	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600
13CrMo9-10	N+T or Q+T	10 000								(309)	(285)	(263)	240	219	196	176	155	137	122	108	96	85	76	68	61
		30 000								(276)*	(254)*	322*	213	192	172	152	134	118	103	90	79	70	61	54	48
		50 000								(257)*	236*	217*	197*	177*	158*	139*	123*	107	93	80	71	62	54	47	42
		100 000								221*	204*	186*	170*	153*	137*	122*	107*	93	79	69	59	51	44	(38)	(34)
		150 000								209*	192*	175*	153*	141*	126*	110*	95*	82*	73*	63*	54*	47	40	(35)	(30)
		200 000								203*	186*	169*	152*	135*	119*	103*	89*	77*	68*	58*	50*	43*	(37)*	(32)*	(28)*
		250 000								198*	181*	164*	147*	130*	113*	98*	84*	74*	64*	55*	47*	41*	(35)*	(30)*	(26)*
X20CrMoV12-1	N+T or Q+T	10 000													294	274	253	232	213	192	173	154	136	119	101
		30 000													271	250	228	208	187	167	148	130	113	97	81
		50 000													261	238	217	195	175	155	136	119	102	87	74
		100 000													248	225	202	180	159	139	121	104	88	75	63
		150 000													239*	219*	197*	175*	150*	128*	110*	94*	80*	68*	57*
		200 000													234*	213*	190*	167*	143*	122*	104*	89*	76*	64*	53*
		250 000													229*	208*	185*	161	137	117*	100*	84*	72*	60*	50*

[a] A = annealed; N = normalized; Q = quenched; T = tempered. For temperatures and cooling conditions see Table 1.

[b] Values with an asterisk have involved extended time extrapolation; values in parentheses have involved extended stress extrapolation.

NOTE Inclusion of creep rupture values up to high temperatures does not mean that products can be used in continuous duty up to these temperatures. The governing factor is the total stressing during operation.

STANDARDSISO.COM : Click to view the full PDF of ISO 9327-2:1999

© ISO