TECHNICAL REPORT 7468
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Published 1981-01-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Summary of average stress rupture properties of wrought steels for boilers and pressure vessels

Résumé des caractéristiques moyennes de contrainte de rupture pour les aciers corroyés pour chaudières et appareils à pression

The information given in this document was obtained by co-operative testing amongst a number of the ISO member bodies represented in ISO Technical Committee 17, *Steel*. It was used as a basis for establishing International Standards ISO 2604/I to 2604/IV, which specify quality requirements for the various forms of the steels concerned. Because of the potential usefulness of the experimental data themselves, the ISO Council decided to publish them in a reference document.

This first edition of ISO/TR 7468 contains new and revised data, as described in the Introduction. It cancels and replaces the first and the second edition of ISO/DATA 1 which were published in 1975 and 1978.

UDC 669.14.018.452 : 539.4 : 620.172.251.2 **Ref. No. ISO/TR 7468-1981 (E)**

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Summary of average stress rupture properties of wrought steels for boilers and pressure vessels

INTRODUCTION

ISO DATA No. 1 published in 1975 contained average stress rupture values for 19 grades of steel. Since that time, additional data have been analysed or assessed for several of these grades, and for 3 further grades. The new and revised stress rupture values and updated asterisks, as indicated in the following table, agreed by ISO/TC 17/SC 10 in May 1975, are included in this document, which therefore contains the stress rupture values for all boiler and pressure vessel steels at present in ISO 2604/I to ISO 2604/IV (1975). The master curves used for the derivation of the values, for times of 10 000 to 250 000 h, are also shown. The values contained in this document will be subject to review as more data become available.

Notes on tables

1 *Chemical composition*

The limits of chemical composition for which the properties apply are the ranges of chemical composition of the test material used in the assessment, except where these fall within the relevant range specified in ISO 2604/I to ISO 2604/IV (1975). In such cases the specified limit is listed.

2 *Quantity and duration of data*

The quantity and duration of data in these tables are the data used to derive the values in the average rupture stress tables. The asterisks in the average rupture stress tables are based on the total data available, which are given in the appropriate ISO/TC 17/SC 10/ETP documents, reference to which is made at the top of each set of tables.

3 *Extrapolation*

The values given in the tables are average stress rupture values derived in accordance with ISO/TC 17/SC 10/ETP – SG/N 58, and the data show a ± 20 % scatter about this average value.

The extent to which test data can be reliably extrapolated depends on the number and duration of the tests. Three basic factors are involved : temperature, time and stress. Experience suggests that reliable extrapolations may be made, covering a range of ± 25 °C about each test temperature, on the basis of a series of tests from at least five casts of steel, the longest test of each series exceeding a certain minimum duration.

a) Extended time extrapolation

The confidence which can be placed upon such properties will be related to the extent of extrapolation, and extrapolations exceeding approximately three times the above minimum duration are described as "extended time extrapolations". Stress rupture properties are normally listed at the time intervals shown in the table below, which defines where "extended time extrapolation" is applied.

Test duration (in hours) exceeded by data points from 5* casts at temperatures within 25 °C of that specified	80 000	70 000	50 000	30 000	20 000	10 000
Durations (in hours) *beyond* which the term "extended time extrapolation" is applied	250 000	200 000	150 000	100 000	50 000	30 000

* Results from tests in progress may be included if above the lower 20 % scatter band limit at the appropriate duration. Values which have involved "extended time extrapolation" are marked with an asterisk in the table of estimated average rupture stresses contained in this report. When such values are used, account should be taken of the quantity and duration of the test data on which they are based.

b) Extended stress extrapolation

This applies where values have been obtained by extending the parametric master curves to stresses beyond the range for which tests were carried out. Such values, which are subject to greater uncertainty compared with other values, are shown in parentheses. The numbers of test points shown in the tables of quantity and duration of data include results from tests still in progress where these lie above the lower 20 % scatter band limit.

Abbreviations used in the tables

AC	air cooled
FC	furnace cooled
Q	quenched
OQ	oil quenched
WQ	water quenched
T	tempered
iso	isothermally transformed
thk	thickness
dia	diameter
sq	square

Symbols used in the equation of the parametric master curve

$P(\sigma)$	creep rupture parameter
T	temperature, K
$\log t$	$\log_{10}$ of time to rupture, h
σ	stress, N/mm^2

NOTES

1 Values read off the graphs presented in this report may be subject to discrepancies introduced by the method of reproduction. In all cases the values presented in tabular form should be taken as being correct.

