ECCC DATA SHEETS 2005

APPROVED  **DATE** *5/9/05*

On behalf of ECCC

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FOREWORD

The European Creep Collaborative Committee (ECCC) is an independent group of high temperature plant manufacturers, plant operators and alloy producers formed to co-ordinate creep data development activities throughout Europe. Since its formation in 1992, representatives of industry from Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Holland, Italy, Portugal, Slovakia, Switzerland, Sweden and the UK have signed the ECCC Memorandum of Understanding. The European Commission's Joint Research Centre (Petten) has also been a signatory.

ECCC was formed in 1991. During the period 1992 to 1996 its activities, funded under the European Commission's Concerted Action programme, led to the development of recommendations for the generation, collation/exchange and assessment of creep data for virgin parent materials [1]. Using these guidelines, ECCC WG3x working groups (Table 1) collated and assessed creep rupture data for a number of high temperature steels, and resulting creep strength values were provided to the European Committee for Iron and Steel Standardisation (ECISS) for adoption in the new European product standards under preparation at the time.

From 1997 to 2001, ECCC received support from the European Commission's Thematic Network programme. Its work then focused on the properties of weldments as well as parent materials. Recommendations were developed for the generation and assessment of creep data for weldments [2], and WG3x working groups were established to collate and assess weldment data for ferritic steels, austenitic steels, nickel base alloys and dissimilar metal joints (Table 1). The first issue of ECCC Data Sheets were published during this period [3].

Between 2001-2005, the number of ECCC Recommendation Volumes was extended to nine [4] and the scope of the Data Sheets expanded, this activity again being supported by the EC's Thematic Network programme. The higher number of Recommendation Volumes reflected the increased scope of working group activity to include the consideration of creep strain and ductility assessment, post exposed data, creep crack initiation data and the analysis of high temperature multi-axial features and components.

ECCC WORKING GROUP STRUCTURE

The European Creep Collaborative Committee comprises the working groups listed in Table 1, all of which report to the ECCC Management Committee. WG1 and its sub-groups are responsible for the recommendation of common procedures to be adopted by the WG3x groups [1,2,4]. For example ECCC Recommendations Volume 5 contains guidance for the assessment of large creep-rupture datasets and promotes the use of innovative post assessment tests (PATs) to independently test the effectiveness and credibility of the strength predictions determined by any approved assessment procedure [1e,2e,4e]. The PATs evaluate:

i) the physical realism of the predicted isothermal lines,
ii) the effectiveness of the model prediction within the range of the input data, and
iii) the repeatability and stability of the extrapolations.

The WG3x working groups (shaded area of Table 1) are responsible for managing ECCC test programmes, collating data from all sources, assessing the data and producing the ECCC Creep Property Data Sheets (attached). For administrative purposes, the WG3x working group designations had to be changed from time to time. The changes are summarised in Table 1 (shaded area).

DATA ASSESSMENTS

In order to prepare the attached Data Sheets, the WG3x groups have adopted one of two approaches to data assessment, i.e.

(i) *'formal'* - data assessment according to WG1 guidelines [1e,2e,4e], including application of the post assessment tests (PATs), or

(ii) *'informal'* - a review process in which existing strength values in different national and international standards have been compared and selected (or averaged) to provide preliminary values.

The *'formal'* approach has been applied to steel/alloy grades for which more and longer-term data have become available in recent years, or where the reliability of the data assessment could be improved through the assessment of a larger pan-European database (rather than a national database from which the values in an existing national standard may have been derived). The *'informal'* approach has been applied to those steel grades which have been used widely within Europe for many years and for which no additional long-term data have become available since the existing strength values in the national standards were evaluated. ECCC did not have sufficient resources to collate and formally assess European datasets for these steels. In some cases, strength values were available in ISO standards but these were not acceptable to all parties in Europe.

Table 1 Guide to ECCC working group designations [1]

WORKING GROUP	1992-1996	1997-2001	2001-2005
Data validation and assessment procedures	WG1	WG1	WG1
Post-exposure data sub-group (PEDS)		WG1-PEDs	WG1.1
Creep crack initiation sub-group			WG1.2
Components		WG3.2	WG4
Information dissemination and technology transfer	WG2	WG2	WG2
Special welds (inc. dissimilar metal welds)		WG3.1	
Carbon and low alloy wrought steels	WG3.1		
9-12% chromium steels	WG3.2		
Ferritic steels and weldments [2]		WG3.2	WG3A
Austenitic steels and weldments	WG3.3	WG3.3	WG3B
High temperature bolting alloys	WG3.4	WG3.4	
Nickel-base alloys		WG3.5	WG3C

[1] *Designations for the WG3x working groups responsible for producing the ECCC creep property data sheets are in shaded area of table*

[2] *The activities of the original WG3.1 and WG3.2 working groups were combined in 1997 to become WG3.2 (and subsequently WG3A)*

The following are examples of the steels for which large stress rupture databases have been collated and formally assessed by WG3x:

- ½Cr½Mo¼V (~7 million testing hours, 500 data points, 46 heats)
- Steel 91 (>11 million testing hours, 1749 data points, ~140 heats; with data from seven European countries and sources in Japan and the USA)
- ASTM Grade 92 (>6 million testing hours, 841 data points, 48 heats)
- Type 316/316L (2230 data points, 123 casts)
- Alloy 800H/HT (730 data points, 58 casts)

A list of the steels which have been assessed by ECCC is presented in the List of Data Sheets below. For each steel type, the ECISS designation and material number are listed (where available). New Data Sheets included in this latest compilation are for:

- Cast Steel 91
- Steel E911
- ASTM Grade 92
- HR3C
- NF709
- NF709R
- Alloy 617

- Alloy 80A (3 stage heat treated)
- Alloy 80A (2 stage heat treated)

The results of the data assessments have been recommended by ECCC to the appropriate ECISS technical committees for inclusion in European standards:

ECISS TC29	EN 10216, EN 10217	tubes
ECISS TC28	EN 10222	forgings
ECISS TC22	EN 10028	flat products
ECISS TC23	EN 10269	bolting
ECISS TC54	EN 13445	

ACKNOWLEDGEMENT

The Data Sheets contained in this collection are the result of a major effort by members of ECCC, with much of the work being unfunded. The contributions of these working group members are gratefully acknowledged.

REFERENCES

1 ECCC-WG1 Recommendations, 1996, 'Creep data validation and assessment procedures', ed. Holdsworth, S.R., Orr, J., Granacher, J., Bullough, C.K. & Merckling, G., publ. ERA Technology, (a) Vol.1 - Overview, (b) Vol.2 - Terms and terminology, (c) Vol.3 - Data acceptability criteria, Data generation, (d) Vol.4 - Data exchange and collation, (e) Vol.5 - Data assessment.

2 ECCC Recommendations, 2001, 'Creep data validation and assessment procedures', Holdsworth, S.R. et al. eds., publ. ERA Technology, (a) Vol.1 - Overview, (b) Vol.2 - Terms and terminology, (c) Vol.3 - Data acceptability criteria, Data generation, (d) Vol.4 - Data exchange and collation, (e) Vol.5 - Data assessment.

3 ECCC Data Sheets, 1999, 'Rupture strength, creep strength and relaxation strength values for carbon-manganese, low alloy ferritic, high alloy ferritic and austenitic steels, and high temperature bolting steels/alloys', ed. Robertson, D.G., publ. ERA Technology Ltd.

4 ECCC Recommendations, 2005, 'Creep data validation and assessment procedures', Holdsworth, S.R. et al. eds., publ. ETD, (a) Vol.1 - Overview, (b) Vol.2 - Terms and terminology, (c) Vol.3 - Data acceptability criteria, Data generation, (d) Vol.4 - Data exchange and collation, (e) Vol.5 - Data assessment (uniaxial data), (f) Vol.6 - Residual life assessment and microstructure, (g) Vol.7 – Assessment of creep crack initiation in testpieces and components, (h) Vol.8 – Assessment of multi-axial creep tst data, (i) High temperature component assessment.

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LIST OF ECCC DATA SHEETS

(Rupture strength unless otherwise stated)

ECISS grade	Number	Steel type	
Carbon-manganese and low alloy ferritic steels			
P195	-	C / CMn	
P235	-	C / CMn	
P265	-	C / CMn	
P355	-	CMnNb	
16Mo3	-	0.3Mo	
8MoB5-4	-	MoB	
13CrMo4-5/5-5	-	1CrMo	
25CrMo4	-	1CrMo	
12MoCrV 6-2-2	-	½Cr½Mo¼V	
11CrMo9-10+NT	-	2¼Cr1Mo (Normalised +Tempered)	
11CrMo9-10+QT	-	2¼Cr1Mo (Quenched + Tempered)	
20CrMoV13-5	-	3CrMoV	
X11CrMo5+I	-	5CrMo (Annealed)	
X11CrMo5+NT1, +NT2	-	5CrMo (Normalised +Tempered)	
9NiMoCuNb5-6-4	-	1NiMoCuNb	
High alloy ferritic steels			
X11CrMo9-1+I1, +I2	-	9Cr1Mo (Annealed)	
X11CrMo9-1+NT	-	9Cr-1Mo (Normalised +Tempered)	
X10CrMoVNb9-1	-	Steel 91 (P91/T91)	
GX12CrMoVNbN9-1	-	Cast Steel 91	
X11CrMoWVNb9-1-1	-	Steel E911	
X10CrWMoVNb9-2	-	ASTM Grade 92 (P92/T92)	
X20CrMoNiV11-1	-	12CrMoV	
Austenitic steels			
X2CrNi18-9	1.4307	Type 304L	
X2CrNiN18-10	1.4311	Type 304 LN	
X6CrNi18-10	1.4948	Type 304H	
X2CrNiMo17-12-2	1.4404	Type 316L	
X5CrNiMo17-12-2	1.4401	Type 316	
X6CrNiMoTi17-12-2	1.4571	Type 316 Ti	
X2CrNiMoN17-13-3	1.4429	Type 316 LN	
X2CrNiMo17-12-2	1.4909	Type 316 L(N)	
X3CrNiMoBN17-13-3	1.4910	Type 316 LNB	
X7CrNiTi18-10	1.4941	Type 321H, SA 1070-1150°C	
X7CrNiTi18-10	1.4941	Type 321H, SA 950-1070°C	
X6CrNiNb18-10	1.4550	Type 347, SA 1070-1125°C	
X6CrNiNb18-10	1.4550	Type 347, SA 950-1070°C	
X8CrNiNb16-13	1.4961	16-13Nb	
X5NiCrAlTi31-20	1.4958	Alloy 800, solution annealed	+
X8NiCrAlTi32-21	1.4959	Alloy 800H, solution annealed	
X8NiCrAlTi32-21	-	Alloy 800HT, restricted Al + Ti	
X5NiCrAlTi31-20 RK	-	Alloy 800, recrystallized	+
X6NiCrNbCe32-27	1.4877	AC 66	
X7CrNiSiNCe21-11	-	253MA	
X10CrNiMoMnNbVB15-10-1	1.4982	Esshete 1250	
-	-	BS1503 310S31 (Type 310)	
-	-	Fine grained TP347H	
-	-	Super 304H	

-	-	HR3C	
-	-	NF709	
-	-	NF709R	

Nickel base alloys

NiCr23Co12Mo	-	Alloy 617	
NiCr20TiAl	-	Alloy 80A (3 stage heat treated)	
NiCr20TiAl	-	Alloy 80A (2 stage heat treated)	

High temperature bolting steels

42CrMo5-6	1.7233	Durehete 900	
20CrMoVTiB4-10	1.7729	Durehete 1055	*
21CrMoV 5-7	1.7709	1CrMoV	+

Notes

+ 1% Creep strength as well as Rupture

* Relaxation strength as well as Rupture (note that, in the Data Sheet, the summary of the quantity and duration of the data only indicates the number of tests and their duration; each test consisted of a series of relaxed stress-time data points which were used in the assessment)

DISCLAIMER

Care has been taken to ensure that the data presented in the ECCC Data Sheets are reliable. However, neither ECCC nor the publisher accepts any responsibility whatsoever for any undesirable consequences arising from the use of the data.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel P195

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.13
	Si	wt%	-	-	-	0.35
	Mn	wt%	-	-	-	0.70
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	0.30
	Mo	wt%	-	-	-	0.08
	Ni	wt%	-	-	-	0.30
	V	wt%	-	-	-	0.02
	Nb	wt%	-	-	-	0.010
	Al	wt%	-	-	0.020	-
	Cu	wt%	-	-	-	0.30
	Ti	wt%	-	-	-	0.030
	Cr + Cu + Mo + Ni	wt%	-	-	-	0.70
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	880	940
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	195	-
	R_M	N/mm²	-	-	320	440

Source references of analysed data used in assessment

Source references	Scope of data
ISO2604/II/III, ISO9329-2, ISO9330-2/4 BS3602 A49-212/213 UNI 5462-64 DIN 17175/77 NBN837	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
400	182	141	128	122
410	166	126	115	109
420	151	114	102	97
430	138	100	89	86
440	125	88	77	74
450	112	77	66	64
460	100	66	56	54
470	88	56	46	44
480	77	47	30	35
490	67	39	26	-
500	58	32	24	-

Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

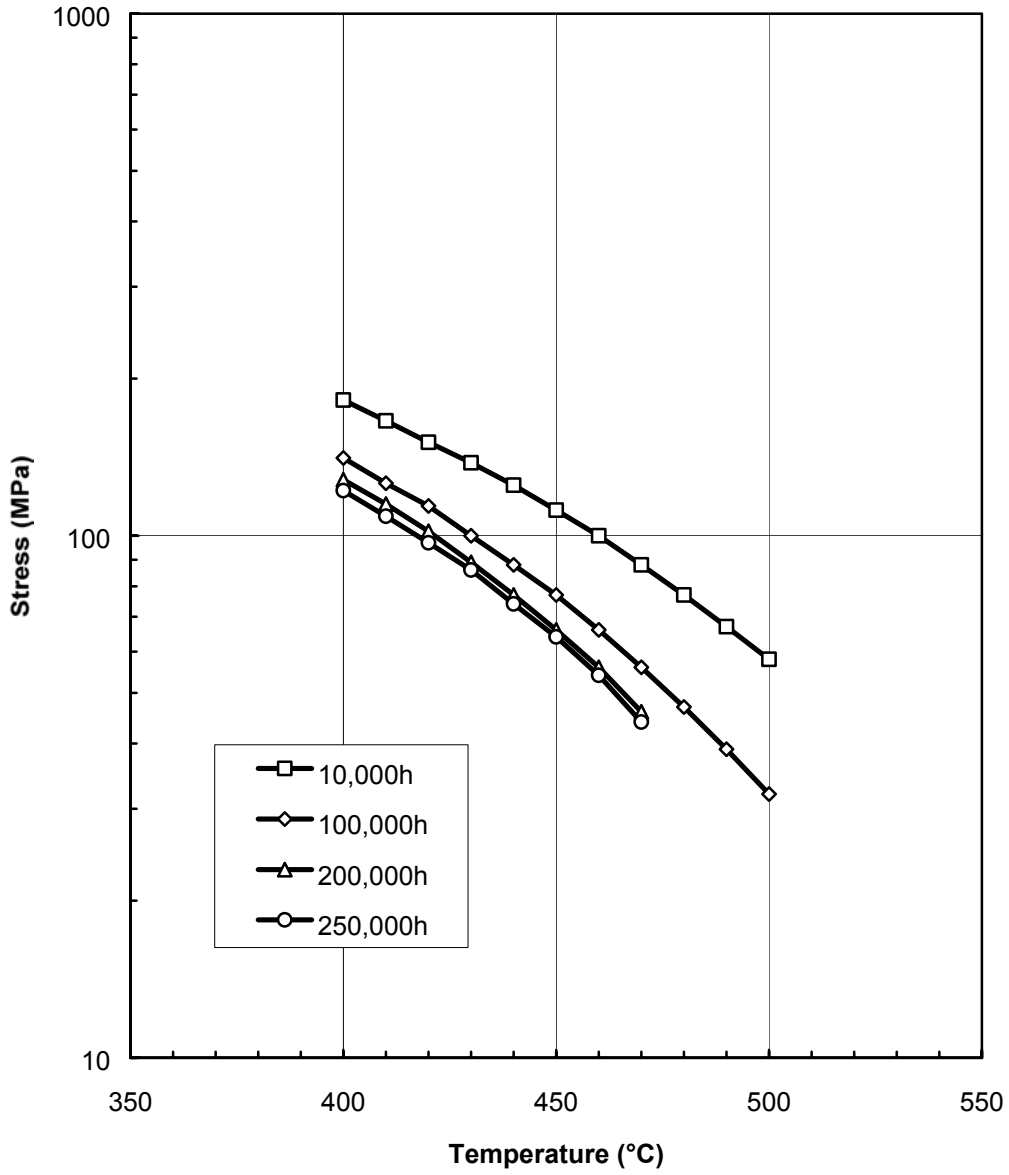
Signed: WG3.2 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel P195

Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel P235

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.16
	Si	wt%	-	-	-	0.35
	Mn	wt%	-	-	-	1.20
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	0.30
	Mo	wt%	-	-	-	0.08
	Ni	wt%	-	-	-	0.30
	V	wt%	-	-	-	0.02
	Nb	wt%	-	-	-	0.010
	Al	wt%	-	-	0.020	-
	Cu	wt%	-	-	-	0.30
	Ti	wt%	-	-	-	0.030
	Cr + Cu + Mo + Ni	wt%	-	-	-	0.70
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	880	940
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	235	-
	R_M	N/mm²	-	-	360	500

Source references of analysed data used in assessment

Source references	Scope of data
ISO2604/II/III, ISO9329-2, ISO9330-2/4 BS3602 A49-212/213 UNI 5462-64 DIN 17175/77 NBN837	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
400	182	141	128	122
410	166	126	115	109
420	151	114	102	97
430	138	100	89	86
440	125	88	77	74
450	112	77	66	64
460	100	66	56	54
470	88	56	46	44
480	77	47	30	35
490	67	39	26	-
500	58	32	24	-

Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

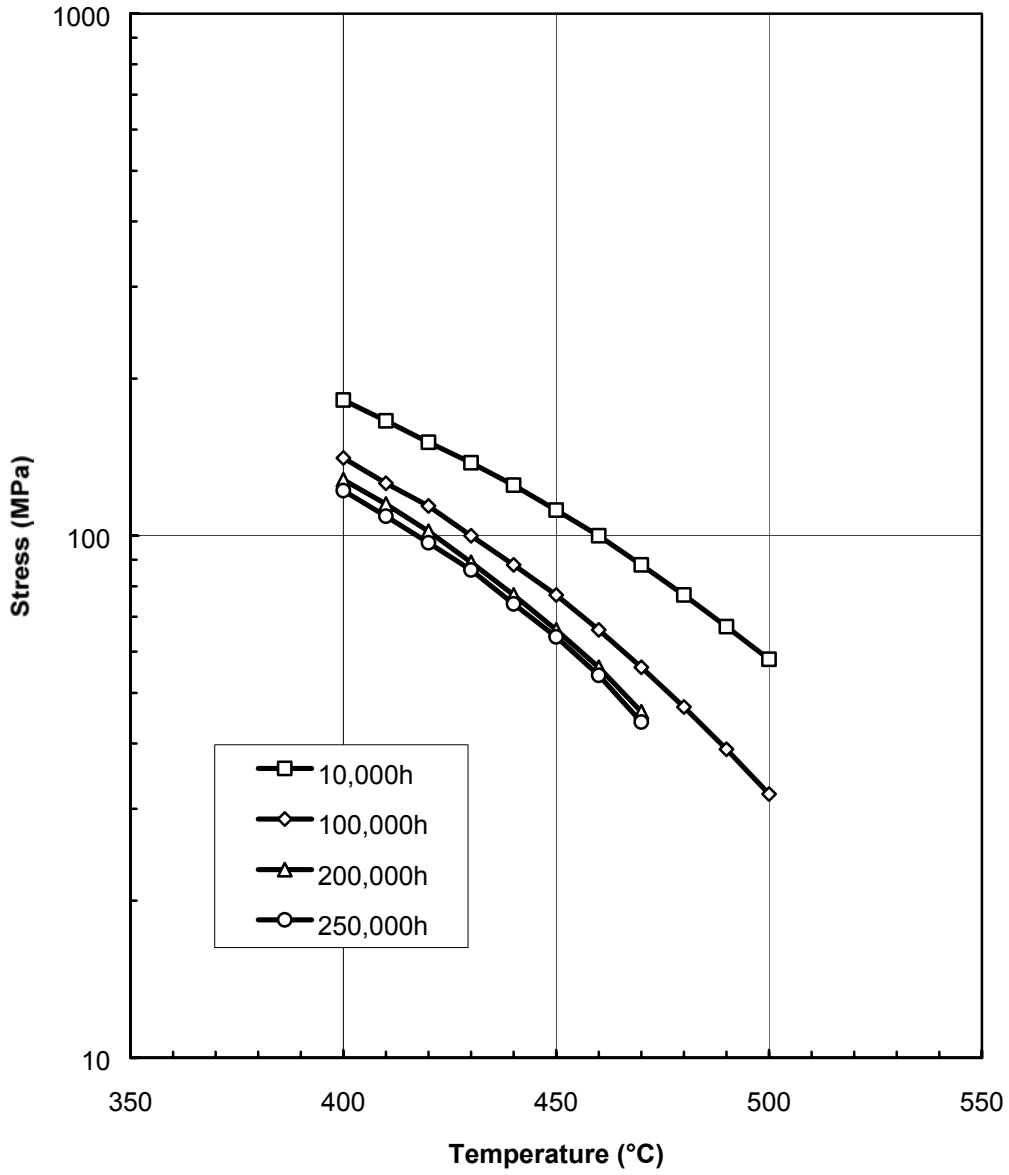
Signed: WG3.2 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel P235

Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel P265

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.20
	Si	wt%	-	-	-	0.40
	Mn	wt%	-	-	-	1.40
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	0.30
	Mo	wt%	-	-	-	0.08
	Ni	wt%	-	-	-	0.30
	V	wt%	-	-	-	0.02
	Nb	wt%	-	-	-	0.010
	Al	wt%	-	-	0.020	-
	Cu	wt%	-	-	-	0.30
	Ti	wt%	-	-	-	0.030
	Cr + Cu + Mo + Ni	wt%	-	-	-	0.70
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	880	940
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	265	-
	R_M	N/mm²	-	-	410	570

Source references of analysed data used in assessment

Source references	Scope of data
ISO2604/II/III, ISO9329-2, ISO9330-2/4 BS3602 A49-212/213 UNI 5462-64 DIN 17175/77 NBN837	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
400	182	141	128	122
410	166	126	115	109
420	151	114	102	97
430	138	100	89	86
440	125	88	77	74
450	112	77	66	64
460	100	66	56	54
470	88	56	46	44
480	77	47	30	35
490	67	39	26	-
500	58	32	24	-

Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

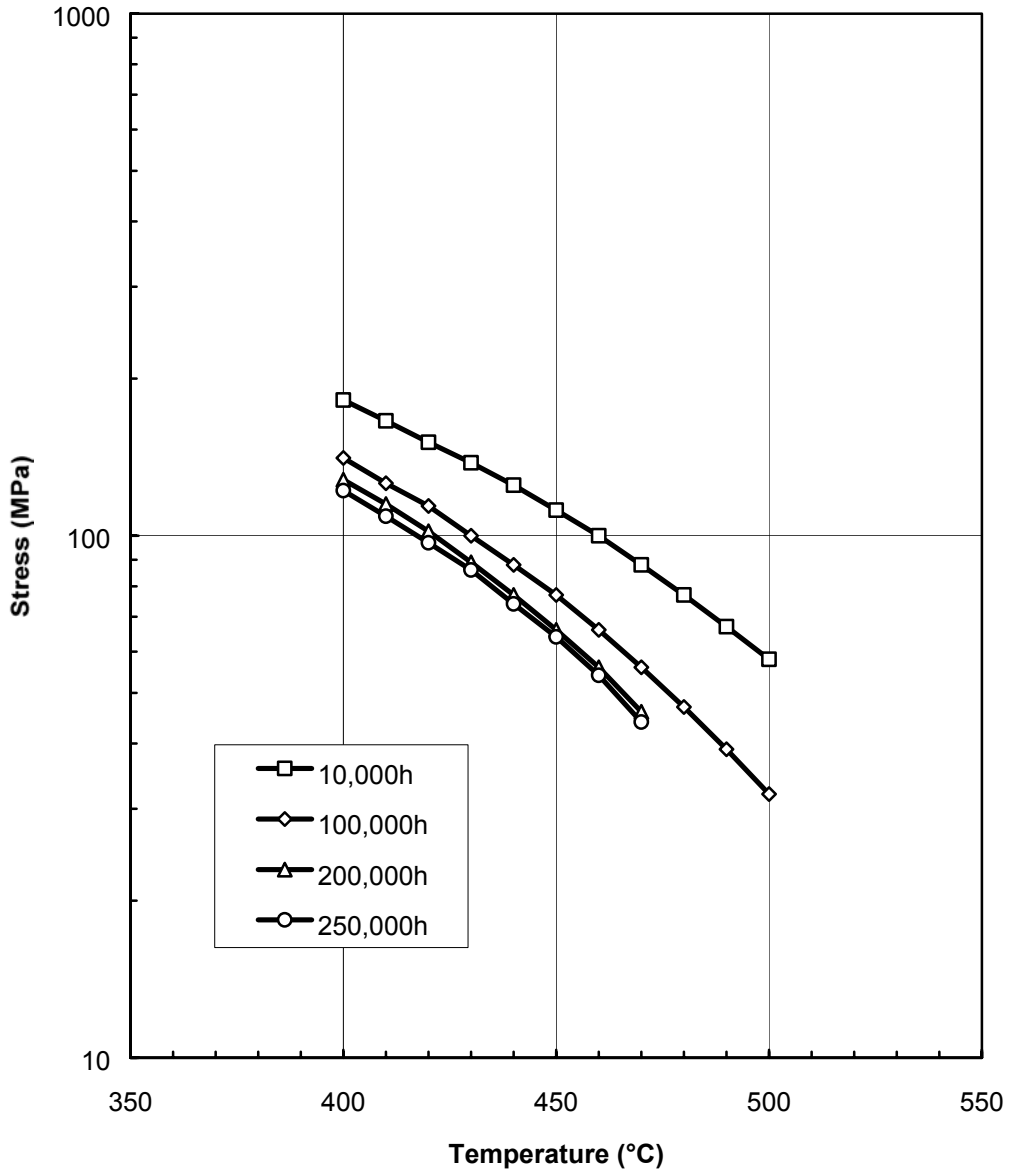
Signed: WG3.2 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel P265

Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel P355

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.22
	Si	wt%	-	-	0.15	0.35
	Mn	wt%	-	-	1.00	1.50
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	-
	Mo	wt%	-	-	-	-
	Ni	wt%	-	-	-	-
	V	wt%	-	-	-	-
	Nb	wt%	-	-	0.015	0.10
	Al	wt%	-	-	-	0.060
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	900	960
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	355	-
	R_M	N/mm²	-	-	500	650

Source references of analysed data used in assessment

Source references	Scope of data
BS3602	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
400	243	179	157*	150*
410	221	157	135*	128*
420	200	136	115*	108*
430	180	117	97*	91*
440	161	100	82*	77*
450	143	85	70*	66*
460	126	73	60*	56*
470	110	63	52*	(48)*
480	96	55	(44)*	(41)*
490	84	(47)	(37)*	(32)*
500	74	(41)	-	-

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

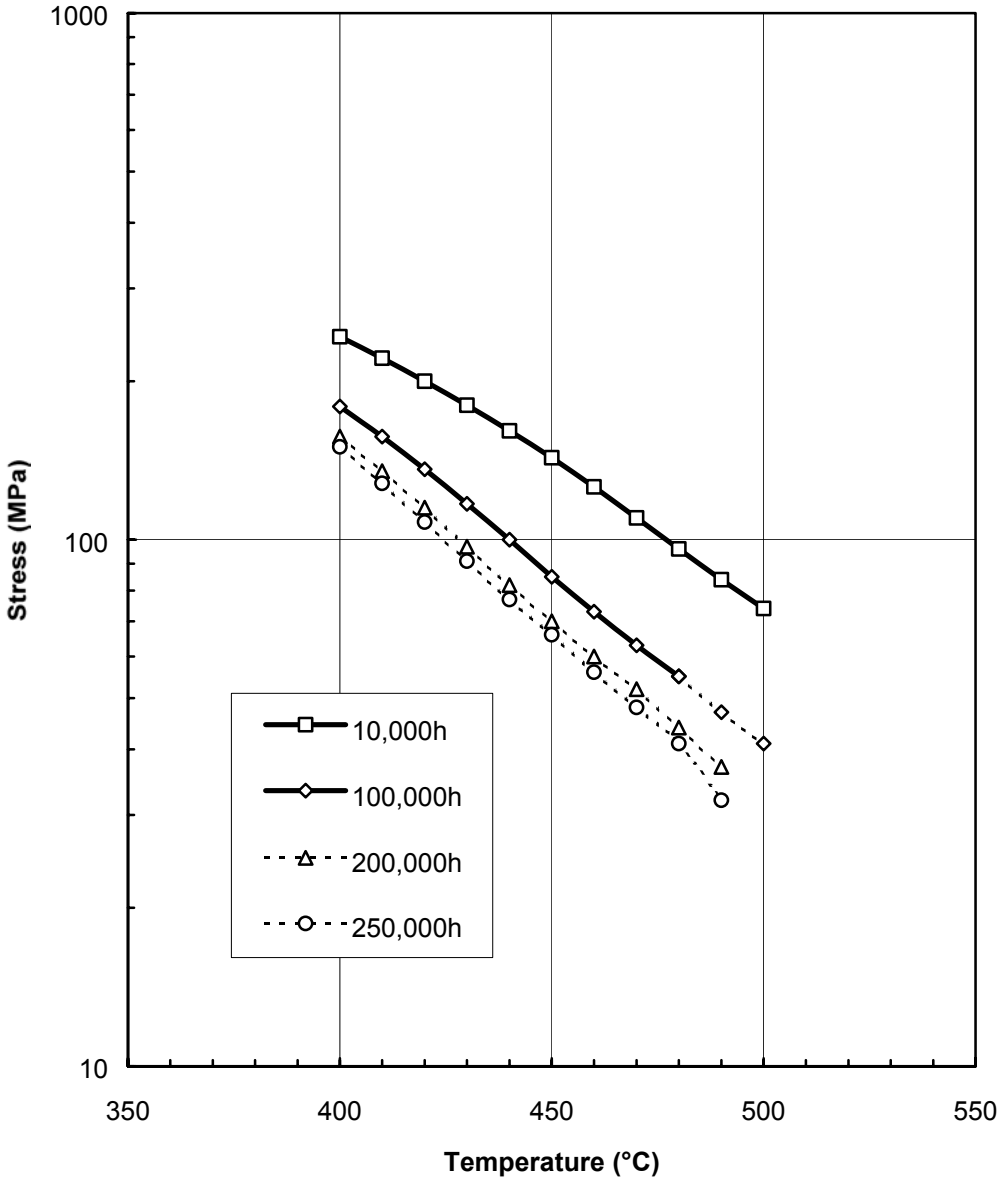
Signed: WG3.2 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel P355

Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel 16Mo3

Working group: WG3.2
Year: 1996

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.12	0.20
	Si	wt%	-	-	0.15	0.35
	Mn	wt%	-	-	0.40	0.80
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Mo	wt%	-	-	0.25	0.35
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	880	950
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	280	-
	R_M	N/mm²	-	-	450	600

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2 ISO9330-2/4 BS3059-2 A49-213/15 UNI 5462-64 DIN 17175/77	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	298	236	218	210
460	273	205	186	179
470	247	176	156	148
480	221	149	129	122
490	196	124	105	98
500	171	102	84	78
510	148	83	67	63
520	125	65	53	50
530	104	51	42	38
540	84	40	34	-
550	64	32	25	-

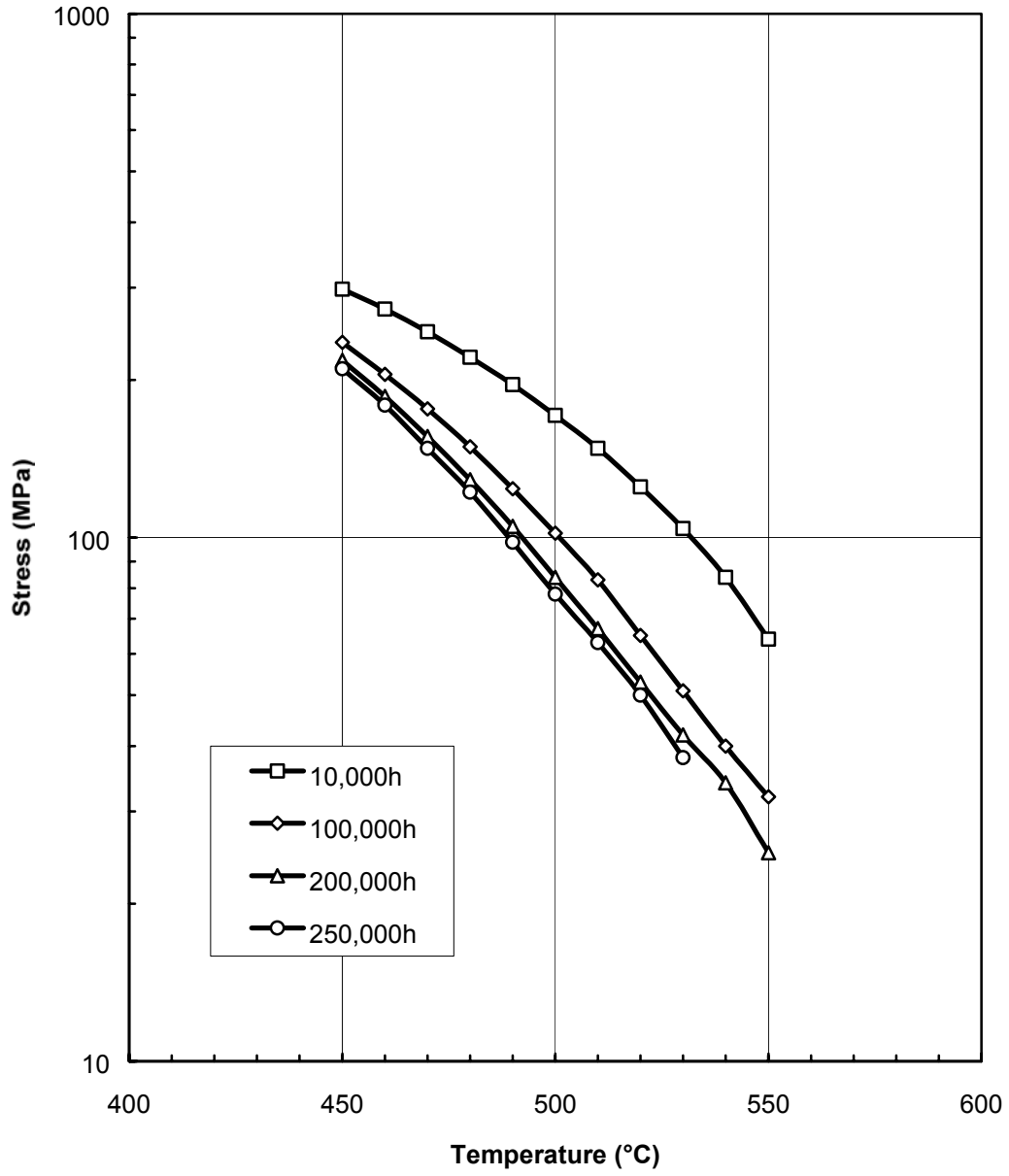
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 16Mo3

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel 8MoB5-4

Working group: WG3.2
Year: 1996

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.06	0.10
	Si	wt%	-	-	0.10	0.35
	Mn	wt%	-	-	0.60	0.80
	P	wt%	-	-	-	0.020
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	0.20
	Mo	wt%	-	-	0.40	0.50
	Al	wt%	-	-	-	0.060
	Ti	wt%	-	-	-	0.060
	B	wt%	-	-	0.002	0.006
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	920	960
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	400	-
	R_M	N/mm²	-	-	540	690

Source references of analysed data used in assessment

Source references	Scope of data
Manufacturer's data	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
400	534	494		
410	522	446		
420	512	395		
430	500	347		
440	484	298		
450	457	255		
460	417	214		
470	364	174		
480	307	136		
490	252	106		
500	207	80		
510	172	62		
520	145	50		
530	119	41		
540	95	34		
550	70	25		

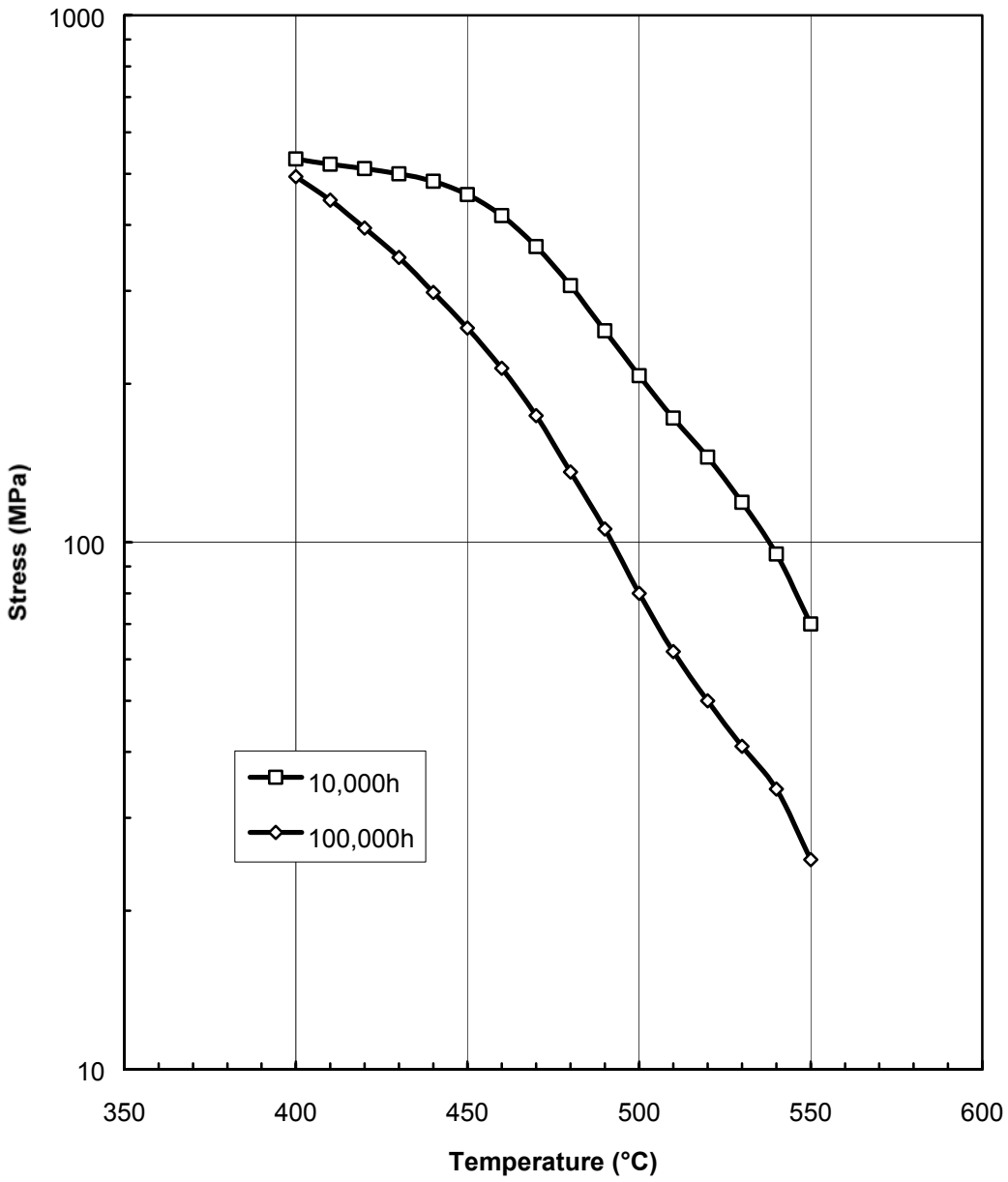
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 8MoB5-4

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 13CrMo4-5/5-5

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.10	0.17
	Si	wt%	-	-	0.15	0.35
	Mn	wt%	-	-	0.40	0.70
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	0.70	1.10
	Mo	wt%	-	-	0.45	0.65
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	900	960
	Temper	°C	-	-	660	730
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	290	-
	R_M	N/mm²	-	-	440	590

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2, ISO9330-2/4 BS3604 A49-213 UNI 5462-64 DIN 17175/76	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	373	290	264	257
460	347	258	233	225
470	319	227	203	193
480	292	198	175	164
490	264	170	148	138
500	238	145	123	114
510	209	121	102	92
520	181	100	82	73
530	155	80	66	58
540	131	65	51	46
550	109	53	41	37
560	90	44	35	31
570	74	38	30	-
580	60	31	25	-
590	50	26	-	-
600	41	20	-	-

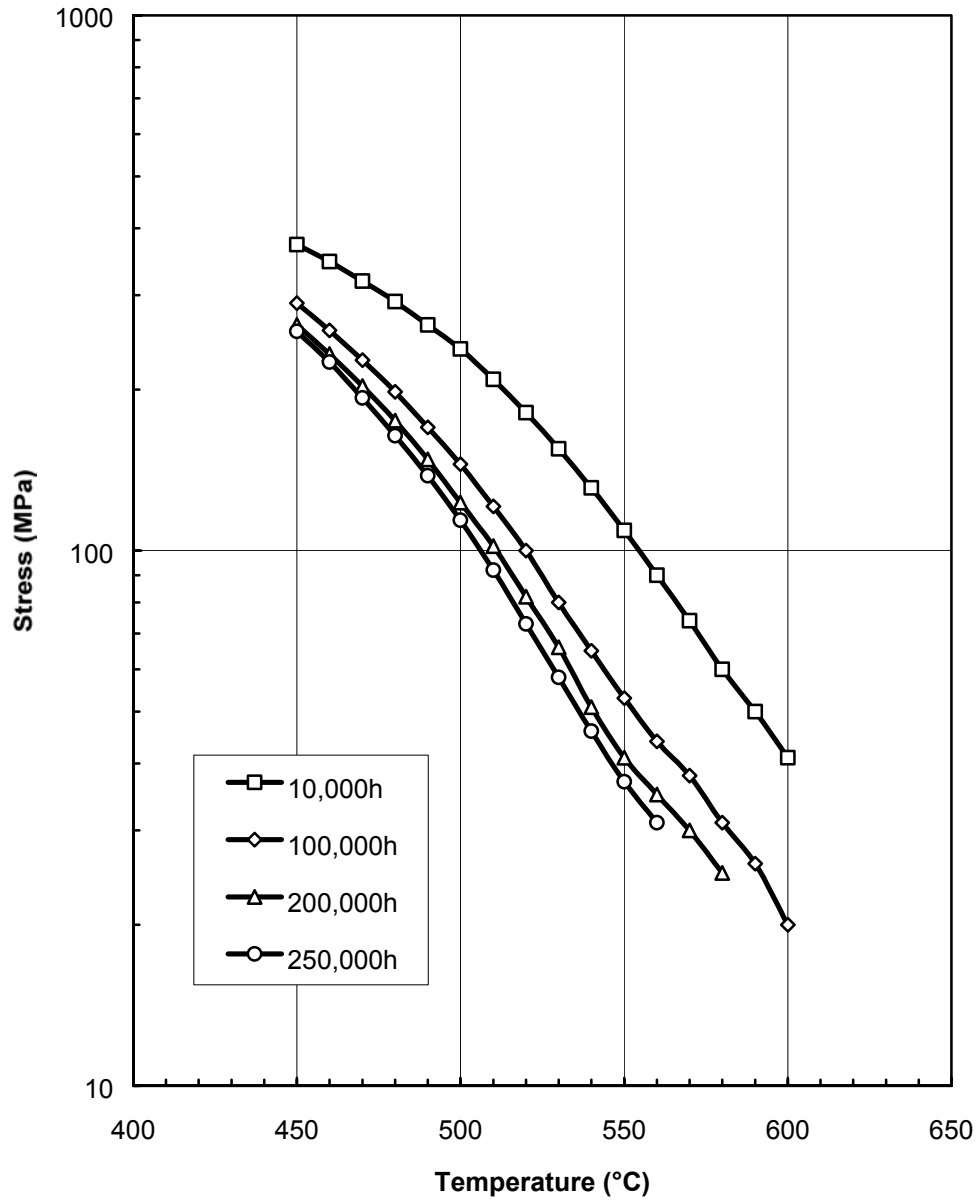
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 13CrMo4-5/5-5

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 25CrMo4

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.22	0.29
	Si	wt%	-	-	-	0.40
	Mn	wt%	-	-	0.60	0.90
	P	wt%	-	-	-	0.035
	S	wt%	-	-	-	0.030
	Cr	wt%	-	-	0.90	1.20
	Mo	wt%	-	-	0.15	0.30
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Harden / Solution	°C	-	-	860	900
	Temper	°C	-	-	620	680
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	345	-
	R_M	N/mm²	-	-	540	690

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17176	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
420	387	308		
430	364	281		
440	338	253		
450	311	226		
460	283	200		
470	255	178		
480	226	157		
490	200	136		
500	176	118		
510	153	100		
520	133	82		
530	114	66		
540	95	51		
550	79	36		

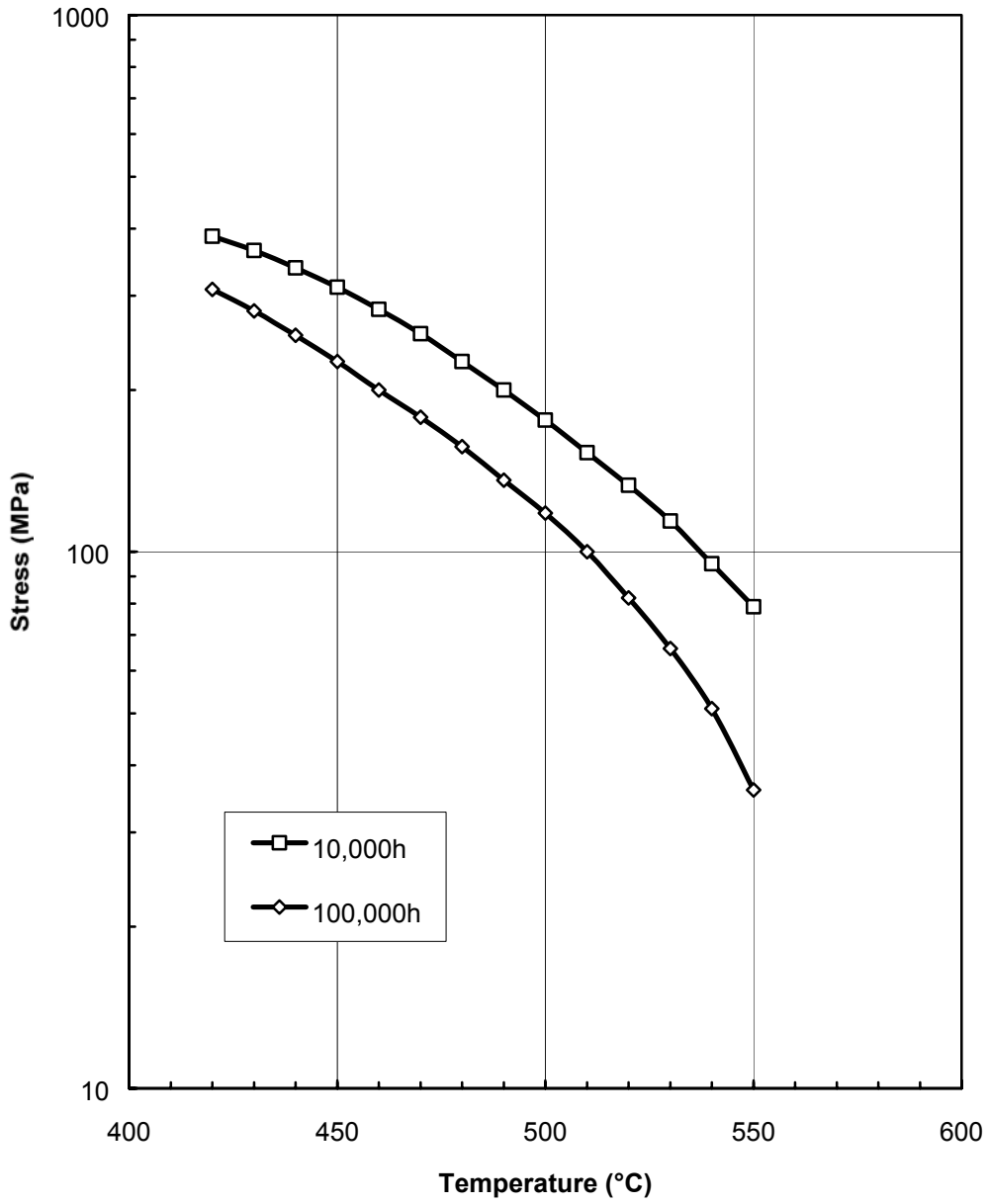
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 25CrMo4

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel 12CrMoV6-2-2

Working group: WG3.2
Year: 1996

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.09	0.17	0.10	0.15
	Si	wt%	0.12	0.34	0.15	0.35
	Mn	wt%	0.37	0.66	0.40	0.70
	P	wt%	0.006	0.031	-	0.030
	S	wt%	0.007	0.035	-	0.025
	Cr	wt%	0.30	0.55	0.30	0.60
	Mo	wt%	0.51	0.70	0.50	0.70
	Ni	wt%	0.00	0.22	-	-
	V	wt%	0.21	0.34	0.22	0.28
	Al	wt%	0.000	0.040	-	0.040
	N	wt%	0.0015	0.0160	-	-
Product	Form		Tube/Pipe			
	Outer diameter	mm	162	521	10.2	711
	Wall thickness	mm	19	89	1.6	100
	Form		Forging			
	Section size	mm	381	508		
	Form		Bar			
	Section size	mm	-	200		
Heat treatment	Normalize	°C	940	980	930	990
	Temper	°C	660	730	680	750
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	320	-
	R_M	N/mm²	-	-	470	610

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
475	6	12 (1)	4 (2)	1 (1)	2 (1)	1	2	3
500	9	22	7	3 (1)	6 (2)	1	2 (1)	(2)
520	1	1						
525	6	15	(1)	2 (1)	6		1	2
540	2	2						
550	39	96	16 (1)	13	8 (1)	4 (1)	5	(1)
560	2	2						
570	1	1						
575	35	86 (2)	21 (1)	2 (1)	3 (1)	5	3	
580	1	1						
600	37	69	33	9	4			
620	2	4						
640	2	4						
650	2	2						
660	2	4						
670	2	2						
680	1	1						
690	2	2						
700	2	2						
720	2	2						
740	1	1						
Totals	46	331 (3)	81 (5)	30 (4)	29 (5)	11 (1)	13 (1)	5 (3)