2 Throughout this document, a point is used as the decimal sign.

CARBON STEEL (Semi killed and Si killed)

Properties agreed March 1974
(Based on ISO document ISO/TC17/SC10/ETP-SG(Secretariat 82) 100)
Supersedes ISO document ISO/TC17/SC10/ETP-SG(Secretariat 23) 28

CONDITIONS OF STEEL TO WHICH THE PROPERTIES APPLY

	Details of Materials Actually Tested		Range for which Data are Expected to Apply Agreed by TC17/SC10/ETP	
Chemical Composition % (*m/m*)			min	max
	C	0.07 - 0.24	-	0.30
	Si	0.005 - 0.330	-	0.50
	Mn	0.32 - 0.80	→ 0.40	-
	P	0.003 - 0.048	-	0.050
	S	0.003 - 0.050	-	0.050
Heat Treatment	1. 899 - 950°C AC 2. 850 - 920°C AC + T500 - 690°C		1. Normalised 2. Normalised and Tempered† 3. Hot Finished 4. Hot Finished and Tempered† † See page 10	
Products	Form	Size, mm	All wrought product forms	
	Plates	18 - 75 thk		
	Tubes	6.5 - 435 thk x 25 - 191 dia		
	Bars	178 - 305 thk + 16 - 25 dia		
	Forgings	25 - 146 thk x 575 - 1194 dia		

QUANTITY AND DURATION OF DATA UPON WHICH THE PROPERTIES ARE BASED

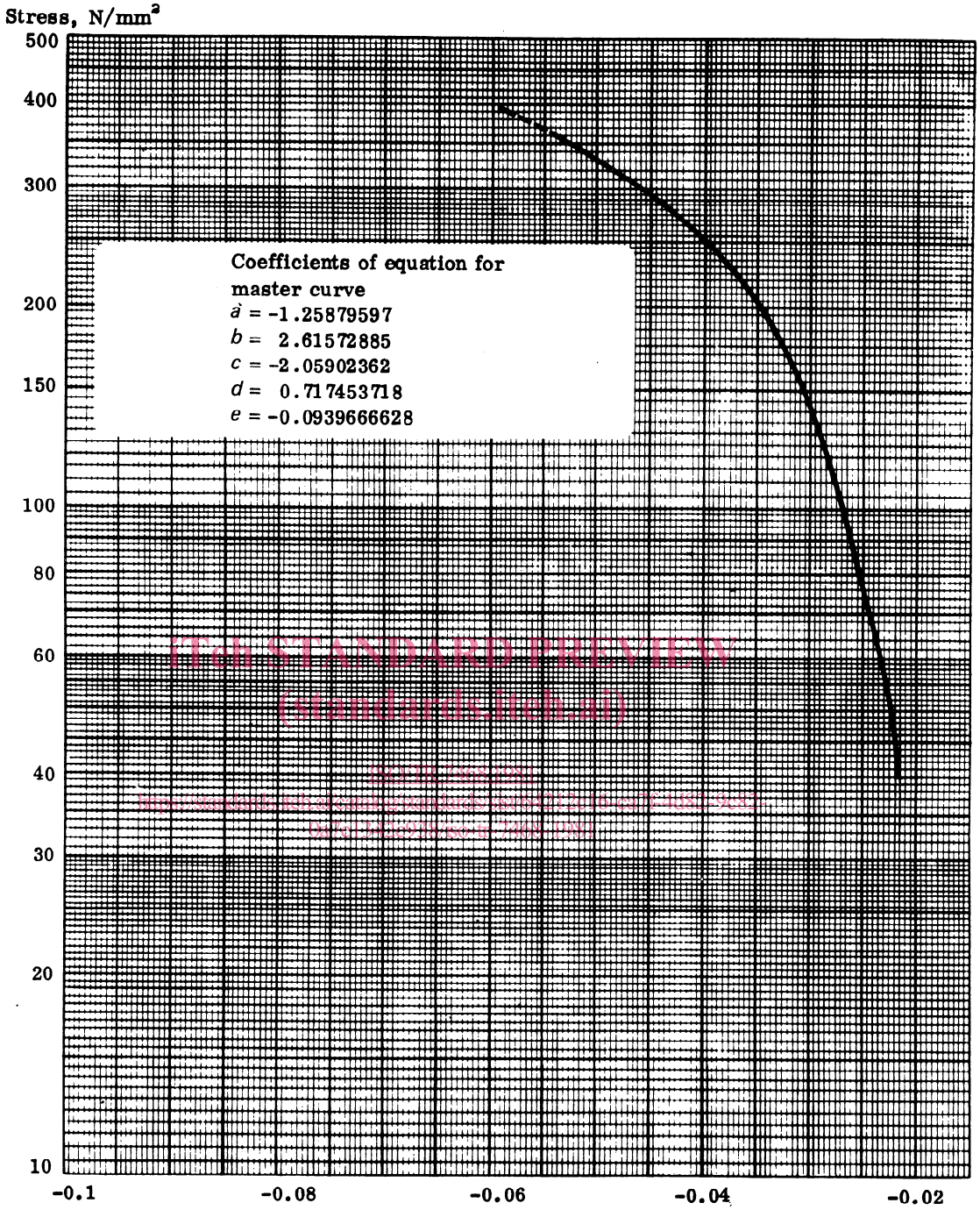
Temperature °C	Test Duration, h					
	<10 000	10 000 - 20 000	20 000 - 30 000	30 000 - 50 000	50 000 - 70 000	>70 000
	Number of Test Points Available					
400	292	41	18	19	6	2
450	461	55	16	7	3	1
500	463	33	16	9	4	3

AVERAGE RUPTURE STRESSES N/mm^2

Temperature °C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
380	277	251	238	219	207	199*	192*
390	255	228	215	196	184	175*	167*
400	233	206	193	173	160	151*	143*
410	213	185	171	151	137	128*	121*
420	193	164	150	129	116	107*	101*
430	173	144	129	109	98*	90*	84*
440	154	124	110	92	82*	76*	71*
450	136	107	94	78	70*	64*	60*
460	118	91	80	67	60*	55*	50*
470	102	79	69	57	50*	44*	
480	89	68	60	48			
490	77	59	51				
500	68	51	41				
510	60	41					
520	52						

Note: * Values which have involved extended time extrapolation)
() Values which have involved extended stress extrapolation) See notes on page 2

→ This minimum Mn level was selected since lower levels are known to reduce stress rupture properties



$$P(\sigma) = \frac{\log t - 10.677261}{T - 500} = a + b\,(\log \sigma) + c\,(\log \sigma)^2 + d\,(\log \sigma)^3 + e\,(\log \sigma)^4$$

C STEEL (SEMI AND SI KILLED) - TEMPERATURE RANGE 380-520°C

(R/2159)

CARBON STEEL (Si and Al killed)

Properties agreed March 1974
(Based on ISO document ISO/TC17/SC10/ETP-SG(Secretariat 82) 100)
Supersedes ISO document ISO/TC17/SC10/ETP-SG(Secretariat 23) 28

CONDITIONS OF STEEL TO WHICH THE PROPERTIES APPLY

	Details of Materials Actually Tested		Range for which Data are Expected to Apply Agreed by TC17/SC10/ETP	
Chemical Composition % (m/m)			min	max
	C	0.10 - 0.185	-	0.30
	Si	0.01 - 0.32	-	0.50
	Mn	0.36 - 0.79	→ 0.40	-
	P	0.007 - 0.029	-	0.050
	S	0.011 - 0.028	-	0.050
	Al (sol)	0.016 - 0.102	0.015	-
Heat Treatment	1. 880 - 950°C AC 2. 899 - 925°C AC + T 600°C		1. Normalised 2. Normalised and Tempered† 3. Hot Finished 4. Hot Finished and Tempered† † See page 10	
Products	Form	Size, mm	All wrought product forms	
	Tubes	4 - 28 thk x 38 - 194 dia		
	Plates	15 - 50 thk		
	Bars	20 dia		
	Forgings	25 thk		