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	377	305	282	275
460	349	276	255	247
470	324	249	228	220
480	298	224	202	195
490	274	200	179	171
500	249	177	156	150
510	225	155	136	129
520	203	135	117	110
530	181	117	101	95
540	162	102	86	82
550	143	87	74	70
560	126	75	63	59
570	112	65	54	50
580	97	56	47	43
590	85	48	40	37
600	74	41	34	32

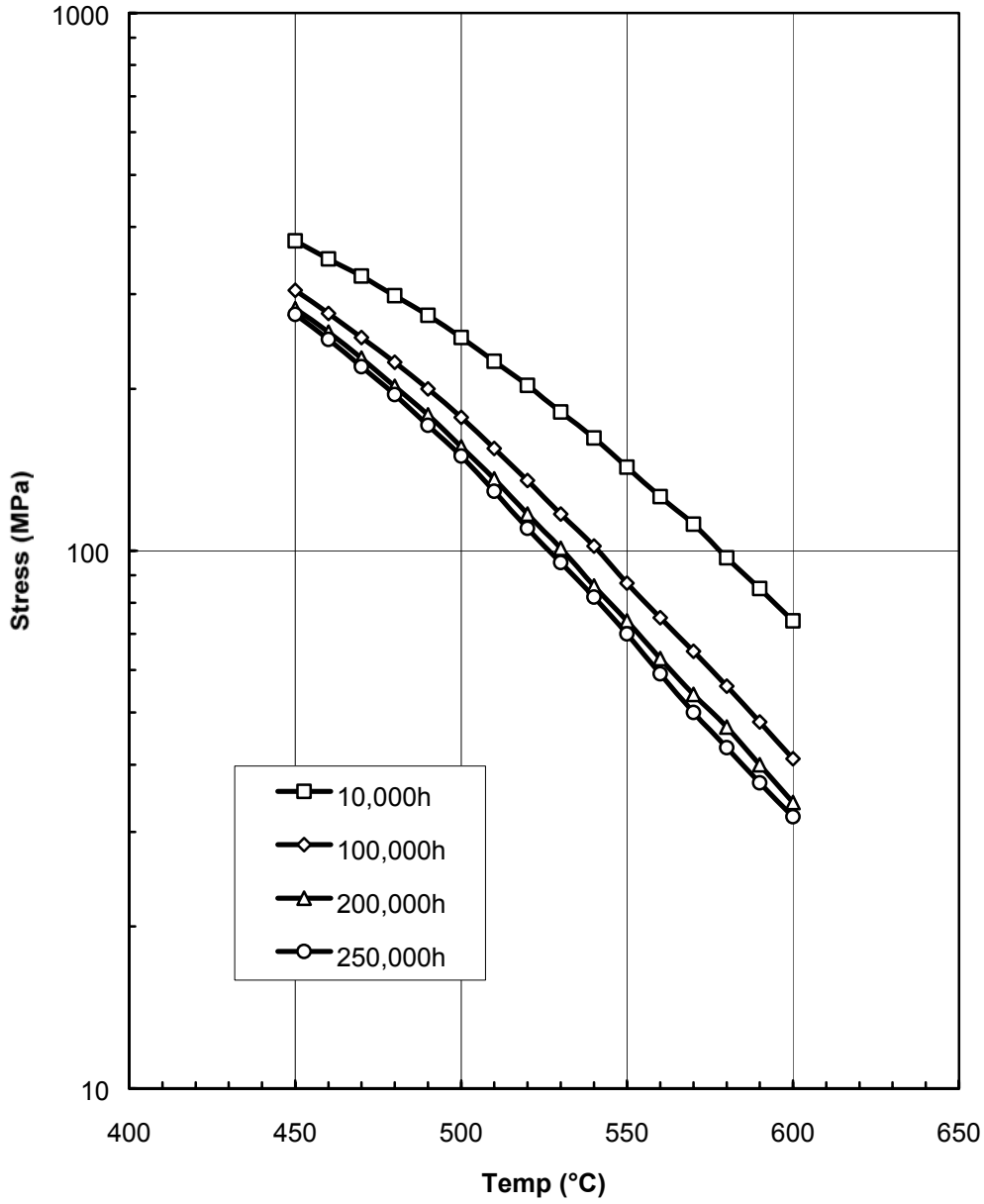
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3.2 Convenor

ECCC data sheet

Steel 12CrMoV6-2-2

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.2
Year: 1996



Master equation

The data were assessed using the Minimum-Commitment parameter, and the following master curve was derived:

$P(\sigma) = \ln (t_r^*) - a - e\,T - f/T = b \log \sigma_0 + c\,\sigma_0 + d\,\sigma_0^2$

Where $P(\sigma)$ is the creep rupture parameter, t_r^* is the predicted rupture time in hours, T is the absolute temperature, σ_0 is the stress in N/mm^2, and a, b, c, d, e and f are constants.
a = -39.7658730, b = -8.43513298, c = -0.00186616660, d = -2.91037377E-05, e = 0.00935613085 and f = 49662.4102

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 11CrMo9-10+NT

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.15	0.40
	Mn	wt%	-	-	0.30	0.70
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	2.00	2.50
	Mo	wt%	-	-	0.90	1.20
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	900	960
	Temper	°C	-	-	680	750
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	280	-
	R_M	N/mm²	-	-	480	630

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2 ISO9330-4 BS3604 A49-213/15 UNI 5462-64 DIN 17175/76	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	308	229	204	196
460	284	212	188	180
470	261	194	172	165
480	238	177	156	150
490	216	160	140	134
500	195	141	124	118
510	176	124	108	103
520	158	108	94	88
530	142	95	80	76
540	126	81	68	64
550	111	70	57	54
560	99	61	49	46
570	88	53	43	40
580	78	46	38	34
590	69	40	33	30
600	60	35	28	26

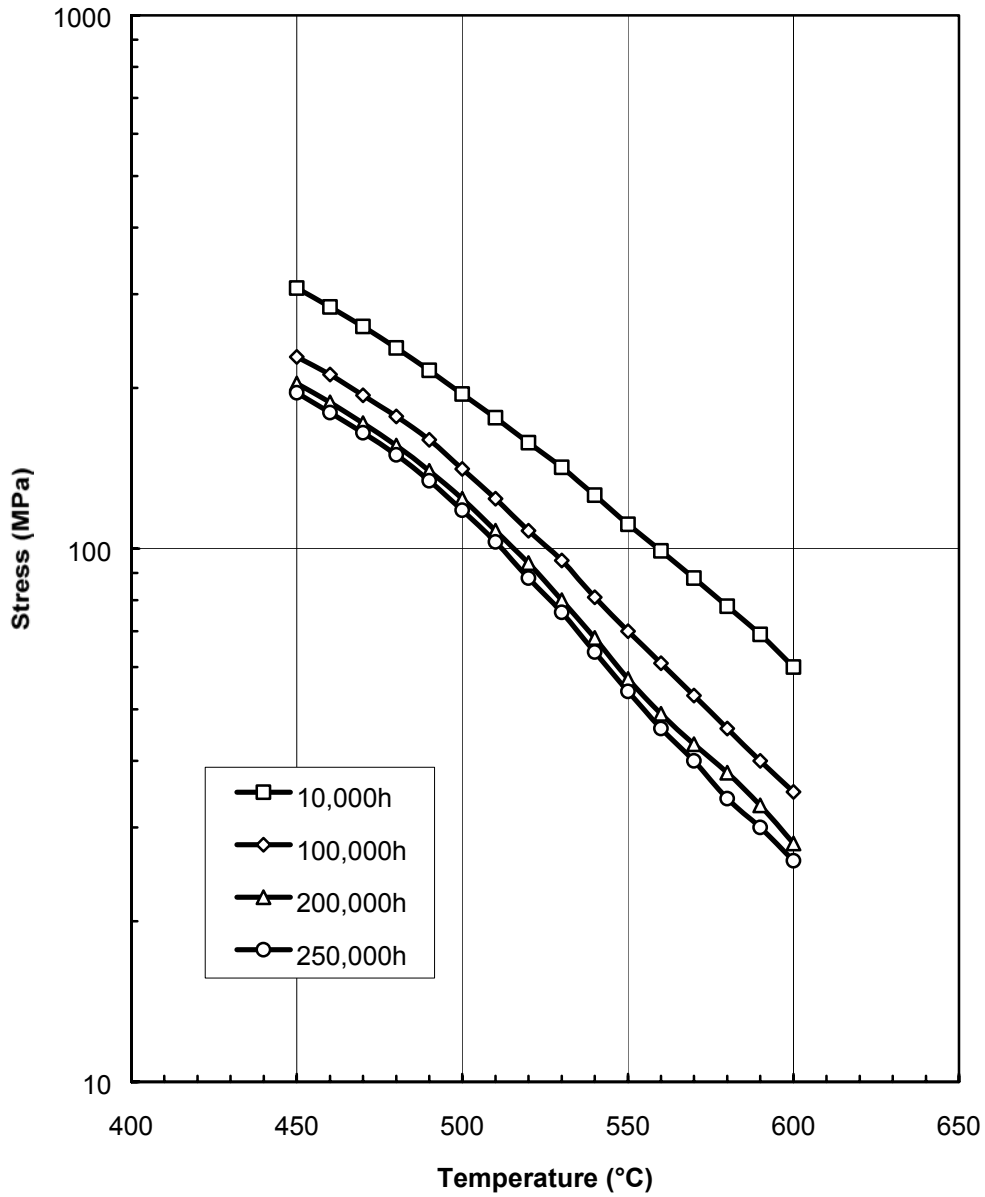
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 11CrMo9-10+NT

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 11CrMo9-10+QT

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.15	0.40
	Mn	wt%	-	-	0.30	0.70
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	2.00	2.50
	Mo	wt%	-	-	0.90	1.20
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Harden / Solution	°C	-	-	960	1000
	Temper	°C	-	-	710	780
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	355	-
	R_M	N/mm²	-	-	540	620

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17176	-

Description of method used to assess data

-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
400	382	313		
410	355	289		
420	333	272		
430	312	255		
440	294	238		
450	276	221		
460	259	204		
470	242	187		
480	225	170		
490	208	153		
500	191	137		
510	174	122		
520	157	107		

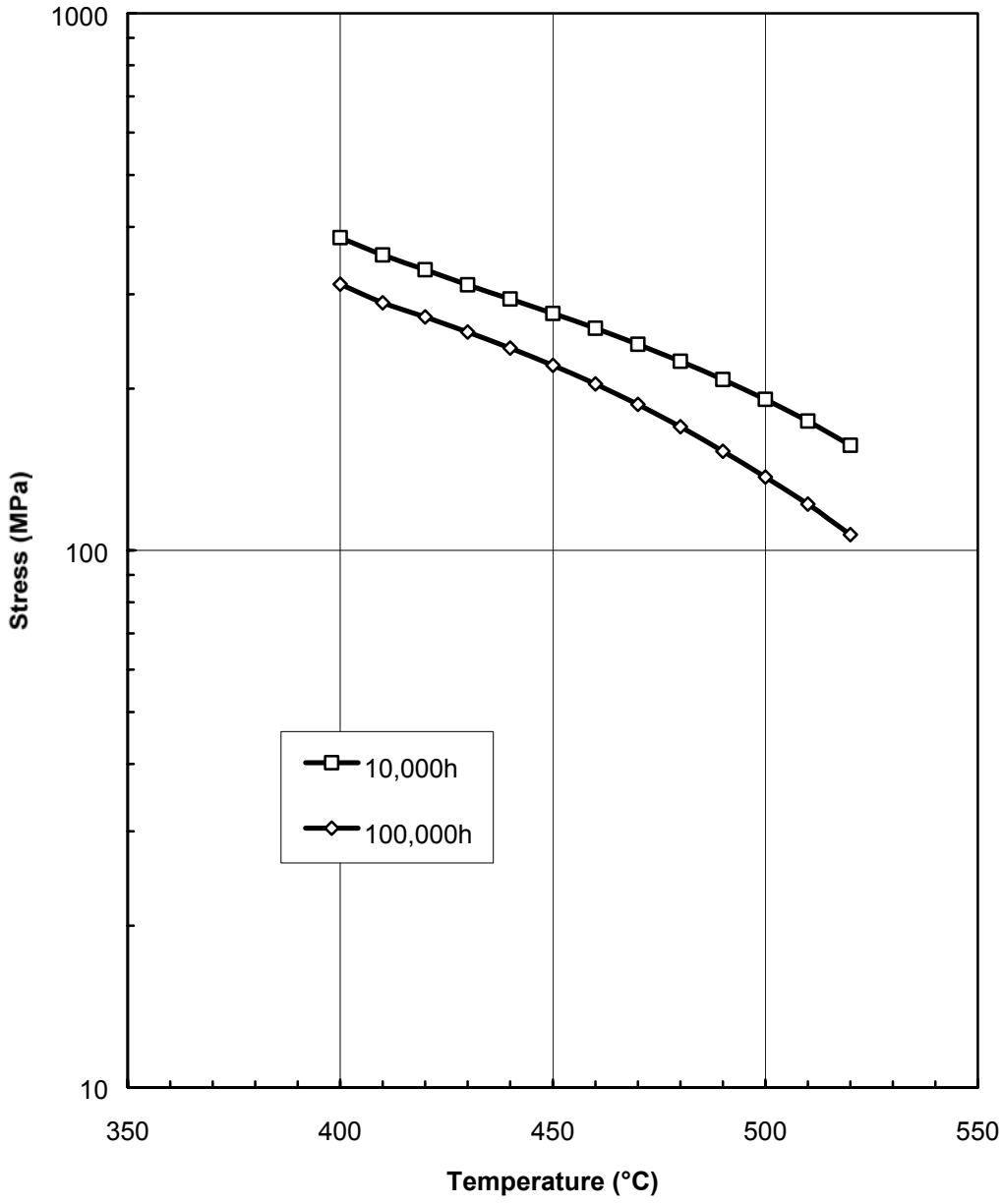
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 11CrMo9-10+QT

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 20CrMoV13-5

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.17	0.23
	Si	wt%	-	-	0.15	0.35
	Mn	wt%	-	-	0.30	0.50
	P	wt%	-	-	-	0.020
	S	wt%	-	-	-	0.020
	Cr	wt%	-	-	3.00	3.30
	Mo	wt%	-	-	0.50	0.60
	V	wt%	-	-	0.45	0.55
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Harden / Solution	°C	-	-	890	1030
	Temper	°C	-	-	680	730
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	590	-
	R_M	N/mm²	-	-	740	880

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17176	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
420	470	420		
430	440	370		
440	410	310		
450	360	260		
460	310	220		
470	270	190		
480	240	165		
490	210	145		
500	186	127		
510	169	114		
520	152	101		
530	134	87		
540	117	74		
550	98	59		

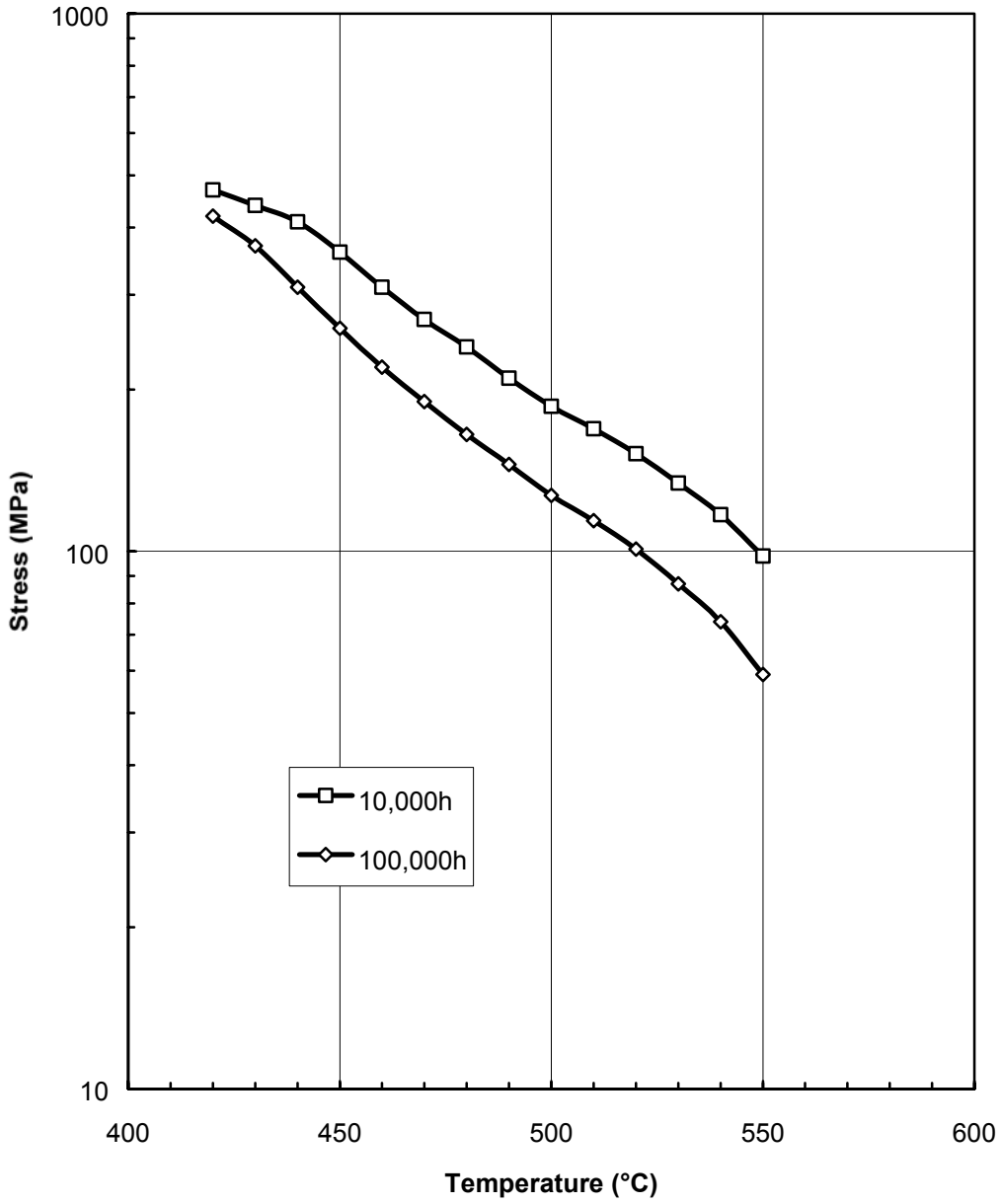
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 20CrMoV13-5

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel X11CrMo5+I

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.15	0.50
	Mn	wt%	-	-	0.30	0.60
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	4.00	6.00
	Mo	wt%	-	-	0.45	0.65
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Anneal	°C	-	-	890	950
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	175	-
	R_M	N/mm²	-	-	430	580

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2 BS3604 A49-213 DIN 17176	-

Description of method used to assess data
Averaging and graphical assessment of rupture strength values in national and international standards.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	196	147	130	126
460	180	133	118	114
470	166	119	107	102
480	152	108	96	90
490	140	98	86	81
500	128	89	76	72
510	116	79	67	63
520	105	69	58	55
530	95	62	52	49
540	85	55	46	43
550	77	49	41	38
560	69	44	36	34
570	63	38	31	29
580	56	34	27	25
590	50	30	24	-
600	45	26	22	-
610	41	24	-	-
620	37	-	-	-
630	33	-	-	-

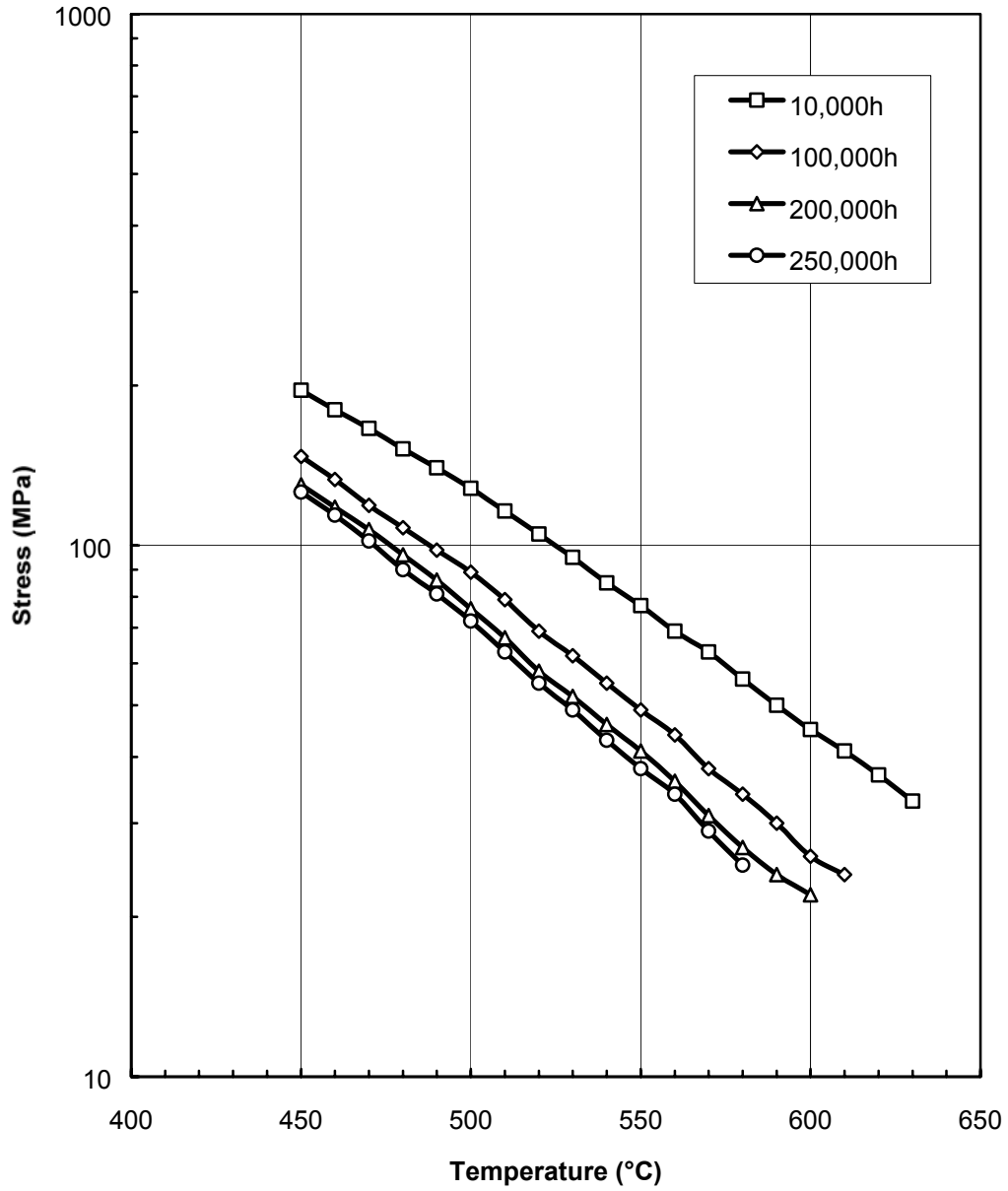
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel X11CrMo5+I

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel X11CrMo5+NT1, +NT2

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.15	0.50
	Mn	wt%	-	-	0.30	0.60
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	4.00	6.00
	Mo	wt%	-	-	0.45	0.65
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment (NT1)	Normalise	°C	-	-	900	960
	Temper	°C	-	-	710	760
Heat treatment (NT2)	Normalise	°C	-	-	930	980
	Temper	°C	-	-	710	760
Tensile Properties (NT1)	$R_{P,0.2}$	N/mm²	-	-	280	-
	R_M	N/mm²	-	-	480	640
Tensile Properties (NT2)	$R_{P,0.2}$	N/mm²	-	-	390	-
	R_M	N/mm²	-	-	570	740

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	-	270	237	226
460	-	225	202	189
470	242	188	170	159
480	215	157	141	131
490	188	131	116	108
500	164	113	96	90
510	145	96	80	75
520	128	82	68	64
530	113	70	58	54
540	100	60	48	45
550	88	50	40	37
560	78	-	-	-
570	69	-	-	-
580	60	-	-	-
590	53	-	-	-
600	46	-	-	-