QUANTITY AND DURATION OF DATA UPON WHICH THE PROPERTIES ARE BASED

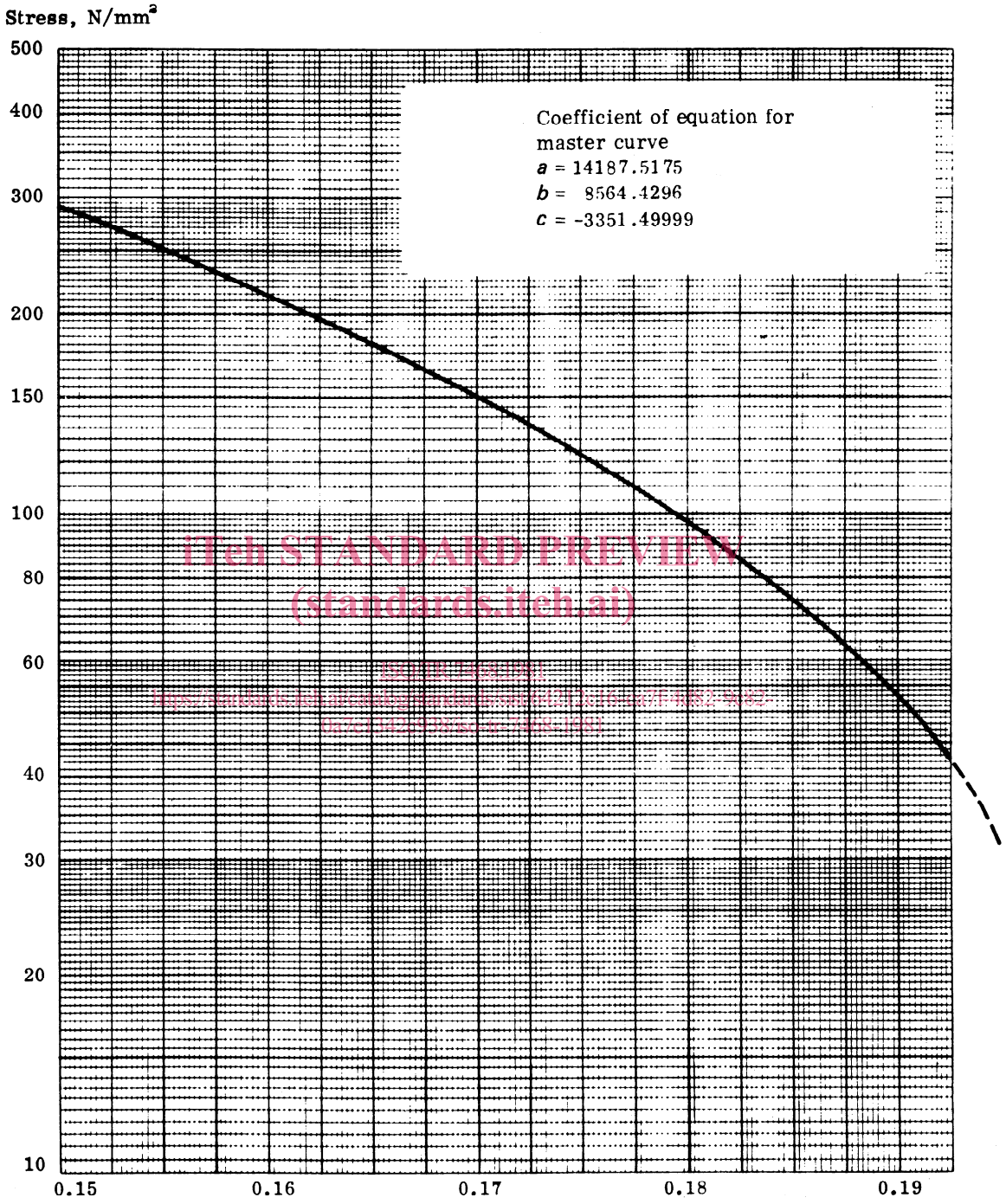
Temperature °C	Test Duration, h				
	<10 000	10 000 - 20 000	20 000 - 30 000	30 000 - 50 000	>50 000
	Number of Test Points Available				
400	30	7	6	2	
450	61	6	2	3	
500	24	3	2	2	

AVERAGE RUPTURE STRESSES N/mm^2

Temperature °C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
380	213	192	183	171*	164*	159*	155*
390	197	176	167	155*	149*	144*	140*
400	181	161	152	141*	134*	130*	126*
410	166	147	138	127*	121*	116*	113*
420	151	133	125	114*	108*	104*	101*
430	138	120	112	102*	96*	92*	89*
440	125	107	100	90*	84*	80*	77*
450	112	95	88	78*	73*	69*	66*
460	100	84	77	67*	62*	58*	55*
470	89	73	66	57*	52*	48*	45*
480	78	63	56*	47*	41*	37*	34*
490	67	52	46*	36*	(29)*	(23)*	
500	57	42	35*				
510	47	31					
520	37						

Note: * Values which have involved extended time extrapolation)
() Values which have involved extended stress extrapolation) See notes on page 2

→ This minimum Mn level was selected since lower levels are known to reduce stress rupture properties



$$P(\sigma) = T(\log t + 20.429050) = a + b(\log \sigma) + c(\log \sigma)^2$$

C STEEL, Si + Al KILLED - TEMPERATURE RANGE 380-520°C

(R/2162)

CARBON MANGANESE STEELS (Semi killed or fully killed carbon manganese steels including Nb treated steels)

Properties agreed March 1974
(Based on ISO document ISO/TC17/SC10/ETP-SG (Secretariat 81)99)

Supersedes ISO document ISO/TC17/SC10/ETP-SG(Secretariat 23) 28

CONDITIONS OF STEEL TO WHICH THE PROPERTIES APPLY

	Details of Materials Actually Tested		Range for which Data are Expected to Apply Agreed by TC17/SC10/ETP	
Chemical Composition % (*m/m*)			min	max
	C	0.09 - 0.29	-	0.30
	Si	0.006 - 0.49	-	0.50
	Mn	0.80 - 1.64	0.80	-
	P	0.008 - 0.048	-	0.050
	S	0.001 - 0.103	-	0.050
	Nb	0.001 - 0.077	-	0.10
Heat Treatment	1. 860 - 960°C AC 2. 840 - 960°C AC + T550 - 720°C		1. Normalised 2. Normalised and Tempered† 3. Hot Finished 4. Hot Finished and Tempered† † See page 11	
Products	Form	Size, mm		
	Plates Tubes	1 - 133 thk 6 - 66 thk x 6 - 273 dia	All wrought product forms	
	Forgings	25 - 150 thk 25 - 1425 dia		