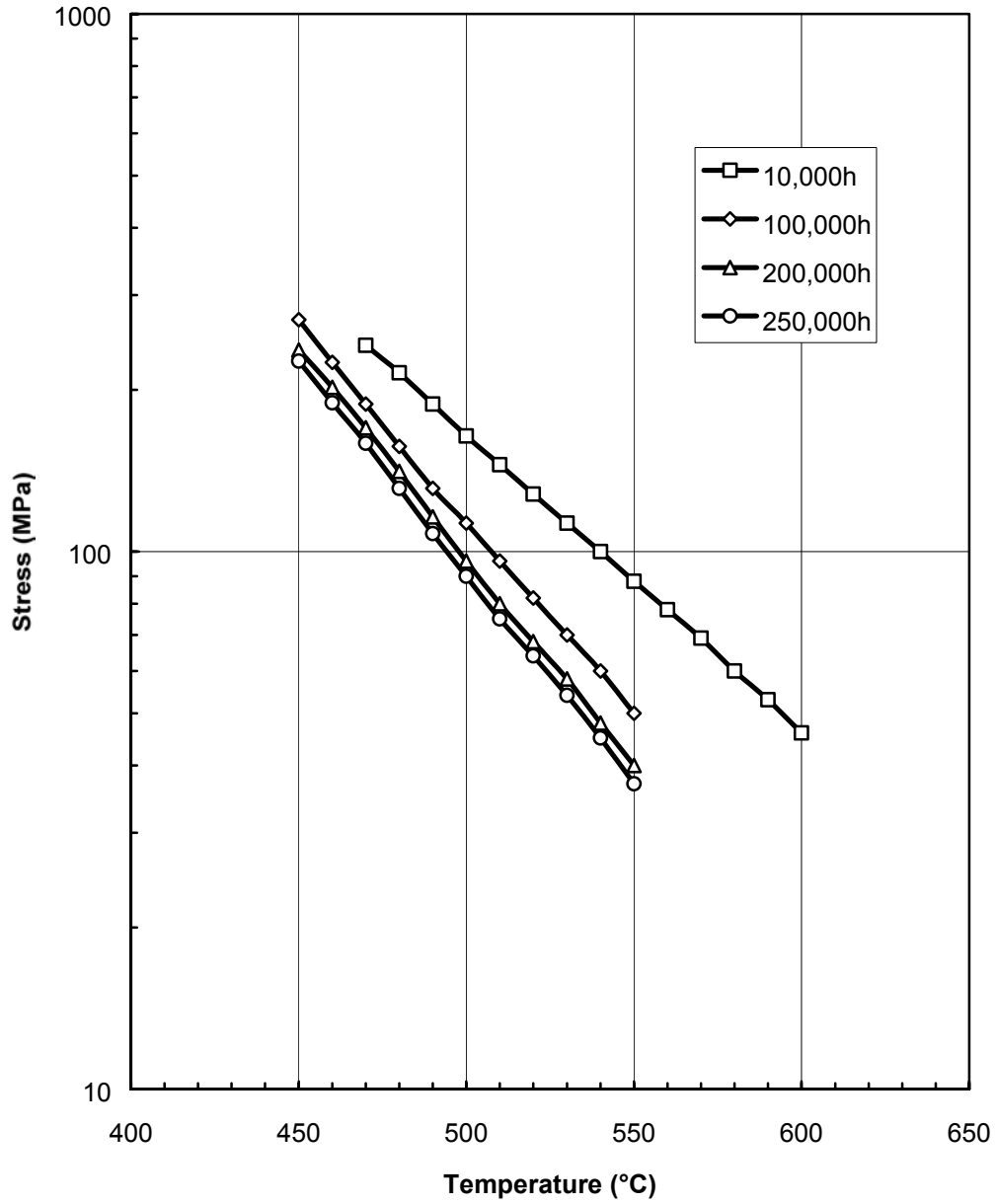
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3.2 Convenor

ECCC data sheet

Steel X11CrMo5+NT1, +NT2

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel 9NiMoCuNb5-6-4

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.17
	Si	wt%	-	-	0.25	0.50
	Mn	wt%	-	-	0.80	1.20
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	-	0.30
	Mo	wt%	-	-	0.25	0.50
	Ni	wt%	-	-	1.00	1.30
	Nb	wt%	-	-	0.015	0.045
	Al	wt%	-	-	-	0.050
	Cu	wt%	-	-	0.50	0.80
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	880	980
	Temper	°C	-	-	580	680
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	440	-
	R_M	N/mm²	-	-	610	780

Source references of analysed data used in assessment

Source references	Scope of data
VdTüV data sheet 377/2	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
400	402	373		
410	385	349		
420	368	325		
430	348	300		
440	328	273		
450	304	245		
460	274	210		
470	242	175		
480	212	139		
490	179	104		
500	147	69		

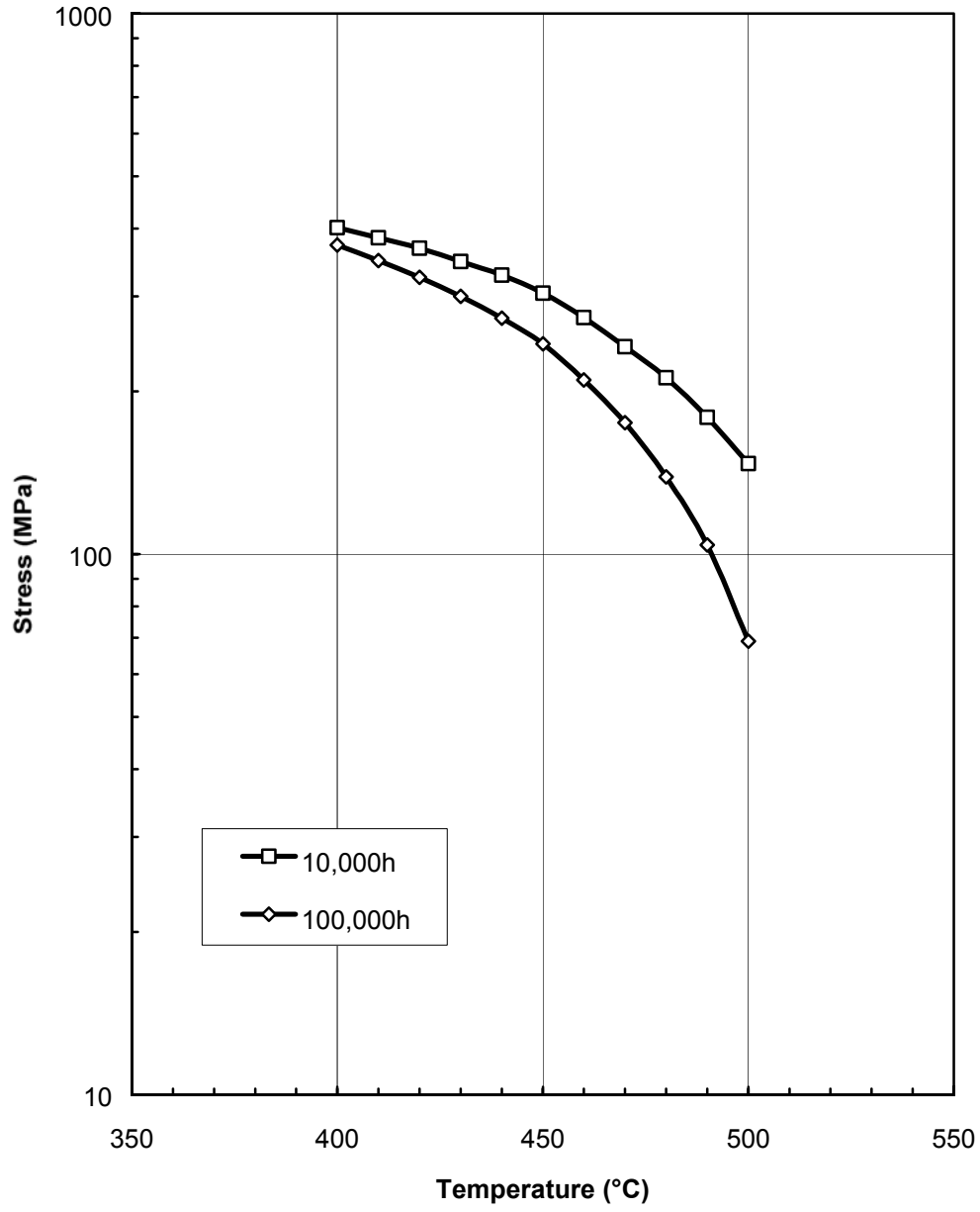
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel 9NiMoCuNb5-6-4

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel X11CrMo9-1+I1

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.25	1.00
	Mn	wt%	-	-	0.30	0.60
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	8.00	10.00
	Mo	wt%	-	-	0.90	1.10
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Anneal	°C	-	-	890	950
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	185	-
	R_M	N/mm²	-	-	410	620

Source references of analysed data used in assessment

Source references	Scope of data
ISO9329-2 BS3604	-

Description of method used to assess data
Averaging.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	
°C	N/mm²	N/mm²	N/mm²	
450	278	229*	214*	
460	250	203*	188*	
470	226	179*	164*	
480	203	157*	143*	
490	182	138*	124*	
500	163	120*	107*	
510	145	104*	92*	
520	129	90*	80*	
530	114	79*	70*	
540	101	69*	61*	
550	89	61*	54*	
560	79	55*	48*	
570	71	49*	43*	
580	63	44*	38*	
590	57	39*	-	
600	52	(34)*	-	
610	47	-	-	
620	43	-	-	
630	39	-	-	
640	35	-	-	

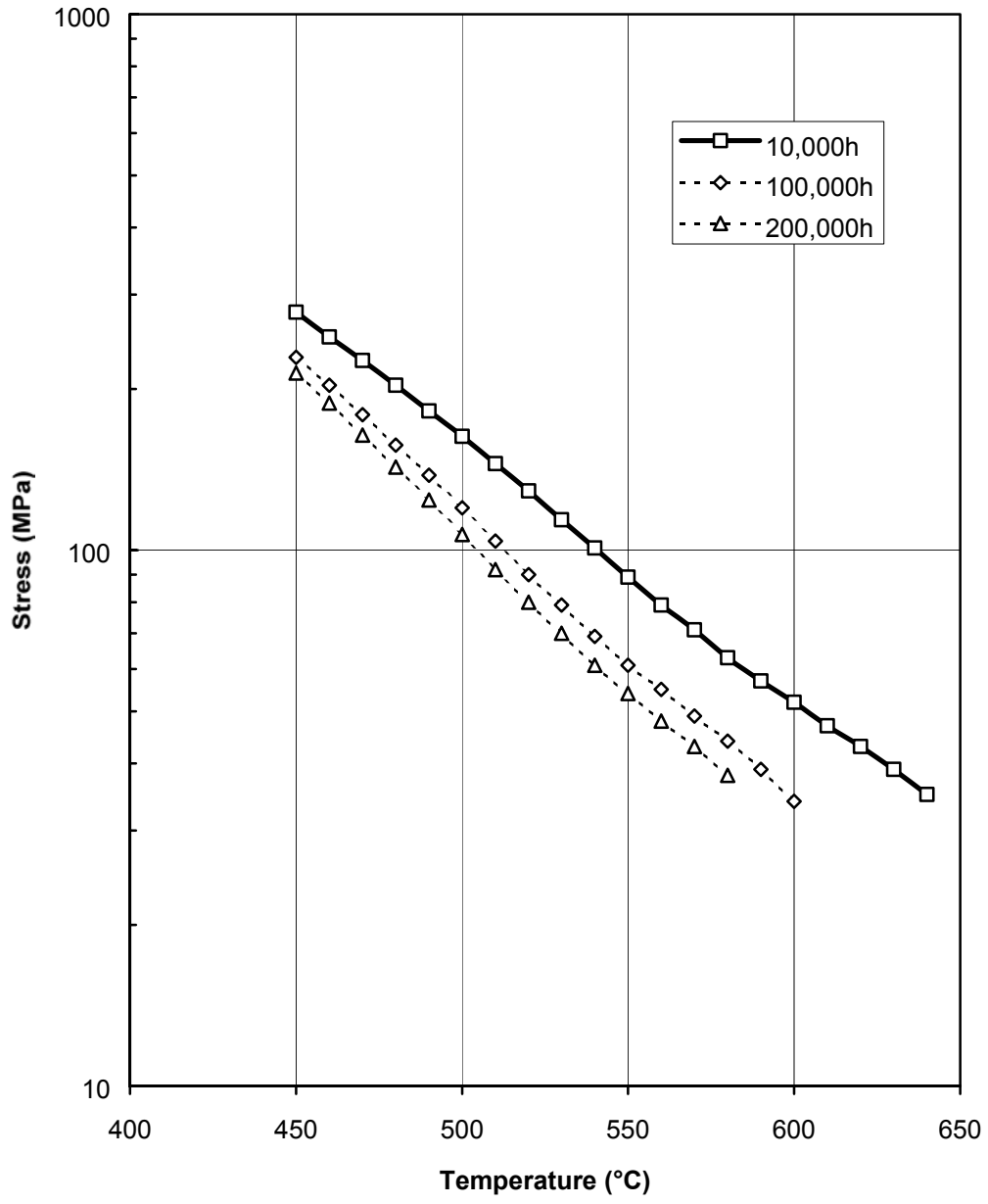
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3.2 Convenor

ECCC data sheet

Steel X11CrMo9-1+I1

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel X11CrMo9-1+I2

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.25	1.00
	Mn	wt%	-	-	0.30	0.60
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	8.00	10.00
	Mo	wt%	-	-	0.90	1.10
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Anneal	°C	-	-	950	980
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	210	-
	R_M	N/mm²	-	-	460	640

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17176	-

Description of method used to assess data
-

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h		
°C	N/mm²	N/mm²		
460	275	190		
470	240	170		
480	210	150		
490	190	130		
500	170	115		
510	152	102		
520	134	89		
530	118	78		
540	104	67		
550	90	58		
560	78	49		
570	68	42		
580	60	37		
590	53	33		
600	48	30		

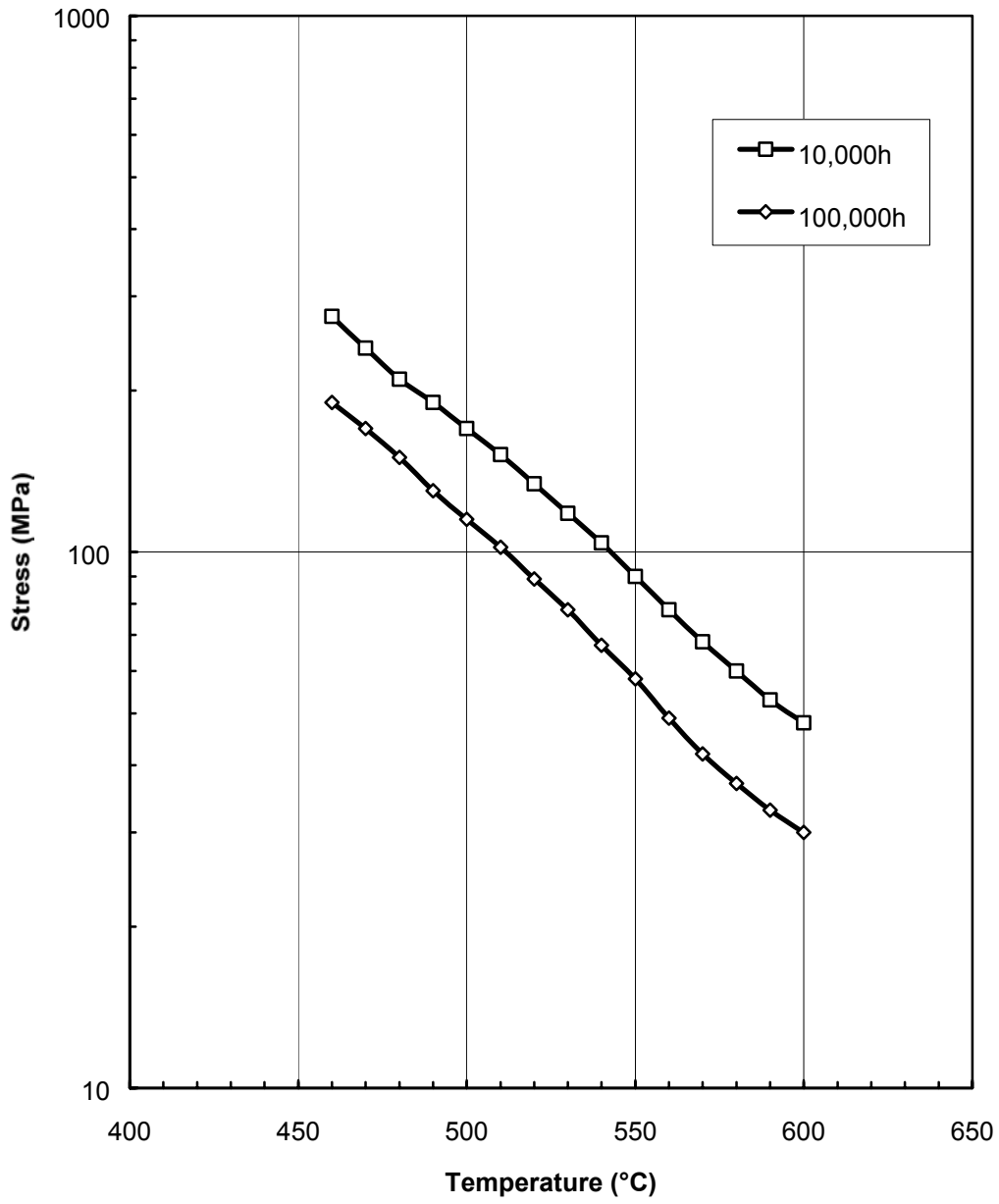
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel X11CrMo9-1+I2

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996

Steel X11CrMo9-1+NT

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.08	0.15
	Si	wt%	-	-	0.25	1.00
	Mn	wt%	-	-	0.30	0.60
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	8.00	10.00
	Mo	wt%	-	-	0.90	1.10
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	890	950
	Temper	°C	-	-	720	800
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	390	-
	R_M	N/mm²	-	-	590	740

Source references of analysed data used in assessment

Source references	Scope of data
BS3604 Part I (1990) VdTüV Werkstoffblatt 109 (03.95)	-

Description of method used to assess data
Averaging of the rupture strength values for steel type 9%Cr-1%Mo (normalized and tempered) in BS3604 and steel type X12 CrMo 9-1 V in the VdTüV data sheet.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	
°C	N/mm²	N/mm²	N/mm²	
450	335	276	259	
460	308	253	236	
470	284	231	215	
480	261	211	196	
490	239	192	177	
500	219	174	160	
510	200	156	142	
520	182	139	126	
530	164	123	111	
540	148	107	95	
550	132	92	80	
560	117	78	67	
570	102	66	55	
580	89	55	45	
590	77	45	37	
600	65	37	32	
610	55	31	27	
620	47	27	24	
630	40	24	-	
640	34	21	-	
650	30	-	-	

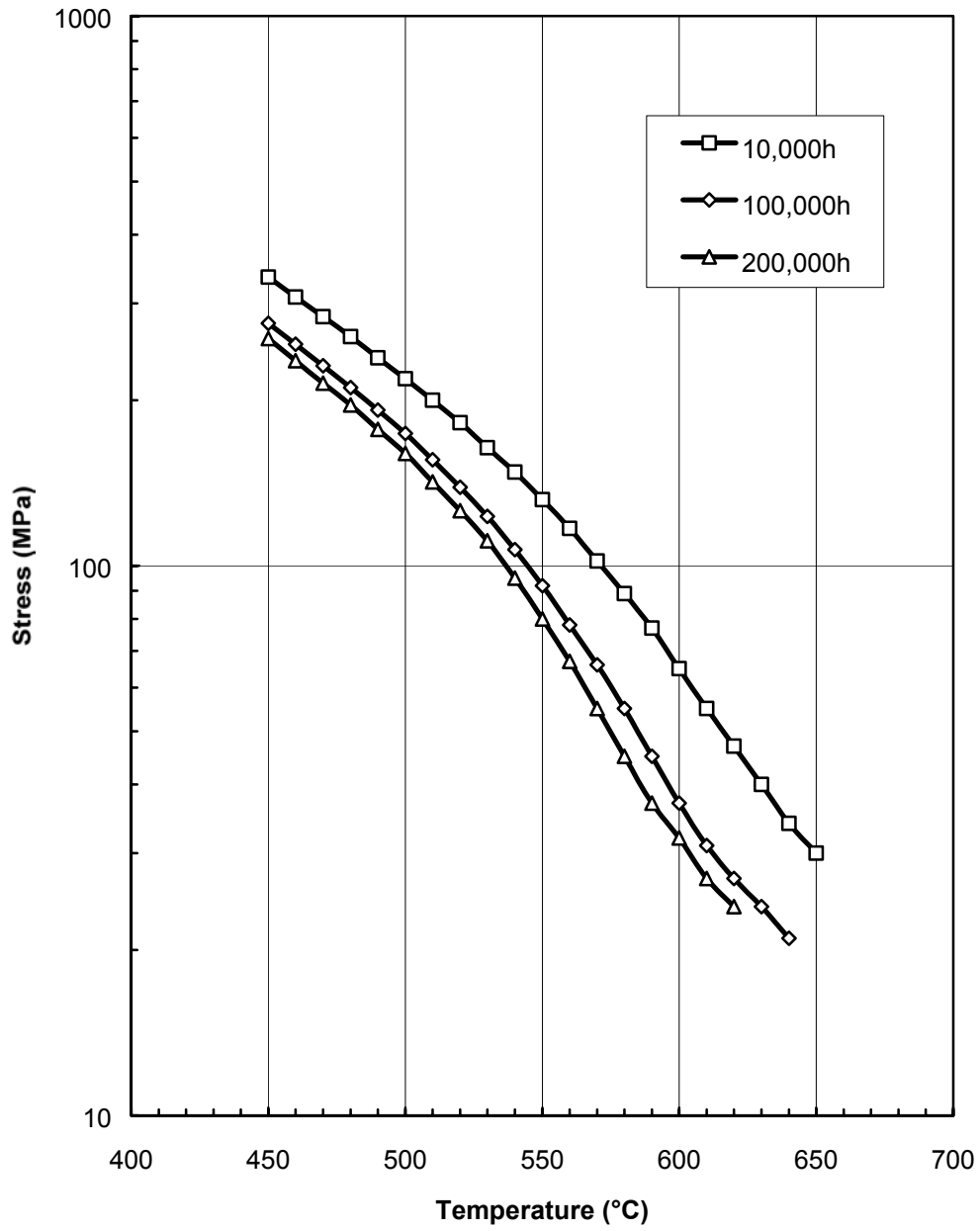
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3.2 Convenor

ECCC data sheet

Steel X11CrMo9-1+NT

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.2
Year: 1996



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X10CrMoVNb9-1

Working group: WG3.2
Year: 1995

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.08	0.12	0.08	0.12
	Si	wt%	0.11	0.49	0.20	0.50
	Mn	wt%	0.31	0.59	0.30	0.60
	P	wt%	0.001	0.024	-	0.020
	S	wt%	0.0008	0.010	-	0.010
	Cr	wt%	8.05	9.45	8.00	9.50
	Mo	wt%	0.85	1.09	0.85	1.05
	Ni	wt%	0.01	0.37	-	0.40
	V	wt%	0.18	0.25	0.18	0.25
	Nb	wt%	0.05	0.10	0.06	0.10
	Al	wt%	0.001	0.035	-	0.040
	N	wt%	0.030	0.069	0.030	0.070
Product	Form		Tube/Pipe			
	Outer diameter	mm	13.5	600	10.2	711
	Wall thickness	mm	2	198	1.6	100
	Form		Plate			
	Section size	mm	12.7	430		
	Form		Forging			
	Section size	mm	254	300		
	Form		Bar			
	Section size	mm	20	295		
Heat treatment	Normalize	°C	1038	1090	1040	1090
	Temper	°C	730	800	730	780
Tensile Properties	$R_{P,0.2}$	N/mm²	473	767	450	-
	R_M	N/mm²	648	813	630	830

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
500	27	66 (6)	6 (4)	2		1 (3)	(2)	
525	8	6 (3)	1	1 (2)		1 (2)	(2)	
538/540	12	18	4	(2)	(1)	(5)	1 (1)	
550	69	194 (12)	31 (3)	20 (4)	7 (3)	1 (1)	1	
575	32	68 (1)	12 (2)	1				
593	15	39 (1)	9	3	3 (1)		(1)	
600	104	405 (17)	57 (2)	13 (8)	10 (6)	4 (5)	(1)	
625	24	64 (1)	1 (1)					
649/650	93	334 (9)	35 (4)	11 (2)	3	2		
675/677	17	32		1				
700	16	34	3					
Totals	141	1260 (50)	159 (16)	52 (18)	23 (11)	9 (16)	2 (7)	

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
500	289	273	258*	246*
510	271	255	239*	227*
520	252	236	220*	208*
530	234	218	201	189*
540	216	200	183	171*
550	199	183	166	154*
560	182	166	150	139*
570	166	150	134	124*
580	151	136	120	110*
590	136	122	106	97*
600	123	108	94	86*
610	110	97	83	75*
620	99	86	73	65*
630	89	77	65	57*
640	79	68	56	49*
650	70	59	49	42*
660	62	52	42	35*
670	55	45	36	-

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

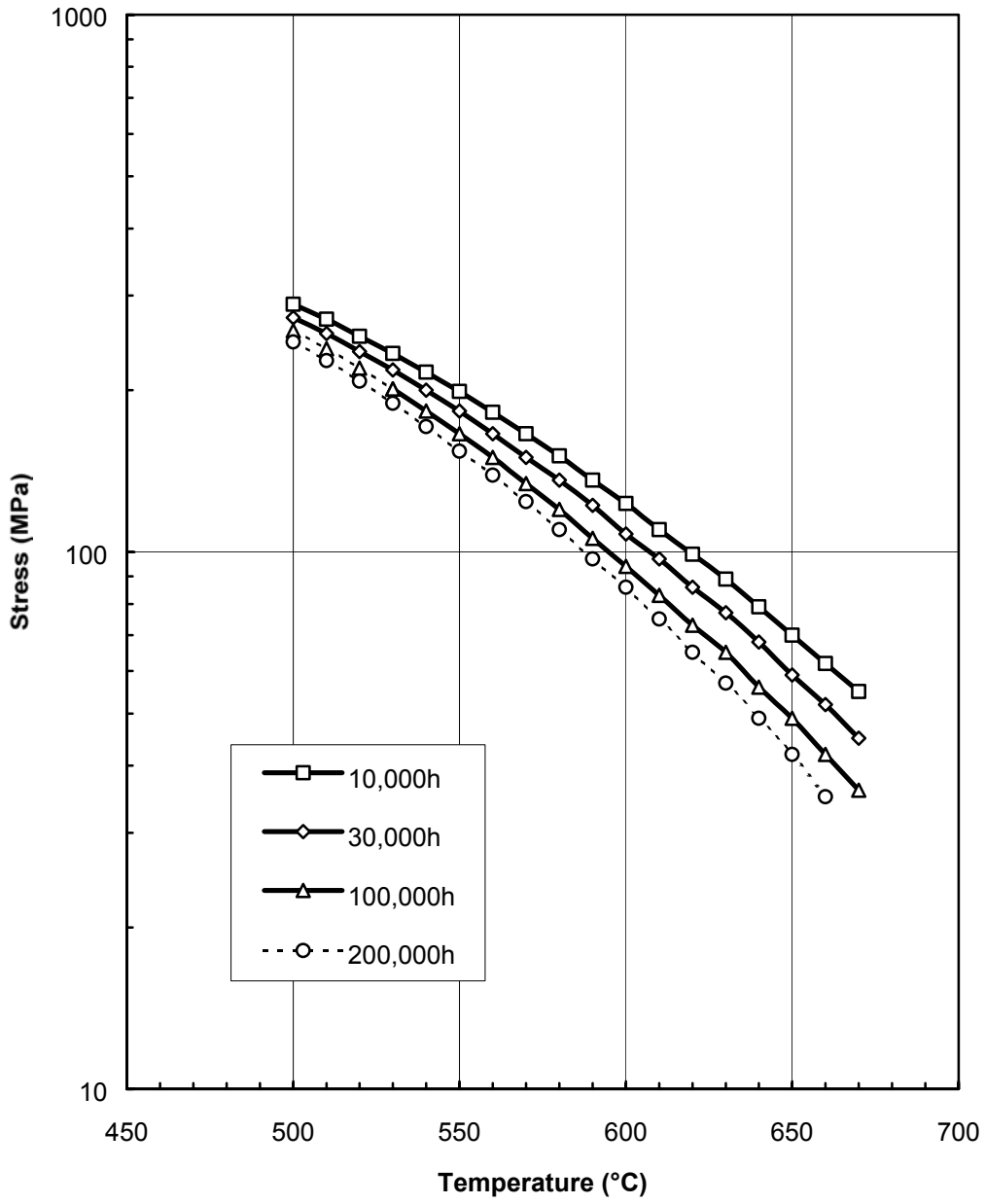
Signed: WG3.2 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X10CrMoVNb9-1

Working group: WG3.2
Year: 1995



Master equation

Not applicable. The rupture strength values are the average of the results of two different assessments of the same database. One assessment was performed using the ISO 6303 procedure and the other was carried out using the German graphical cross-plotting and averaging technique. The two sets of assessment results were very similar.