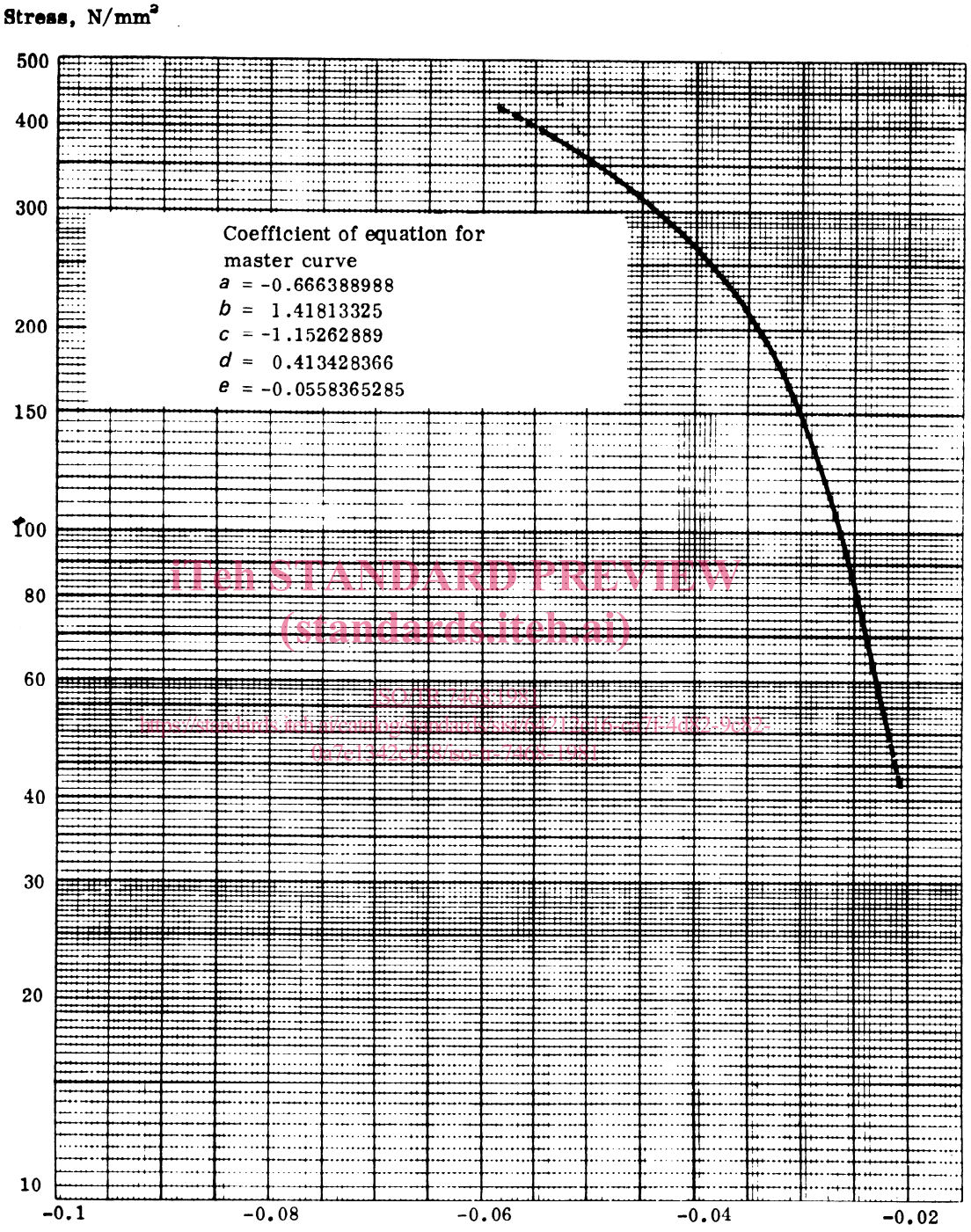
QUANTITY AND DURATION OF DATA UPON WHICH THE PROPERTIES ARE BASED

Temperature °C	Test Duration, h					
	<10 000	10 000 - 20 000	20 000 - 30 000	30 000 - 50 000	50 000 - 70 000	>70 000
	Number of Test Points Available					
400	454	107	51	75	5	4
450	639	84	36	49	16	3
500	596	88	24	38	21	3

AVERAGE RUPTURE STRESSES N/mm^2

Temperature °C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
380	291	262	248	227	215	206*	199*
390	266	237	223	203	190	181*	174*
400	243	214	200	179	167	157*	150*
410	221	192	177	157	144	135*	128*
420	200	171	156	136	124	115*	108*
430	180	151	136	117	105	97*	91*
440	161	132	118	100	89	82*	77*
450	143	115	102	85	76	70*	66*
460	126	99	87	73	65	60*	56*
470	110	86	75	63	56	52*	(48)*
480	96	74	65	55	(49)	(44)*	(41)*
490	84	65	57	(47)	(42)	(37)*	(32)*
500	74	57	50	(41)	(34)		
510	65	50	(44)	(32)			
520	58	(44)	(37)				

Note: * Values which have involved extended time extrapolation)
() Values which have involved extended stress extrapolation) See notes on page 2



$$P(\sigma) = \frac{\log t - 10.656877}{T - 500} = a + b\,(\log \sigma) + c\,(\log \sigma)^2 + d\,(\log \sigma)^3 + e\,(\log \sigma)^4$$

ALL C-Mn STEELS - TEMPERATURE RANGE 380-520°C

(R/2166)

CARBON STEEL

Semi killed, Si killed and Si + Al killed.
Tempered stress relieved, or post weld heat treated for times in excess of 3 hours at 620°C.

Properties agreed:

May 1975

In the case of carbon steels which have been tempered, stress relieved or post weld heat treated for times in excess of 3 hours at 620°C or equivalent times at other temperatures, the average rupture stresses should be taken as 10% lower than the values given for Si + Al killed carbon steels as indicated below.