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Cast Steel-91 (GX12CrMoVNbN9-1)

Working group: WG3A
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.090	0.140	0.10	0.14
	Si	wt%	0.230	0.310	0.20	0.50
	Mn	wt%	0.490	0.600	0.30	0.80
	P	wt%	0.004	0.016	-	0.020
	S	wt%	0.001	0.006	-	0.010
	Cr	wt%	8.300	9.360	8.00	9.50
	Mo	wt%	0.870	0.950	0.85	1.05
	Ni	wt%	0.120	0.390	-	0.40
	V	wt%	0.190	0.230	0.18	0.25
	Nb	wt%	0.062	0.089	0.06	0.10
	N	wt%	0.044	0.055	0.030	0.070
	Al	wt%	0.004	0.016	-	0.020
	N/Al		3.06	13.75		
Product	Form					
	Section size	mm				
Heat treatment	Harden / Solution	°C	1040	1060	1040	1070
	Temper / Age 1	°C	730	760	730	760
	Temper / Age 2	°C	730	750		
Tensile Properties	$R_{p0.2}$	N/mm²	460	573		
	R_m	N/mm²	630	708		

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
500	2	5	2	1	1	(2)		
550	4	8	3	2	2	2(4)	1	
565	1	5	1					
580	1	5						
590	1	3						
600	9	27	6	2	5	2(10)		
610	1	3						
650	1	4		1				
Totals	9	60	12	6	8	4(16)	1	

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
470	(316)*	(299)*	280*	269*
480	(294)*	278*	260*	249*
490	274*	258*	240*	230*
500	255*	240*	223*	212*
510	238*	223*	206*	196*
520	223*	208*	190*	180*
530	207*	192*	175*	164*
540	193*	178*	160*	150*
550	179*	164*	146*	135*
560	166*	151*	132*	121*
570	153*	137*	119*	108*
580	140	124	106	96*
590	128	112	95	87*
600	116	101	86	79*
610	105	91		
620	95	83		

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

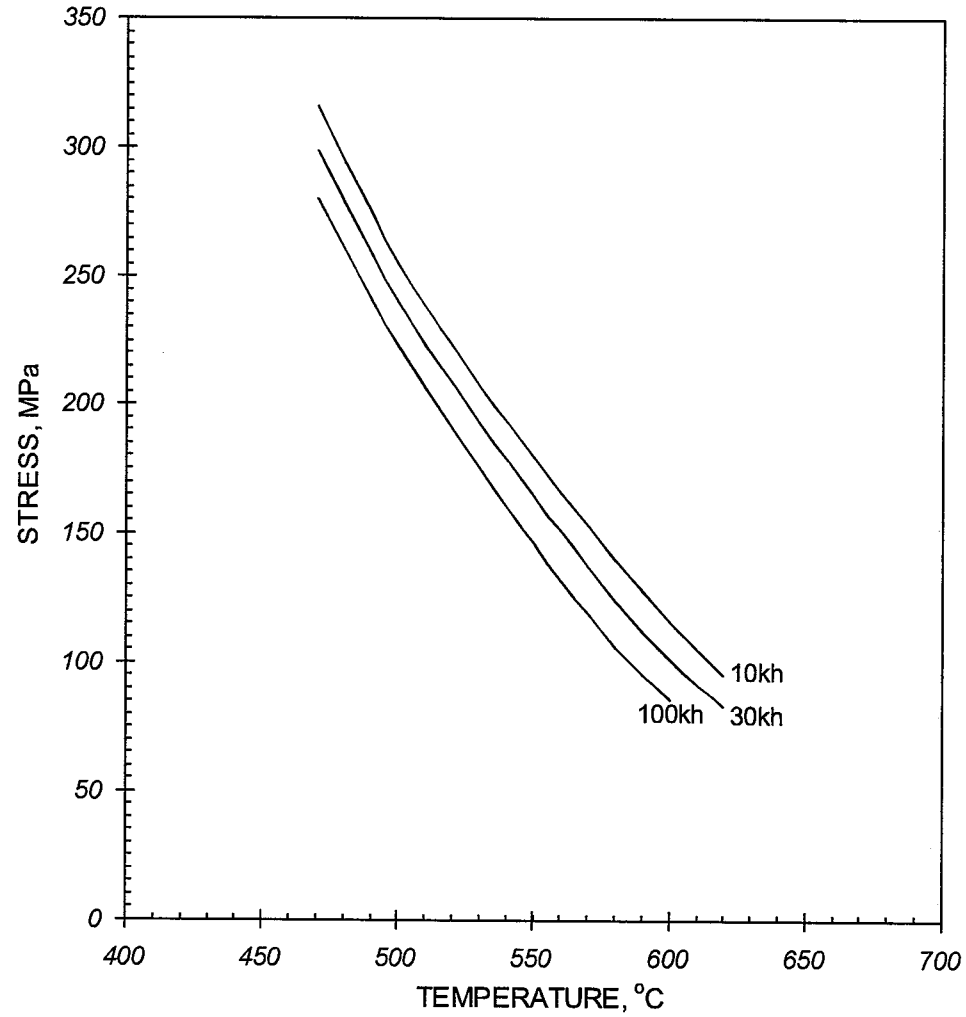
Signed: WG3A Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Cast Steel-91 (GX12CrMoVNbN9-1)

Working group: WG3A
Year: 2005



Master equation

The data were assessed using the BS PD6605 procedure, in which the Manson-Haferd model was selected

$t_u^* = \exp\{(\beta_0 + \beta_1.\log(\sigma_o) + \beta_2.\log(\sigma_o)^2 + \beta_3.\log(\sigma_o)^3).(T - T_0) + \beta_5\}$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2 and β_0, β_1, β_2, β_3, β_5 and T_0 are constants, i.e.
β_0 = 2.47219276, β_1 = -3.74460554, β_2 = 1.86186361, β_3 = -0.31367442, β_5 = 32.7190208 and T_0 = 590

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel E911 (X11CrMoWVNb9-1-1)

Working group: WG3A
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.105	0.120	0.09	0.13
	Si	wt%	0.130	0.250	0.10	0.50
	Mn	wt%	0.350	0.560	0.30	0.60
	P	wt%	0.007	0.018	-	0.020
	S	wt%	0.001	0.007	-	0.010
	Cr	wt%	8.610	9.160	8.50	9.50
	Mo	wt%	0.920	1.010	0.90	1.10
	Ni	wt%	0.210	0.290	0.10	0.40
	V	wt%	0.190	0.230	0.18	025
	W	wt%	0.950	1.000	0.90	1.10
	Nb	wt%	0.062	0.089	0.06	0.10
	N	wt%	0.065	0.084	0.050	0.090
	Al	wt%	0.003	0.013	-	0.040
	B	wt%	0.0004	0.0028	0.0005	0.0050
Product	Form		Tube/pipe			
	Section size	mm	44.5x7.1	490x70		
Heat treatment	Harden / Solution	°C	1060	1060		
	Temper / Age 1	°C	760	780		
	Temper / Age 2	°C				
Tensile Properties	$R_{p0.2}$	N/mm²			450	
	R_m	N/mm²			620	850

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
550	3	11	1	2		2	(1)	
575	8	23	4	4	2	2		
600	12	57	19	6	4	1(1)	1	
612	1	1	1					
620	3		2	1	1			
625	10	42(3)	7	2	1	1		
630	3	3						
635/7	3	6						
640/5	7	9	1					
650	11	57(7)	11	2(1)	2	2		
655-700	7	42						
Totals	12	251(10)	46	17(1)	10	8(1)	1(1)	
( ) Figures in parentheses denote unfailed tests								

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
520	252	237	220*	
530	237	222	204*	
540	222	207	188*	
550	208	192	173*	
560	194	178	157*	
570	180	163	142*	
580	166	148	126	113*
590	152	134	111	98*
600	139	119	98	86*
610	125	106	85	75*
620	111	93	75	65*
630	99	82	65	56*
640	88	73	56*	
650	78	64		
* Values which have involved extended time extrapolation				
( ) Values which have involved extended stress extrapolation				

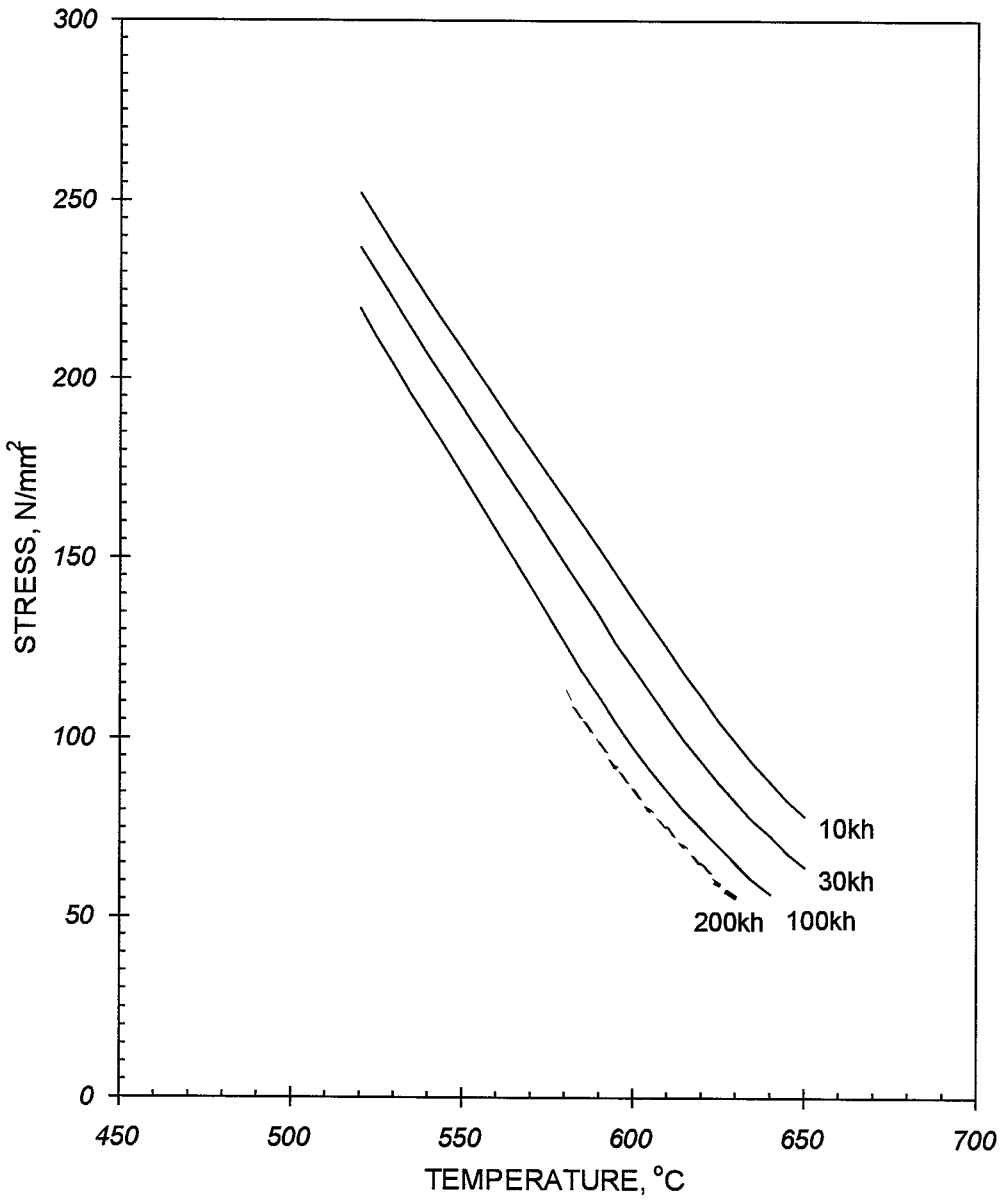
Signed: WG3A Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel E911 (X11CrMoWVNb9-1-1)

Working group: WG3A
Year: 2005



Master equation

The data were assessed using the ISO method to derive:

$$\log t_u^* = (a + b.\log(\sigma_o) + c.\log(\sigma_o)^2 + d.\log(\sigma_o)^3 + e.\log(\sigma_o)^4).(T - T_o) + f$$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2, and a, b, c, d, e, f and T_o are constants, i.e.
a = -2.4726, b = 5.1073, c = -3.9845, d = 1.3796, e = -0.17956, f = 13.3 and T_o = 613.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel ASTM Grade 92

Working group: WG3A
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.070	0.124	0.07	0.13
	Si	wt%	0.020	0.490	-	0.50
	Mn	wt%	0.330	0.510	0.30	0.60
	P	wt%	0.001	0.018	-	0.020
	S	wt%	0.001	0.006	-	0.010
	Cr	wt%	8.820	9.630	8.50	9.50
	Mo	wt%	0.360	0.520	0.30	0.60
	Ni	wt%	0.010	0.260	-	0.40
	V	wt%	0.160	0.210	0.15	0.25
	W	wt%	1.610	1.940	1.50	2.00
	Nb	wt%	0.034	0.076	0.040	0.090
	N	wt%	0.036	0.053	0.030	0.070
	Al	wt%	0.001	0.012	-	0.040
	B	wt%	0.001	0.006	0.001	0.006
Product	Form		Tube/pipe			
	Section size	mm	38	560		
	Wall thickness	mm	6	150		
	Form		Plate			
	Section size	mm	14	122		
Heat treatment	Normalise	°C	1040	1070	1040	
	Temper	°C	750	800	730	
Tensile Properties	$R_{p0.2}$	N/mm²	440	606	440	
	R_m	N/mm²	657	766	620	

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
550	17	79	3(1)	4		(2)		
575	6	9(1)	2(1)	1	2	(2)		(1)
600	41	177(6)	29	15(1)	13(3)	7(1)	2	1(1)
612/614	3	2(1)	2		(2)			
620	1	1	2					
625	15	33	9	2(1)	(1)	1		
630	3	6						
637/640	4	7(1)	1					
650	44	195(1)	23	14	13(2)	3		
655-700	20	141	4	1				
Totals	48	650(10)	73(2)	37(2)	28(8)	11(5)	2	1(2)

( ) Figures in parentheses denote unfailed tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
520	272*	255*	235*	
530	256	238	218*	
540	240	222	202*	
550	225	207	187*	
560	210	192	172*	
570	195	177	157*	
580	181	163	142	129*
590	167	148	127	115*
600	153	134	113	101*
610	139	121	100	88*
620	126	107	87	76*
630	113	95	75	65*
640	100	83	65	56*
650	88	72	56	48*

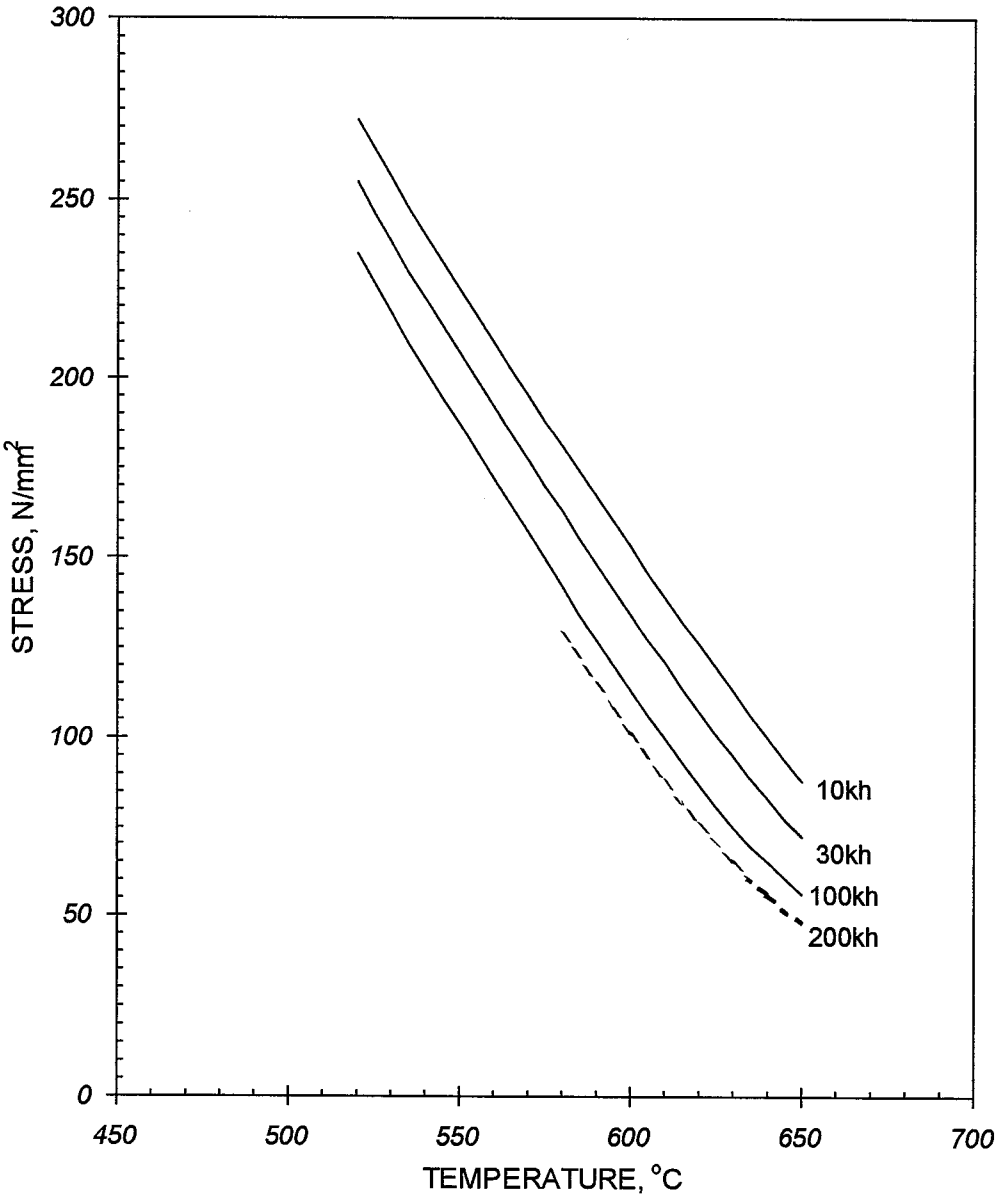
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3A Convenor

ECCC data sheet

Steel ASTM Grade 92

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3A
Year: 2005



Master equation

The data were assessed using the PD-6605 procedure to derive:

$$t_u^* = \exp\{(\beta_0 + \beta_1.\log(\sigma_o) + \beta_2.\log(\sigma_o)^2 + \beta_3.\log(\sigma_o)^3 + \beta_4.\log(\sigma_o)^4).(T - T_o) + \beta_5 \}$$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2, and β_0, β_1, β_2, β_3, β_4, β_5 and T_o are constants, i.e.
β_0 = -0.921890616, β_1 = 1.94211233, β_2 = -1.62884569, β_3 = 0.603966355, β_4 = -0.08465305, β_5 = 40.5120506 and T_o = 500.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3A
Year: 2004

Steel X20CrMoNiV11-1

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.17	0.23
	Si	wt%	-	-	0.15	0.50
	Mn	wt%	-	-	-	1.00
	P	wt%	-	-	-	0.030
	S	wt%	-	-	-	0.025
	Cr	wt%	-	-	10.00	12.50
	Mo	wt%	-	-	0.80	1.20
	Ni	wt%	-	-	0.30	0.80
	V	wt%	-	-	0.25	0.35
	Al	wt%	-	-	-	0.040
Product	Tube/Pipe					
	Outer diameter	mm	-	-	10.2	711
	Wall thickness	mm	-	-	1.6	100
Heat treatment	Normalize	°C	-	-	1020	1080
	Temper	°C	-	-	680	730
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	490	-
	R_M	N/mm²	-	-	690	840

Source references of analysed data used in assessment

Source references	Scope of data
BS PD6525 DIN 17175	-

Description of method used to assess data
Averaging of the rupture strength values for steel type 12%Cr-1%Mo-0.5%V in PD6525 and steel type X20 CrMoV 12-1 in DIN 17175.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h	
°C	N/mm²	N/mm²	N/mm²	
480	348	289	270	
490	319	263	242	
500	292	236	218	
510	269	212	194	
520	247	188	170	
530	225	167	149	
540	205	147	129	
550	184	128	112	
560	165	111	96	
570	147	95	81	
580	130	81	68	
590	113	69	58	
600	97	59	49	
610	84	51	42	
620	72	43	36	
630	61	36	30	
640	52	31	-	
650	44	26	-	

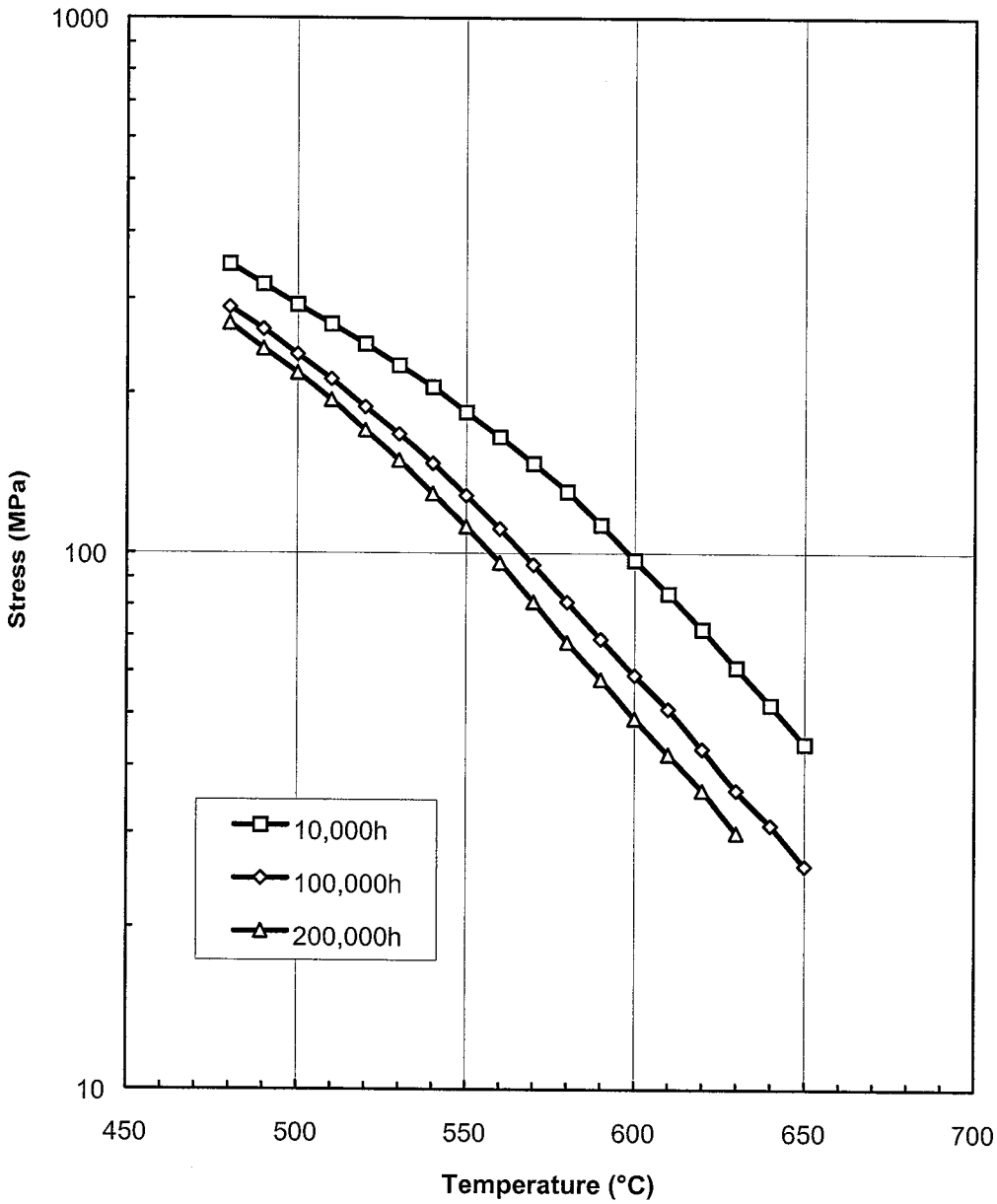
Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Signed: WG3A Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3A
Year: 2004

Steel X20CrMoNiV11-1



Master equation
Not applicable.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X2CrNi 18-9 (1.4307, Type 304L)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.030
	Si	wt%	-	-	-	1.0
	Mn	wt%	-	-	-	2.0
	P	wt%	-	-	-	0.045
	S	wt%	-	-	-	0.015
	Cr	wt%	-	-	17.5	19.5
	Ni	wt%	-	-	8.0	10.0
	N	wt%	-	-	-	0.11
Product	Form		-			
	Section size	mm	-	-	-	250
Heat treatment	Solution Anneal	°C	-	-	1000	1100
Tensile Properties at RT	$R_{P,0.2}$	N/mm²	-	-	175	-
	R_M	N/mm²	-	-	450	680

Source references of analysed data used in assessment

Source references	Scope of data			
SIMR report IM-2121, 1986, Swedish standard SS 14 23 52	Test Temps (°C)	550	600	700
	No. Data	14	26	12
Description of method used to assess data Not specified				

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h
°C	N/mm²	N/mm²
550	(156)	(92)
560	(138)	(85)
570	(124)	(78)
580	(113)	(72)
590	(104)	(65)
600	(97)	(59)
610	(90)	(54)
620	(83)	(49)
630	(76)	(45)
640	(70)	(40)
650	(64)	(36)
660	(59)	(32)
670	(54)	(28)
680	(49)	(25)
690	(43)	(21)
700	(38)	(18)
710	(34)	(16)
720	(30)	(15)

() Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Note
As a pragmatic approach to ensure safe design, the ECCC WG3.3 creep rupture strength values for Type 304L should not be used for heats that have carbon contents of less than 0.02 wt%. This lower limit is based on the minimum carbon content of the heats included in the creep rupture data assessment for these materials. It is intended to prevent the use of the ECCC creep strength values for heats that may exhibit low creep rupture strength.

Michael Spindler

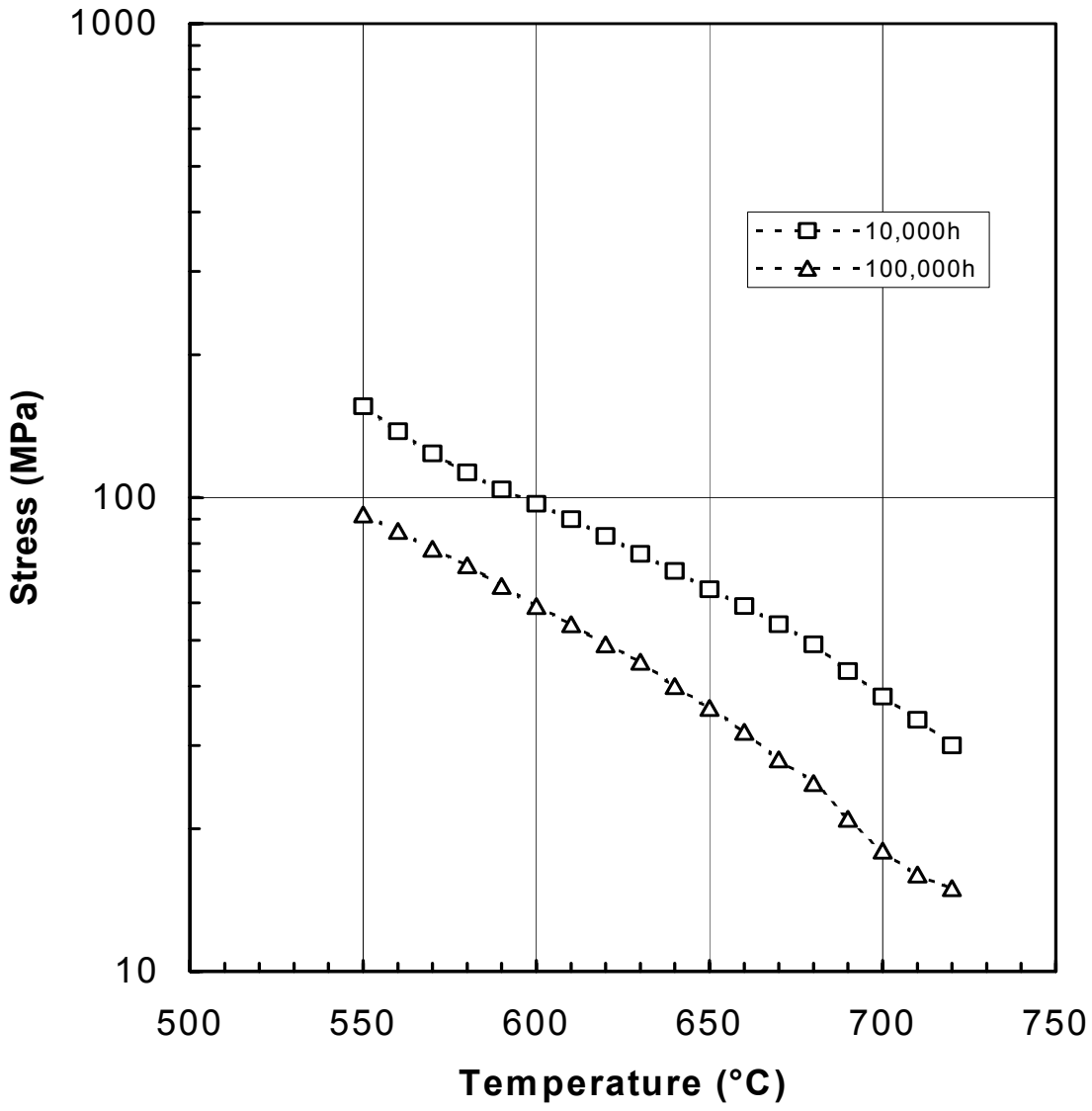
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X2CrNi 18-9 (1.4307, Type 304L)

Working group: WG3.3
Year: 1999



Master equation
Unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X2CrNiN 18-10 (1.4311, Type 304 LN)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.019	0.026	-	0.030
	Si	wt%	0.43	0.51	-	1.00
	Mn	wt%	0.81	1.83	-	2.00
	P	wt%	0.009	0.01	-	0.045
	S	wt%	0.018	0.01	-	0.015
	Cr	wt%	18.0	18.9	17.0	19.5
	Ni	wt%	8.7	11.2	8.5	11.5
	N	wt%	0.145	0.192	0.12	0.22
Product	Form		-			
	Section size	mm	-	-	-	250
Heat treatment	Solution Anneal	°C	-	-	1000	11000
Tensile Properties at RT	$R_{P,0.2}$	N/mm²	261	-	270	-
	$R_{P1.0}$	N/mm²	290	-	305	-
	R_M	N/mm²	603	629	550	750

Source references of analysed data used in assessment

Source references	Scope of data			
SIMR report IM-2121, 1986 Swedish standard SS 14 23 71	Test Temps (°C)	600	700	800
	No. Data	35	39	24

Description of method used to assess data
Not specified

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
580	162	106*	90*
590	150	96*	80*
600	139	86*	72*
610	128	77*	64*
620	117	69*	57*
630	108	61*	50*
640	98	55*	45*
650	89	49*	40*
660	80	44*	36*
670	73	39*	32*
680	66	35*	29*
690	59	32*	26*
700	53	28*	24*
710	48	25*	22*
720	43	22*	20*
730	39	20*	(19)*
740	35	(19)*	-
750	31	(18)*	-
760	28	-	-
770	25	-	-
780	23	-	-
790	21	-	-
800	20	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

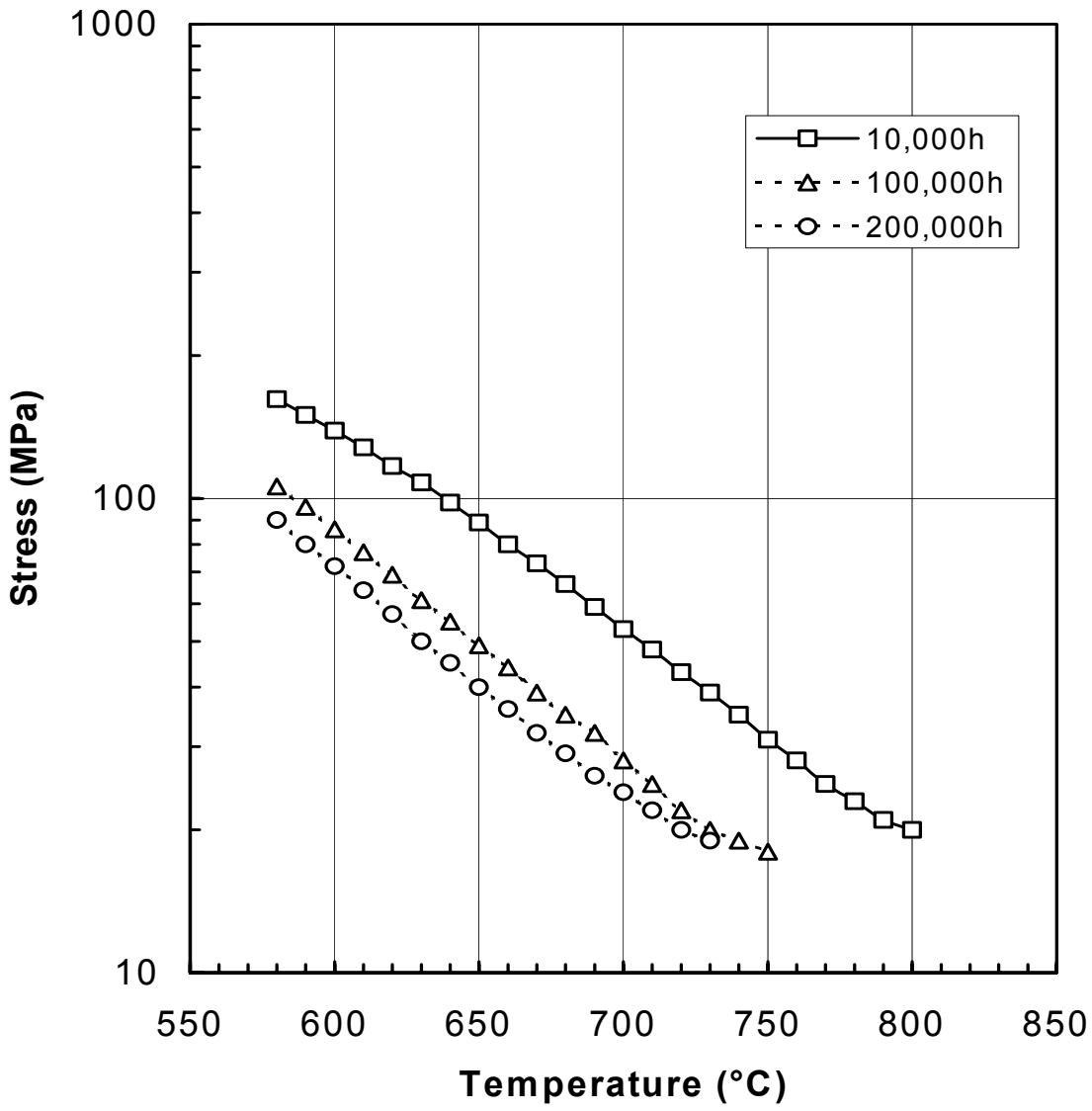
M Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X2CrNiN 18-10 (1.4311, Type 304 LN)



Master equation

unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X6CrNi 18-10 (1.4948, Type 304H)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.04	0.08
	Si	wt%	-	-	-	1.00
	Mn	wt%	-	-	-	2.0
	P	wt%	-	-	-	0.045
	S	wt%	-	-	-	0.015
	Cr	wt%	-	-	17.0	19.0
	Ni	wt%	-	-	8.0	11.0
	N	wt%	-	-	-	0.11
Product	Form		-			
	Section size	mm	-	-	-	250
Heat treatment	Solution Anneal	°C	-	-	1050	1110
Tensile Properties at RT	$R_{P,0.2}$	N/mm²	-	-	190	-
	$R_{P1.0}$	N/mm²	-	-	230	-
	R_M	N/mm²	-	-	510	710

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17460, 1992	188 creep data from 7 casts (temperature range : 500-800°C)

Description of method used to assess data
Not specified

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10.000h	100.000h	200.000h
°C	N/mm²	N/mm²	N/mm²
500	250	192	176
510	239	182	166
520	227	172	156
530	215	162	146
540	203	151	136
550	191	140	125
560	177	128	114
570	165	117	104
580	154	107	95
590	143	98	86
600	132	89	78
610	122	81	70
620	113	73	62
630	104	65	55
640	95	58	49
650	87	52	43
660	80	47	38
670	73	42	34
680	67	37	30
690	61	32	26
700	55	28	22
710	(45)	(22)	-
720	(41)	(20)	-
730	(38)	(18)	-
740	(36)	(16)	-
750	(34)	(15)	-

(1) Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

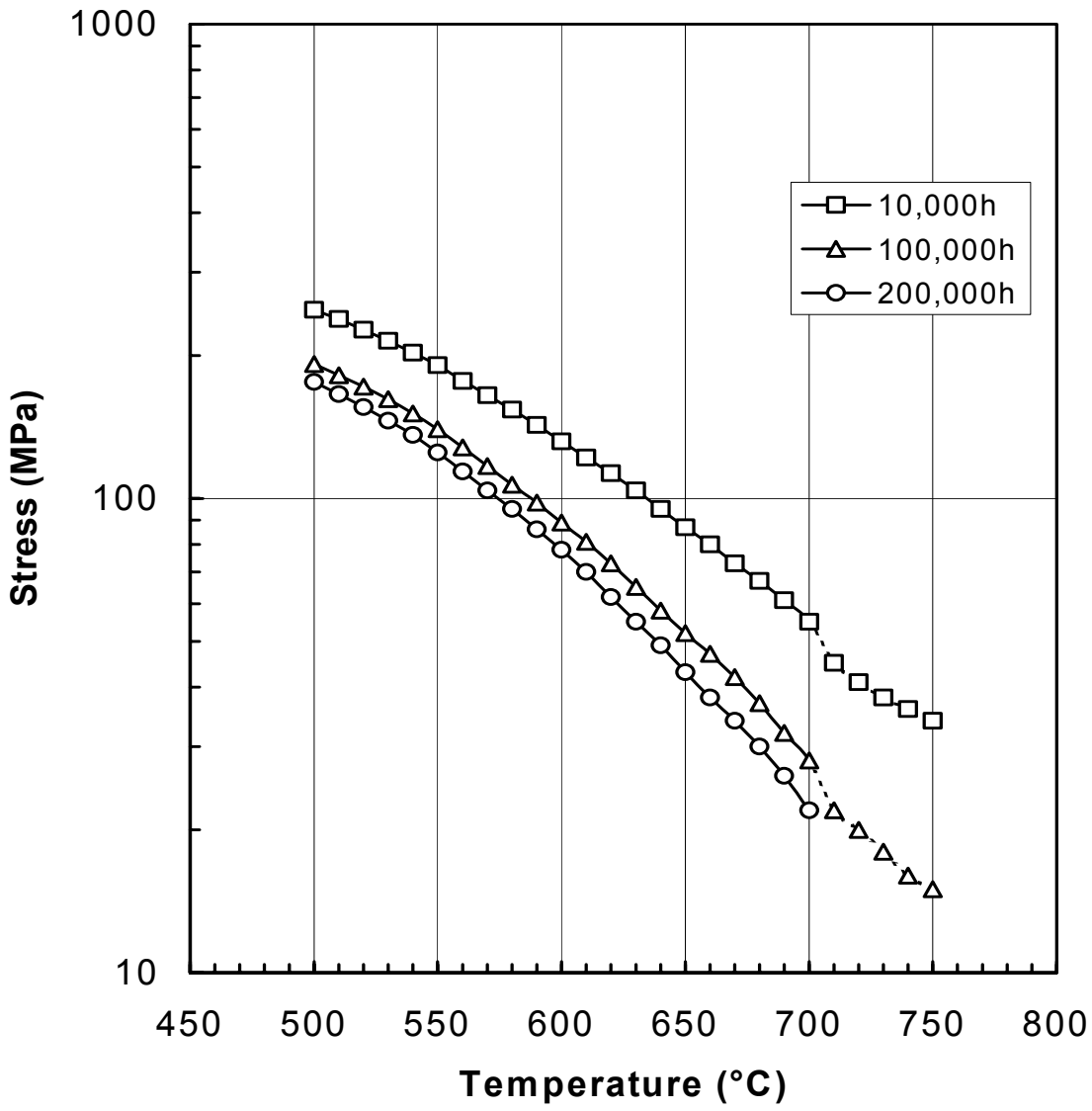
Michael Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X6CrNi 18-10 (1.4948, Type 304H)



Master equation
Unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.3
Year: 1998

Steel X2CrNiMo17-12-2 (1.4404, Type 316L)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.018	0.03	-	0.03
	Si	wt%	0.25	0.6	-	1.0
	Mn	wt%	0.73	1.9	-	2.0
	P	wt%	0.011	0.034	-	0.045
	S	wt%	0.003	0.015	-	0.015
	Cr	wt%	16.7	18.38	16.5	18.5
	Mo	wt%	2.2	2.65	2.0	2.5
	Ni	wt%	11.32	13.66	10.0	13.0
	N	wt%	<0.001	0.024	-	0.11
Product	Form		Bar, Tube & Plate			
	Section size	mm	4.85	20	-	250
Heat treatment	Harden / Solution	°C	1050	1090	1030	1110
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	700

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
400	1	-	-	-	(1)	-	-	-
500	1	3	1	-	-	1	(1)	-
550	3	6	2	1	-	-	-	-
566	2	5	-	-	-	-	-	-
580	1	3	-	-	-	-	-	-
600	6	24	3	1	-	-	1	-
620	1	6	1	-	-	-	-	-
650	7	27	4(1)	-	-	-	1	-
700	5	18	3	1	-	1	-	-
732	1	3	-	-	-	-	-	-
Totals	11	95	14(1)	3	(1)	2	2(1)	-

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
500	321*	294*	265*	250*
510	300*	274*	246*	230*
520	281*	255*	227*	212*
530	262*	237*	210*	195*
540	245*	219*	193*	179*
550	228*	203*	177*	163*
560	211*	187*	163*	149*
570	196*	173*	149*	136*
580	181	159*	135*	123*
590	168	146*	123*	111*
600	155	133*	112*	101*
610	142	122*	101*	91*
620	131	111*	92*	82*
630	120	101*	83*	73*
640	110	92*	75*	66*
650	101	84*	67*	59*
660	92	76*	60*	53*
670	84	69*	54*	(47)*
680	77	62*	(49)*	-
690	70	56*	-	-
700	64	51*	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

Note
As a pragmatic approach to ensure safe design, the ECCC WG3.3 creep rupture strength values for Type 316L should not be used for heats that have carbon contents of less than 0.02 wt%. This lower limit is based on the minimum carbon content of the heats included in the creep rupture data assessment for these materials. It is intended to prevent the use of the ECCC creep strength values for heats that may exhibit low creep rupture strength.

M Spindler

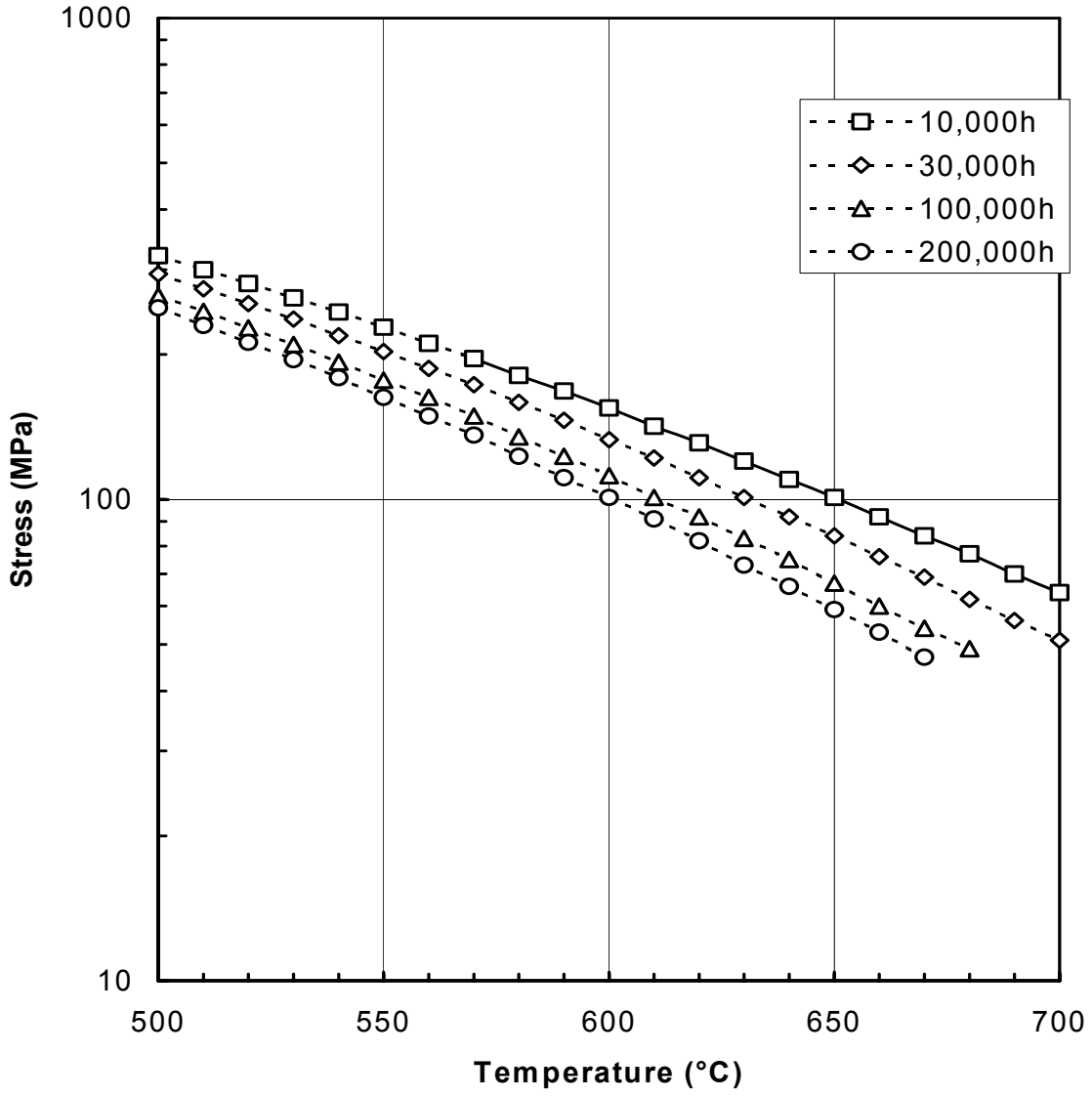
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X2CrNiMo17-12-2 (1.4404, Type 316L)

Working group: WG3.3
Year: 1998



Master equation

$$\log_e(t_r^*) = -672.826172 + 185.925171.\log_{10}(T) - 8250.51465\frac{\log_{10}(\sigma_0)}{T} + \frac{139204.547}{T} - 19.9724884\frac{\sigma_0}{T}$$

where t_r^* is the predicted failure time in hours, T is the absolute temperature and σ_0 is the stress in N/mm^2.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X5CrNiMo17-12-2 (1.4401, Type 316)

Working group: WG3.3
Year: 1998

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.018	0.07	-	0.07
	Si	wt%	0.06	0.82	-	1.0
	Mn	wt%	0.59	2.0	-	2.0
	P	wt%	0.008	0.038	-	0.045
	S	wt%	0.003	0.034	-	0.015
	Cr	wt%	15.82	19.02	16.5	18.5
	Mo	wt%	2.0	3.0	2.0	2.5
	Ni	wt%	10.13	14.0	10.0	13.0
	B	wt%	<0.001	0.056	-	-
	N	wt%	<0.001	0.067	-	0.11
Product	Form		Bar, Plate, Tube & Forging			
	Section size	mm	4.88	135	-	250
Heat treatment	Solution annealed	°C	1038	1125	1030	1110
Tensile Properties	$R_{P,0.2}$	N/mm²	183	312	200	-
	R_M	N/mm²	517	654	500	700