Temperature °C	Estimated Average Stress (N/mm^2) to Produce Rupture in:						
	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
380	192	173	165	154	148	143	140
390	177	158	150	140	134	130	126
400	163	145	137	127	121	117	113
410	149	132	124	114	109	104	102
420	136	120	113	103	97	94	91
430	124	108	101	92	86	83	80
440	113	96	90	81	76	72	69
450	101	86	79	70	66	62	59
460	90	76	69	60	56	52	50
470	80	66	59	51	47	43	41
480	70	57	49	42	37	33	31
490	60	47	41	32	26	21	
500	51	38	32				
510	42	28					
520	33						

No consideration has been given to the inclusion of asterisks but the properties are considered to be conservative.

CARBON MANGANESE STEEL

Semi killed, or fully killed carbon manganese steels including Nb treated steels. Tempered stress relieved or post weld heat treated for times in excess of 3 hours at 620°C.

Properties agreed:

May 1975

In the case of carbon manganese steels which have been tempered, stress relieved, or post weld heat treated for times in excess of 3 hours at 620°C or equivalent times at other temperatures, the rupture stresses should be taken as 10% lower than the values given for carbon manganese steels, as indicated below.

Temperature °C	Estimated Average Stress (N/mm^2) to Produce Rupture in:						
	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
380	262	236	223	204	194	185	179
390	239	213	201	183	171	163	157
400	219	193	180	161	150	141	135
410	199	173	159	141	130	122	115
420	180	154	139	122	112	104	97
430	162	136	122	105	95	87	82
440	145	119	106	90	80	74	69
450	129	104	92	77	68	63	59
460	113	89	78	66	59	54	49
470	99	77	68	57	49	47	(43)
480	86	67	59	50	(44)	(40)	(37)
490	76	59	51	(42)	(38)	(33)	(30)
500	67	51	45	(37)	(31)		
510	59	45	(40)	(29)			
520	52	(40)	(33)				

No consideration has been given to the inclusion of asterisks but the properties are considered to be conservative.

Note: ( ) Values which have involved extended stress extrapolation (see notes on page 2).

0.3% Mo STEEL

Properties agreed May 1975
(Based on ISO document ISO/TC17/SC10/ETP-SG(Secretariat 48) 55)
Updated as ISO document ISO/TC17/SC10/ETP-SG(Secretariat 97) 131

CONDITIONS OF STEEL TO WHICH THE PROPERTIES APPLY

	Details of Materials Actually Tested		Range for which Data are Expected to Apply Agreed by TC17/SC10/ETP	
Chemical Composition % (*m/m*)			min	max
	C	0.13 - 0.20	0.12	0.25
	Si	0.17 - 0.40	0.10	0.40
	Mn	0.48 - 0.81	0.40	0.80
	P	0.005 - 0.027	-	0.040
	S	0.005 - 0.030	-	0.040
	Mo	0.25 - 0.35	0.25	0.35
	Al (met)	0.006 - 0.008	-	0.012
Heat Treatment	1. 890 - 925°C AC 2. 900 - 950°C AC + T650°C		1. 880/950°C AC 2. 880/950°C AC and Tempered 600/650°C	
Products	Form	Size, mm		
	Tubes	6.5 - 36 thk x 133 - 368 dia	All wrought product forms	
	Bars	25 dia		
	Plates	20 thk		
	Forgings	20 - 25 thk + 20 - 210 dia		