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
400	1	-	-	-	(1)	-	-	-
482	1	2	-	-	-	-	-	-
500	14	23	15	2	4	3(1)	3(3)	(1)
550	32	93	19	9	3	1(2)	3(1)	3(4)
566	4	14	-	-	-	-	-	-
575	2	4	1	1	-	-	-	-
580	2	7	1	-	-	-	-	-
590	7	23	4	1	-	-	-	-
593	5	12	-	-	-	-	-	-
600	88	286(1)	83(8)	37(5)	40(3)	17(1)	13(1)	5(2)
610	1	1	-	-	-	-	-	-
620	3	16	-	-	-	-	-	-
625	22	48	21	8	4	-	-	-
640	1	1	-	-	-	-	-	-
650	103	453(2)	74(4)	33(10)	28(1)	12(2)	7	3
660	3	5	-	-	-	-	-	-
675	22	53	5(1)	4(2)	5	2	1	-
677	1	1	-	-	-	-	-	-
680	2	2	-	-	-	-	-	-
690	2	3	-	-	-	-	-	-
700	70	307	57	19(11)	27(4)	7(1)	1	1(1)
710	1	1	-	-	-	-	-	-
720	2	5	-	-	-	-	-	-
730	1	2	-	-	-	-	-	-
732	10	32	2	-	-	-	-	-
740	2	3	-	-	-	-	-	-
750	15	40	10	3	6	1	-	1
760	2	2	-	-	-	-	-	-
770	1	1	-	-	-	-	-	-
775	1	1	-	-	-	-	-	-
800	19	59(3)	7	6	3(1)	-	-	1
816	7	23	2	-	-	-	-	-
830	1	1	-	-	-	-	-	-
850	12	30	-	-	-	-	-	-
Totals	132	1554(6)	301(13)	123(28)	120(10)	43(7)	28(5)	14(8)

( ) Figures in parentheses denote unbroken tests

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X5CrNiMo17-12-2 (1.4401, Type 316)

Working group: WG3.3
Year: 1998

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
500	344	313	280	261
510	323	292	260	242
520	303	273	241	223
530	284	254	222	205
540	265	236	205	188
550	247	218	188	172
560	230	202	172	157
570	213	186	158	142
580	198	171	144	129
590	183	157	130	117
600	168	143	118	105
610	155	131	107	94
620	142	119	96	85
630	130	108	87	76
640	119	98	78	68
650	109	89	70	61
660	99	80	63	54
670	90	73	56	48
680	82	65	50	43*
690	75	59	45	38*
700	68	53	40	34*
710	61	48	36	30*
720	56	43	32	27*
730	50	39	29	24*
740	46	35	26	22*
750	41	32	23	19*
760	37	28	21	17*
770	34	26	19	16*
780	31	23	17*	14*
790	28	21	15*	13*
800	25	19	14*	11*
810	23	17	12*	10*
820	21	16	11*	-
830	19	14*	10*	-
840	18	13*	-	-
850	16	12*	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

M Spindler

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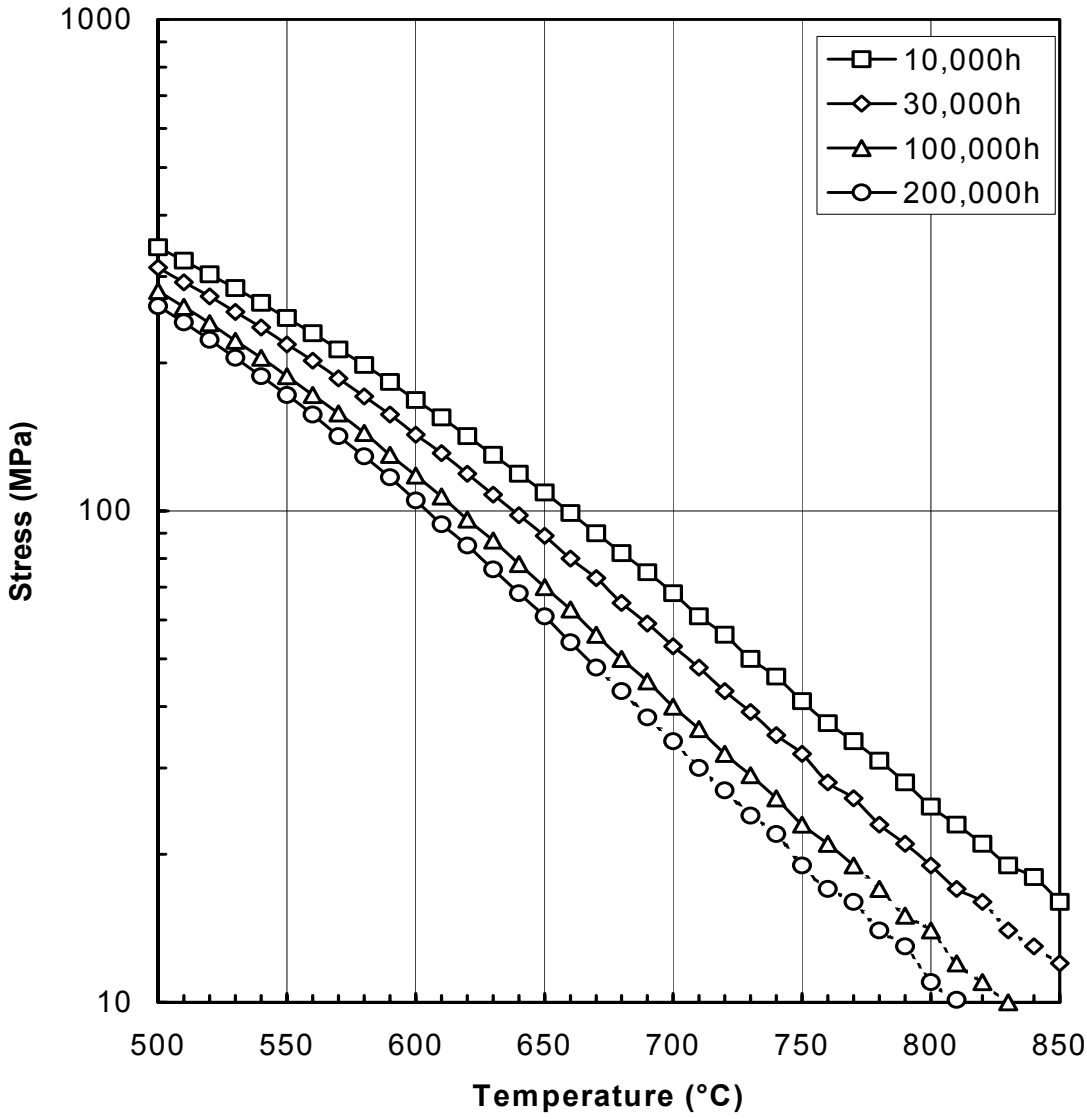
Note
As a pragmatic approach to ensure safe design, the ECCC WG3.3 creep rupture strength values for Type 316 should not be used for heats that have carbon contents of less than 0.02 wt%. This lower limit is based on the minimum carbon content of the heats included in the creep rupture data assessment for these materials. It is intended to prevent the use of the ECCC creep strength values for heats that may exhibit low creep rupture strength.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X5CrNiMo17-12-2 (1.4401, Type 316)

Working group: WG3.3
Year: 1998



Master equation

$$\log_e(t_r^*) = -234.184723 + 62.1417923 \cdot \log_{10}(T) - 7.78331852 \cdot \log_{10}(\sigma_0) + \frac{71314.4609}{T} - 19.3277092 \frac{\sigma_0}{T}$$

where t_r^* is the predicted failure time in hours, T is the absolute temperature and σ_0 is the stress in N/mm^2.

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X6CrNiMoTi17-12-2 (1.4571, Type 316Ti)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.018	0.07	-	0.08
	Si	wt%	0.06	0.82	-	1.00
	Mn	wt%	0.59	2.0	-	2.00
	P	wt%	0.008	0.038	-	0.045
	S	wt%	0.003	0.034	-	0.015
	Cr	wt%	15.82	19.02	16.50	18.50
	Mo	wt%	2.0	3.0	2.00	2.50
	Ni	wt%	10.13	14.0	10.50	13.50
	Ti	wt%	-	-	5x %C	0.70
	B	wt%	<0.001	0.056	-	-
	N	wt%	<0.001	0.067	-	-
Product	Form		Bar, Plate, Tube & Forging			
	Section size	mm	4.88	135	-	250
Heat treatment	Harden / Solution	°C	1038	1125	1030	1110
Tensile Properties	$R_{P,0.2}$	N/mm²	183	312	200	-
	R_M	N/mm²	517	654	500	700

Source references of analysed data used in assessment

Source references	Scope of data
L Linde, R Sandstrom, R Gommans, M Spindler & A Fairman, Evaluation of Creep Rupture Data For The New European Standards For Stainless Steels – Edition 2, ECCC Report No 0509/WG3.3/7, Sept 1998.	(see ECCC Data Sheet for X5CrNiMo17-12-2).

Description of method used to assess data
It was concluded in the above report that the creep rupture strength of X6CrNiMoTi17-12-2 at 600 to 800°C could be described by the values for X5CrNiMo17-12-2 (see ECCC Data Sheet for X5CrNiMo17-12-2).

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
580	198	171	144	129
590	183	157	130	117
600	168	143	118	105
610	155	131	107	94
620	142	119	96	85
630	130	108	87	76
640	119	98	78	68
650	109	89	70	61
660	99	80	63	54
670	90	73	56	48
680	82	65	50	43*
690	75	59	45	38*
700	68	53	40	34*
710	61	48	36	30*
720	56	43	32	27*
730	50	39	29	24*
740	46	35	26	22*
750	41	32	23	19*
760	37	28	21	17*
770	34	26	19	16*
780	31	23	17*	14*
790	28	21	15*	13*
800	25	19	14*	11*
810	23	17	12*	10*
820	21	16	11*	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

M Spindler

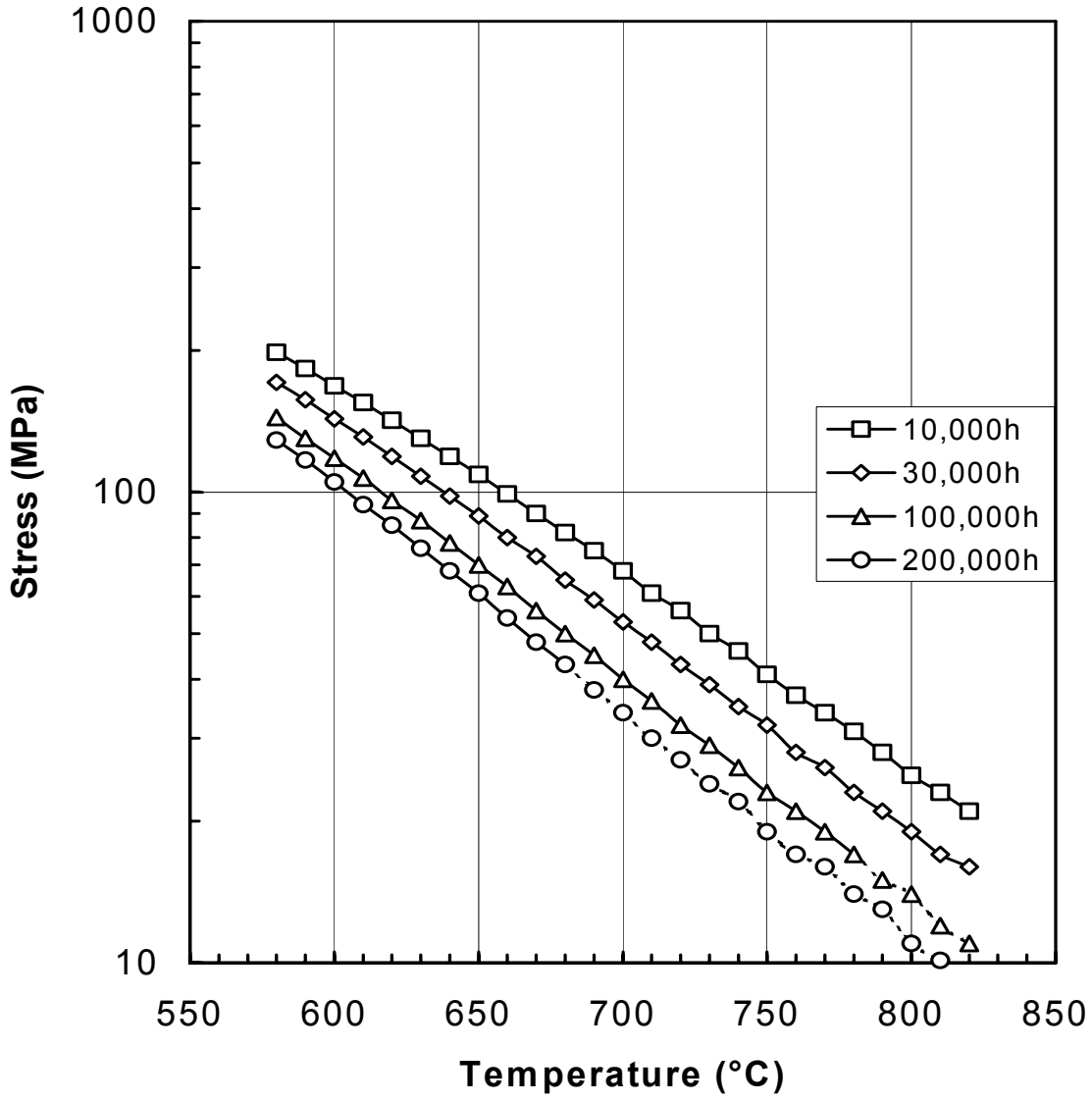
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X6CrNiMoTi17-12-2 (1.4571, Type 316Ti)

Working group: WG3.3
Year: 1999



Master equation

$$\log_e(t_r^*) = -234.184723 + 62.1417923 \cdot \log_{10}(T) - 7.78331852 \cdot \log_{10}(\sigma_0) + \frac{71314.4609}{T} - 19.3277092 \frac{\sigma_0}{T}$$

where t_r^* is the predicted failure time in hours, T is the absolute temperature and σ_0 is the stress in N/mm^2.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X2CrNiMoN 17-13-3 (1.4429, Type 316LN)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.019	0.025	-	0.030
	Si	wt%	0.41	0.50	-	1.00
	Mn	wt%	1.76	1.99	-	2.00
	P	wt%	0.009	0.017	-	0.045
	S	wt%	0.009	0.013	-	0.015
	Cr	wt%	16.6	17.7	16.50	18.50
	Mo	wt%	2.74	2.79	2.50	3.00
	Ni	wt%	12.3	13.3	11.00	14.00
	N	wt%	0.139	0.22	0.12	0.22
Product	Form					
	Section size	mm	-	-	-	250
Heat treatment	Solution Annealed	°C	-	-	1030	1110
Tensile Properties	$R_{P,0.2}$	N/mm²	320	-	280	-
	R_M	N/mm²	628	670	580	800

Source references of analysed data used in assessment

Source references	Scope of data			
B. Ivarsson and L. Yngrén, Krypbrotthållfastheten hos svenska tryckkärlsstål. Del 2. Austenitiska stål, Swedish Institute for Metals Research, Report IM-2121, July 1986.	Test Temps (°C)	600	700	800
	No. of Data	37	40	25

Description of method used to assess data
B. Ivarsson and L. Yngrén, Krypbrotthållfastheten hos svenska tryckkärlsstål. Del 1. Kolstål, kolmanganstål och låglegerade stål, Swedish Institute for Metals Research, Report IM-2120, May 1986.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
550	(300)	(234)	(213)
560	(284)	(217)	(195)
570	(267)	(199)	(179)
580	250	(182)	(162)
590	236	(166)	(145)
600	221	(151)	(130)
610	205	(135)	(114)
620	189	(119)	(100)
630	(173)	(105)	(87)
640	(157)	(92)	(76)
650	(143)	(80)	(66)
660	(128)	(71)	(58)
670	(115)	(62)	(51)
680	(102	(55)	(45)
690	90	(48)	(40)
700	78	(42)	(35)
710	69	(37)	(31)
720	62	(33)	(27)
730	(54)	(29)	(24)
740	(48)	(26)	(21)
750	(42)	(23)	(19)

() Information concerning which strengths are the result of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as 'qualified'.

Michael Spindler

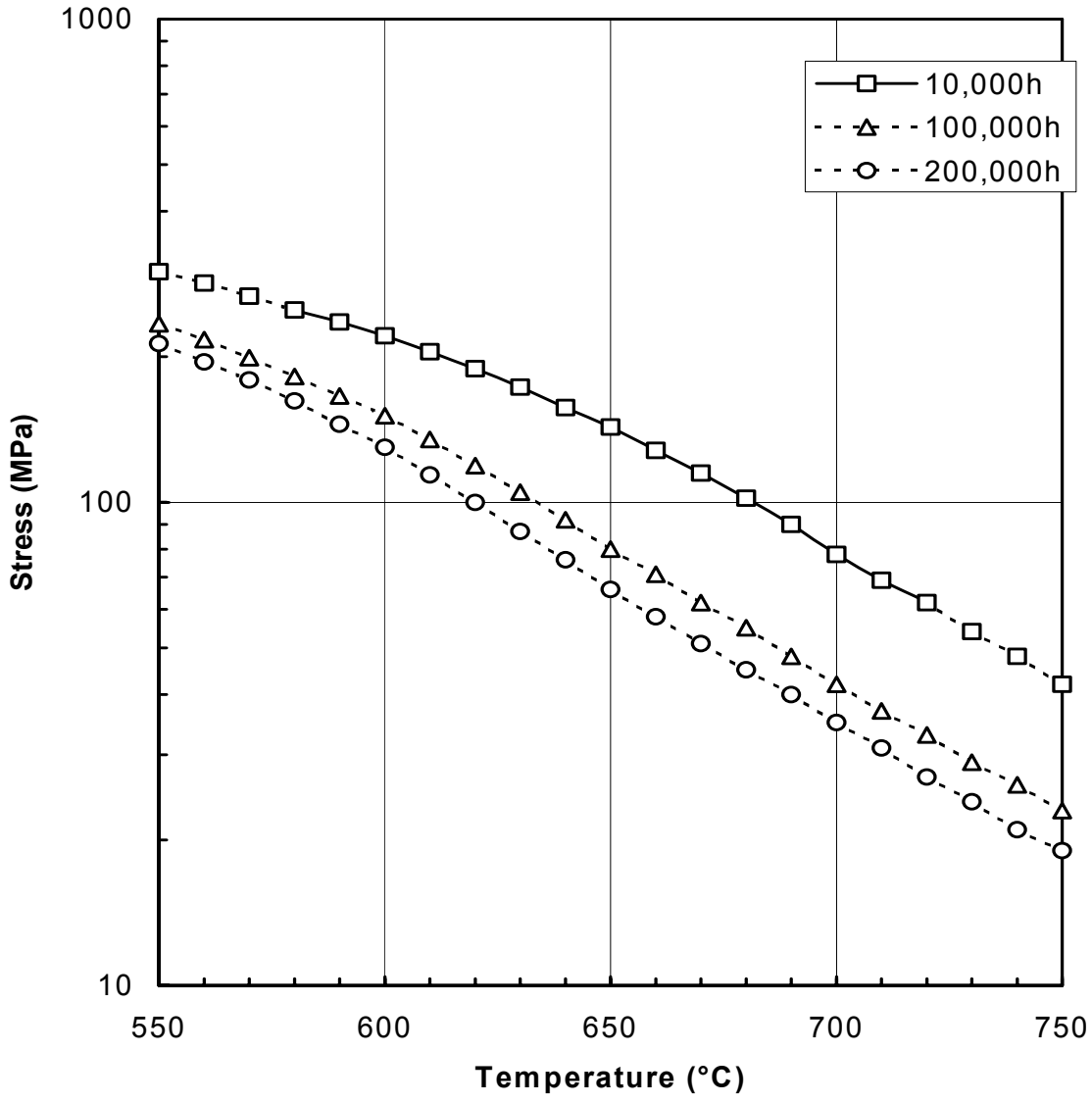
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X2CrNiMoN 17-13-3 (1.4429, Type 316LN)

Working group: WG3.3
Year: 1999



Master equation
Unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X2CrNiMo17-12-2 (1.4909, Type 316L(N))

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.016	0.038	-	0.030
	Si	wt%	0.15	0.72	-	0.50
	Mn	wt%	1.52	2.06	1.60	2.00
	P	wt%	0.01	0.025	-	0.035
	S	wt%	0.001	0.025	-	0.025
	Cr	wt%	17.0	17.9	17.00	18.00
	Mo	wt%	2.30	2.61	2.30	2.70
	Ni	wt%	11.4	12.6	12.00	12.50
	Co	wt%	0.02	0.28	-	0.25
	Cu	wt%	0.03	0.4	-	1.00
	B	wt%	0.0001	0.009	-	0.0020
	N	wt%	0.056	0.086	0.060	0.080
Product	Form		bar & plate			
	Section size	mm	15	70	-	250
Heat treatment	Solution Annealed	°C	1070	1100	1070	1100
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	220	-
	R_M	N/mm²	-	-	525	-

Source references of analysed data used in assessment

Source references	Scope of data								
D Lehmann, Evaluation of the stress to rupture and creep properties of type 316L(N) steel for design use, European Commission Report EUR 16168_{EN} Contract Number RA1 0182 F, 1995.	Test Temp (°C)	500	525	550	600	625	650	700	750
	No. Data	11	8	231	181	1	98	26	15
Description of method used to assess data Multiple linear regression with the Larson-Miller time temperature Parameter									

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
500	386	351	315*	296*
510	361	327	293*	275*
520	338	305	272*	255*
530	316	284	253*	236*
540	295	264	234*	218*
550	275	246	216*	201*
560	255	228	200*	185*
570	237	211	184*	170*
580	220	195	169*	156*
590	204	180	155*	142*
600	189	165	142*	130*
610	174	152	130*	118*
620	160	139	118*	107*
630	147	127	107*	97*
640	135	116	97*	87*
650	124	105	87*	78*
660	113	95	78*	69*
670	102	86	70*	61*
680	93	77*	62*	54*
690	84	69*	54*	47*
700	75	61*	47*	40*
710	67	54*	41*	-
720	60	47*	-	-
730	53*	41*	-	-
740	46*	-	-	-
750	40*	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

Michael Spindler

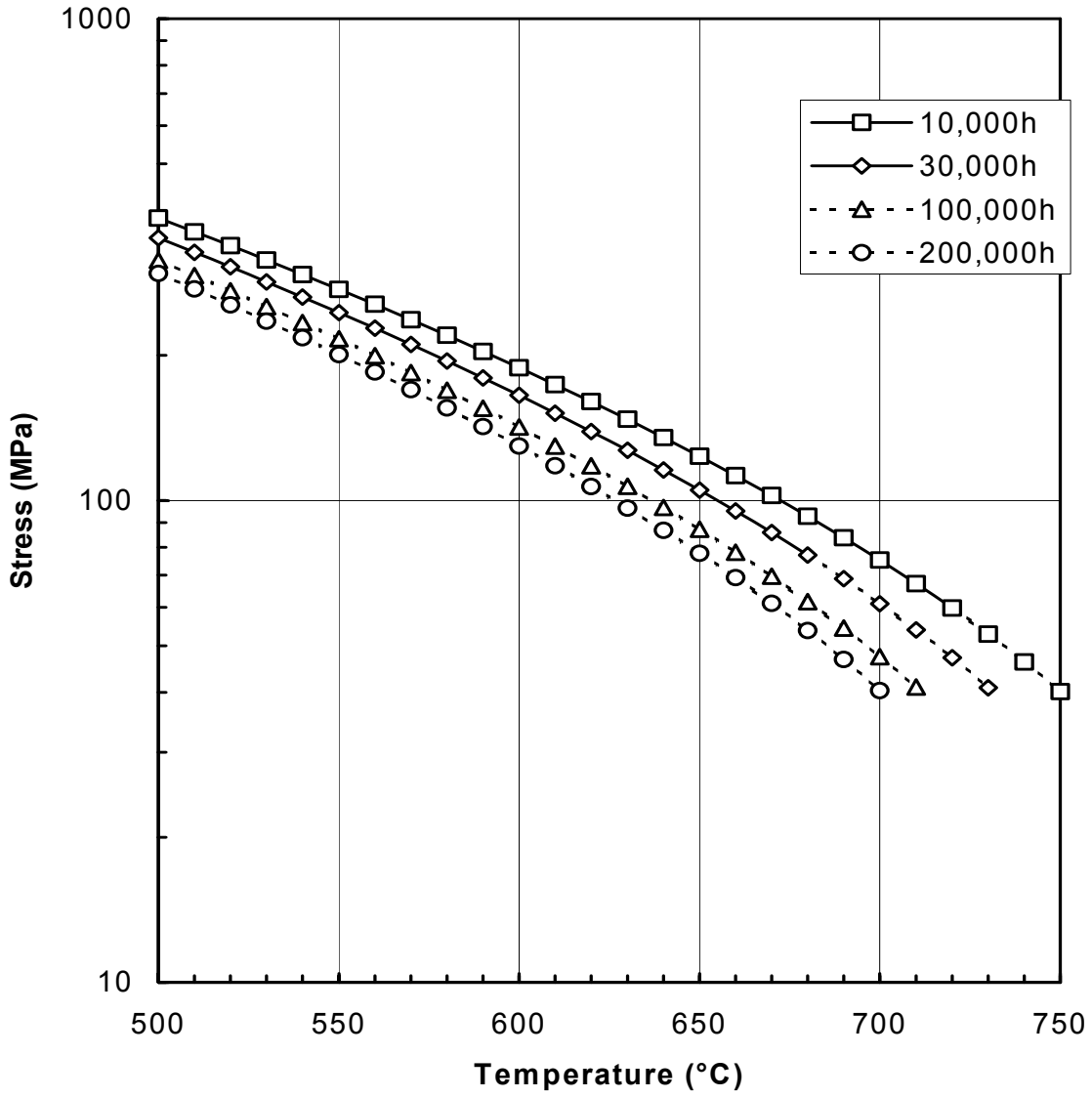
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X2CrNiMo17-12-2 (1.4909, Type 316L(N))

Working group: WG3.3
Year: 1999



Master equation

$$T(\mathrm{Log}_{10}(t_r^*) + 21.5) = 25875 + 4233.3.\mathrm{Log}_{10}(\sigma_0) - 2558.0(\mathrm{Log}_{10}(\sigma_0))^2$$

where t_r^* is the predicted failure time in hours, T is the absolute temperature and σ_0 is the stress in N/mm^2.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X3CrNiMoBN 17-13-3 (1.4910, Type 316LNB)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	-	0.04
	Si	wt%	-	-	-	0.75
	Mn	wt%	-	-	-	2.00
	P	wt%	-	-	-	0.035
	S	wt%	-	-	-	0.015
	Cr	wt%	-	-	16.00	18.00
	Mo	wt%	-	-	2.00	3.00
	Ni	wt%	-	-	12.00	14.00
	B	wt%	-	-	0.0015	0.0050
	N	wt%	-	-	0.10	0.18
Product	Form					
	Section size	mm	-	-	-	160
Heat treatment	Solution Annealed	°C	-	-	1020	1100
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	260	-
	R_M	N/mm²	-	-	550	750

Source references of analysed data used in assessment

Source references	Scope of data											
DIN 17 460, 1992, Hochwarmfeste austeitische Stähle – Technische Lieferbedingungen für Blech, kalt- und warmgewalztes Band, Stäbe und Schmiedestücke, Deutsches Institut für Normung.	Test Temp (°C)	450	500	550	575	590	600	630	650	700	750	800
	No. Data	1	5	34	5	6	42	6	56	21	21	10

Description of method used to assess data
The assessment was made by the German Creep Committee by using the manual method.