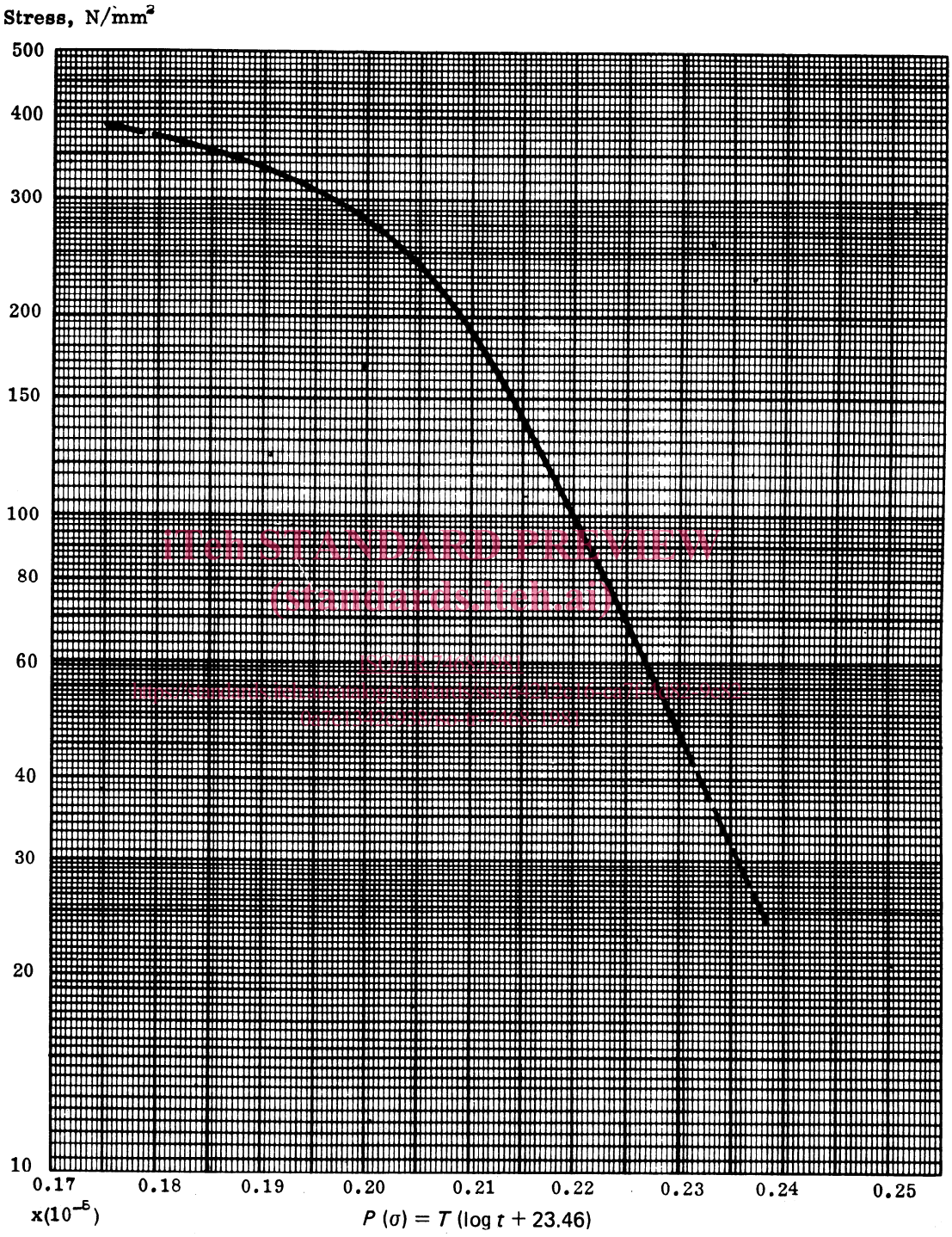
QUANTITY AND DURATION OF DATA ON WHICH THE PROPERTIES ARE BASED

Temperature °C	Test Duration, h				
	<10 000	10 000 - 20 000	20 000 - 30 000	30 000 - 50 000	>50 000
	Number of Test Points Available				
450	30	7	4	2	1
500	110	23	14	6	3
550	81	11	3	2	1

AVERAGE RUPTURE STRESSES N/mm^2

Temperature °C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
450	298	273	260	239*	226*	217*	210*
460	273	244	229	208*	197*	188*	180*
470	247	216	200	178*	168*	159*	151*
480	222	187	172	148	139*	130*	124*
490	196	159	144	123	114*	105*	100*
500	171	134	119	101	91*	84*	80*
510	147	113	99	81	74*	69*	65*
520	125	93	80	66	60*	55*	52*
530	102	76	66	53*	48*	45*	(42)*
540	82	61	53	(42)*	(39)*	(36)*	(33)*
550	64	49	(42)	(34)*			

Note: * Values which have involved extended time extrapolation)
() Values which have involved extended stress extrapolation) see notes on page 2



0.3% Mo STEEL - TEMPERATURE RANGE 450-550°C

(R/7909)