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
550	290	220	(200)
560	272	202	(184)
570	254	186	(166)
580	237	170	(151)
590	220	155	(137)
600	205	141	(122)
610	190	127	(113)
620	174	114	(100)
630	162	102	(91)
640	148	92	(81)
650	135	83	(73)
660	122	75	(65)
670	112	68	(58)
680	102	61	(52)
690	93	56	(46)
700	84	52	(42)
710	78	48	(39)
720	71	45	(36)
730	65	41	(34)
740	58	37	(31)
750	52	34	(28)
760	48	31	(26)
770	44	28	(24)
780	41	25	(21)
790	37	22	(19)
800	33	20	(17)

() Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

Michael Spindler

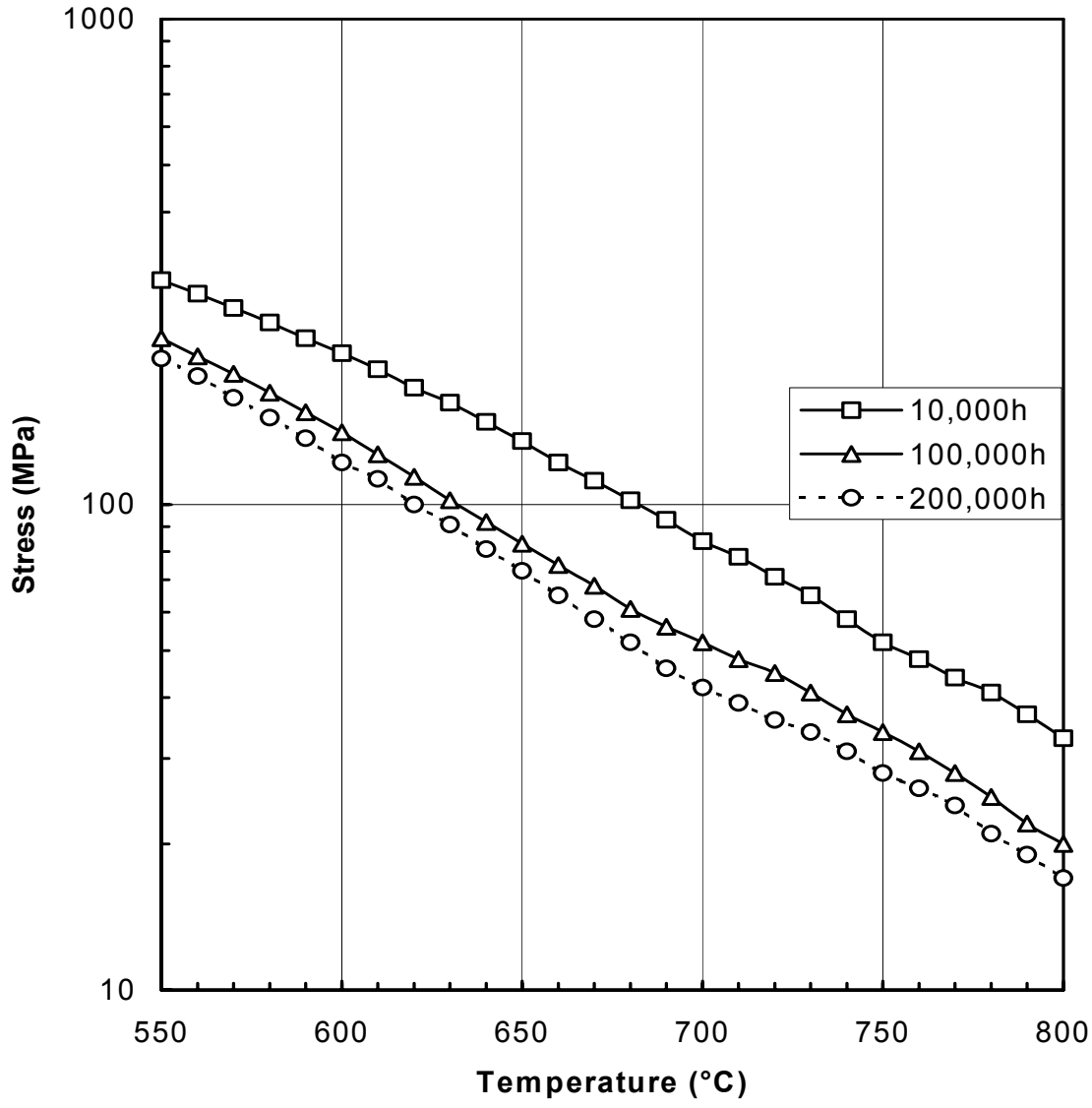
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X3CrNiMoBN 17-13-3 (1.4910, Type 316LNB)

Working group: WG3.3
Year: 1999



Master equation
Not Applicable (graphical assessment)

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X7CrNiTi 18-10 (1.4941, Type 321H, Solution Annealed 1070-1150°C)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.04	0.08
	Si	wt%	-	-	-	1.00
	Mn	wt%	-	-	-	2.0
	P	wt%	-	-	-	0.035
	S	wt%	-	-	-	0.015
	Cr	wt%	-	-	17.0	19.0
	Mo	wt%	-	-	-	0.60
	Ni	wt%	-	-	9.0	12.0
	Ti	wt%	-	-	5 x % C	0.80
	B	wt%	-	-	0.0015	0.0050
Product	Form		Tubes (≤50mm), plate and sheet, cold and hot rolled strip, bars and forgings			
	Section size	mm	-	-	-	-
Heat treatment	Solution Anneal	°C	-	-	1070	1150
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	200	-
	$R_{P,1.0}$	N/mm²	-	-	240	-
	R_M	N/mm²	-	-	500	700

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17459 (Sept. 1992)	Seamless circular high-temperature austenitic tubes; technical delivery conditions Scope of data used in assessment not specified
DIN 17460 (Sept. 1992)	High temperature austenitic steels; technical delivery conditions for plate, cold and hot rolled strip, bars and forgings Scope of data used in assessment not specified
Description of method used to assess data Not specified	

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
550	230	170	150
560	220	150	130
570	210	140	120
580	190	120	110
590	170	110	100
600	160	100	90
610	140	92	82
620	130	84	74
630	120	76	66
640	110	68	60
650	100	62	54
660	90	56	48
670	82	50	43
680	74	44	40
690	66	39	38
700	60	35	29

(1) Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

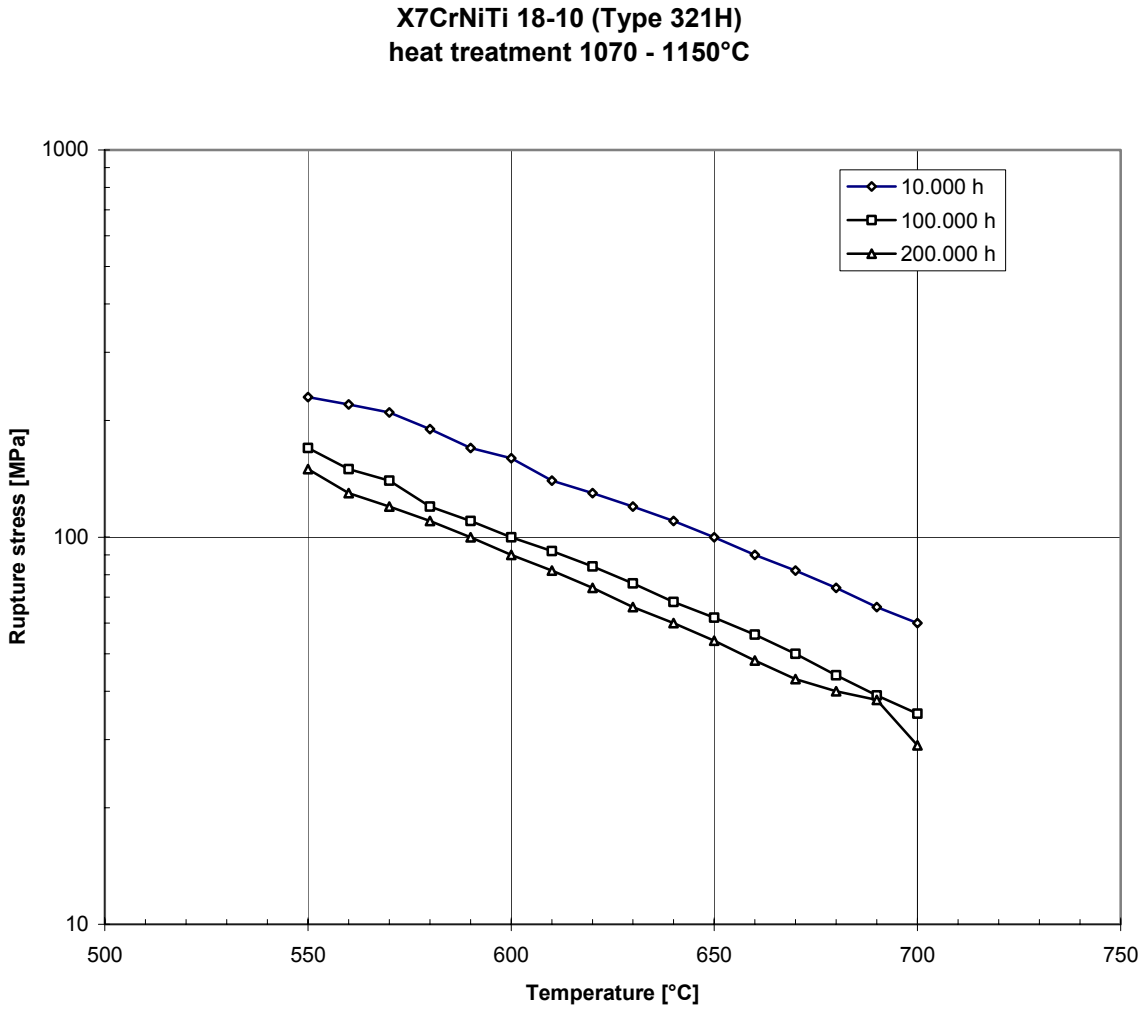
Michael Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X7CrNiTi 18-10 (1.4941, Type 321H, Solution Annealed 1070-1150°C)



Master equation

Unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X7CrNiTi 18-10 (1.4941, Type 321H, Solution Annealed 950-1070°C)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.033	0.10	0.04	0.08
	Si	wt%	0.076	1.15	-	1.00
	Mn	wt%	0.21	1.79	-	2.0
	P	wt%	0.009	0.041	-	0.035
	S	wt%	0.005	0.032	-	0.015
	Cr	wt%	17.06	18.60	17.0	19.0
	Mo	wt%	-	-	-	0.60
	Ni	wt%	8.90	12.69	9.0	12.0
	Ti	wt%	0.21	0.62	5 x % C	0.80
	B	wt%	-	-	0.0015	0.0050
Product	Form		Plates, sections and bars, forgings, bars for bolting, tubes/pipes			
	Section size	mm	-	-	-	-
Heat treatment	Solution Anneal	°C	950	1070	950	1070
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	-	-
	R_M	N/mm²	-	-	-	-

Source references of analysed data used in assessment

Source references	Scope of data
PD 6525: Part 1: 1990	See below

Description of method used to assess data

Standard ISO method. The stress rupture values were approved in 1987.

Quantity and duration of data used in assessment

Temps	No. of Heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
550°C		21 (2)	-	1 (1)	-	-	-	-
600°C		128	19	4	2	(1)	-	-
625°C		20	6	(2)	-	-	-	-
649/650°C		192 (3)	10 (4)	2	-	-	-	-
700/704°C		81	5	2	(3)	1	-	-
Totals		442 (5)	40 (4)	9 (3)	2 (3)	1 (1)	-	-

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	50,000h	100,000h	150,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
540	222	189	174*	154*	143*	136*	130*
550	206	174	160*	142*	131*	123*	118*
560	192	161	147*	129*	119*	112*	107*
570	178	148	135*	118*	108*	101*	96*
580	165	136	124	107*	97*	91*	86*
590	152	125	112	96*	87*	81*	76*
600	140	114	102	86*	78*	72*	67*
610	129	103	92	77*	69*	63*	59*
620	118	93	82	68*	61*	55*	51*
630	108	84	73	60*	53*	48*	45*
640	98	75	65	53*	46*	42*	39*
650	88	67	57	46*	40*	36*	34*
660	79	59	50	40*	35*	32*	30*
670	71	52	44	35*	31*	(28)*	(26)*
680	63	45	38*	31*	(27)*	-	-
690	56	39	34*	(27)*	-	-	-
700	49	35	29*	-	-	-	-
710	43	30	(26)*	-	-	-	-
720	38	(27)	-	-	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

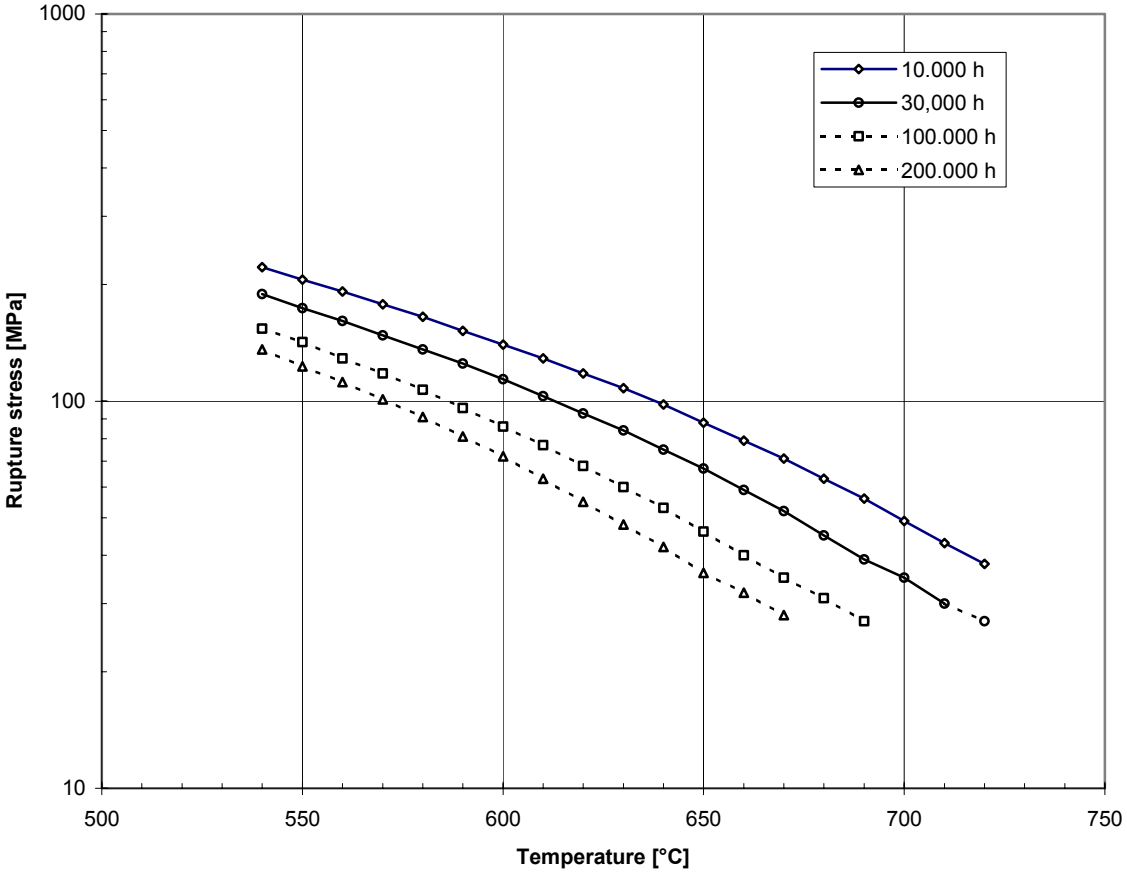
Michael Spindler
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X7CrNiTi 18-10 (1.4941, Type 321H, Solution Annealed 950-1070°C)

Working group: WG3.3
Year: 1999



Master equation

Standard ISO method used to fit data. The master curve is described by:

$$P_{(\sigma)} = a + b(\log\sigma) + c(\log\sigma)^2 + d(\log\sigma)^3 + e(\log\sigma)^4 = \frac{\log t - \log t_a}{(T - T_a)^r}$$

where $P_{(\sigma)}$ is the creep rupture parameter; T is the temperature in Kelvin; t is the time to rupture in hours; σ is the stress in N/mm^2; r is a temperature exponent; and a, b, c, d and e are constants

a = 0.005118919536, b = -0.03954263031, c = 0.02576294728, d = -0.007168778218, e = 0.0005460219108, r = 1, T_a = 0, $\log t_a$ = 21.785516739

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X6CrNiNb 18-10 (1.4550, Type 347, Solution Annealed 1070-1125°C)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.04	0.082	-	0.08
	Si	wt%	0.20	0.78	-	1.00
	Mn	wt%	0.31	1.90	-	2.00
	P	wt%	0.006	0.029	-	0.045
	S	wt%	0.004	0.022	-	0.015
	Cr	wt%	16.90	18.80	17.0	19.0
	Ni	wt%	10.10	13.55	9.0	12.0
	Nb	wt%	0.39	1.14	10 x % C	1.00
Product	Form		Plates, sections and bars, forgings, bars for bolting, tubes/pipes			
	Section size	mm	-	-	-	-
Heat treatment	Solution Anneal	°C	1080	1121	1070	1125
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	700

Source references of analysed data used in assessment

Source references	Scope of data
PD 6525: Part 1: 1990	See below

Description of method used to assess data

Standard ISO method. The stress rupture values were approved in 1988 although the steel is not currently included within British Standards.

Quantity and duration of data used in assessment

Temps	No. of Heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
600°C		65 (3)	6 (1)	1	-	2	(1)	-
625°C		19	1	-	(1)	-	-	-
649/650°C		220 (3)	19 (3)	4 (1)	2	-	(1)	1
700°C		52 (3)	6	1 (1)	(1)	1	(2)	-
Totals		356 (9)	32 (4)	6 (2)	2 (2)	3	(4)	1

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	50,000h	100,000h	150,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
540	253	220*	205*	186*	176*	169*	164*
550	237	204*	190*	172*	163*	156*	151*
560	221	190*	176*	159*	150*	144*	139*
570	206	176*	163*	147*	138*	132*	128*
580	192	163	151*	135*	127*	122*	117*
590	178	151	139*	125*	117*	112*	108*
600	166	139	129*	115*	107*	102*	99*
610	154	129	118	106*	99*	94*	90*
620	142	119	109	97*	90*	86*	83*
630	132	109	100	89*	83*	78*	75*
640	122	101	92	81*	75*	71*	68*
650	112	93	84	74*	68*	64*	61*
660	104	85	77	67*	62*	59*	55*
670	96	78	70	61*	55*	(51)*	(47)*
680	88	71	64	54*	(48)*	-	-
690	81	64	57	-	-	-	-
700	74	58	(50)	-	-	-	-
710	68	(51)	-	-	-	-	-
720	61	-	-	-	-	-	-
730	55	-	-	-	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

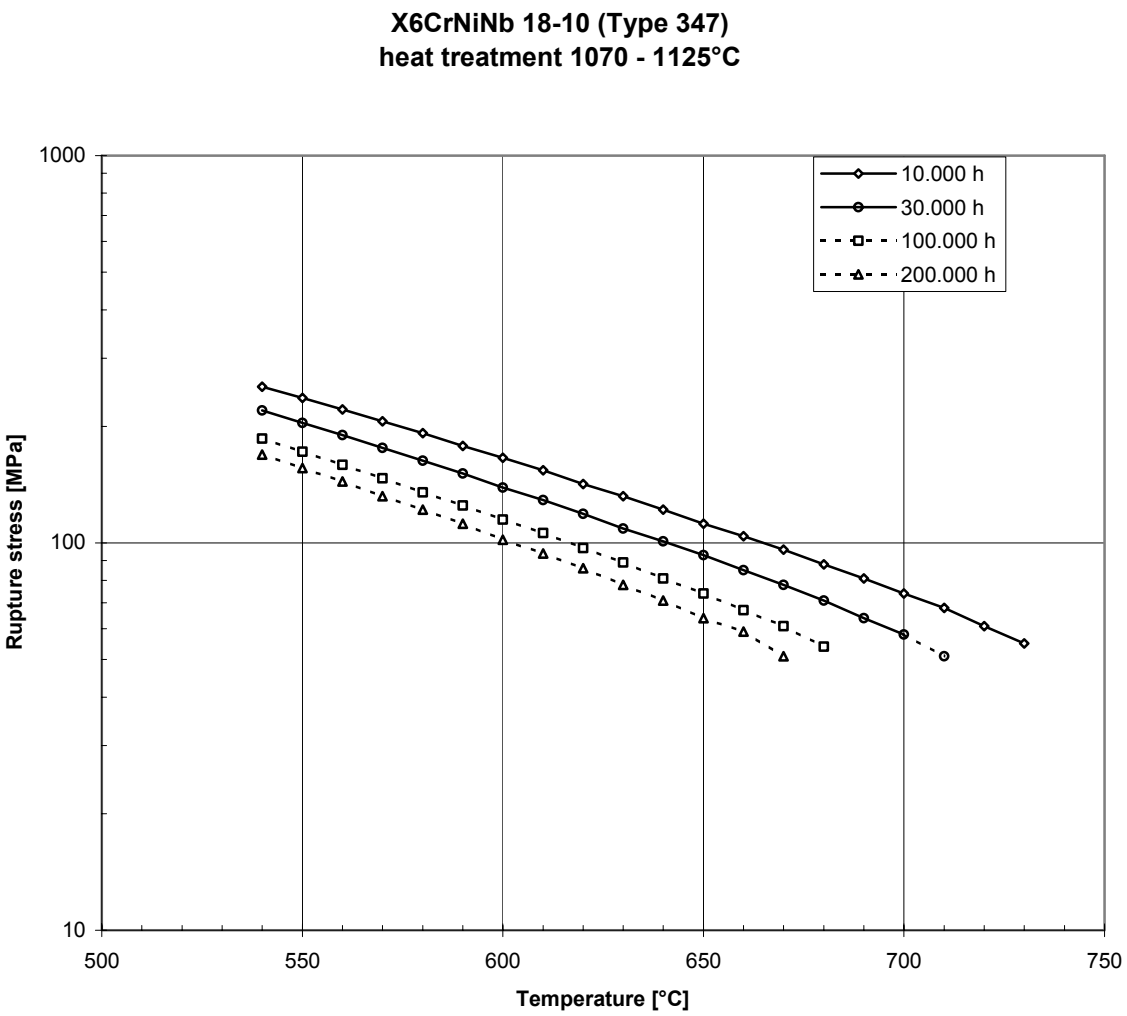
Michael Spindler
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X6CrNiNb 18-10 (1.4550, Type 347, Solution Annealed 1070-1125°C)

Working group: WG3.3
Year: 1999



Master equation

Standard ISO method used to fit data. The master curve is described by:

$$P_{(\sigma)} = a + b(\log\sigma) + c(\log\sigma)^2 + d(\log\sigma)^3 + e(\log\sigma)^4 = \frac{\log t - \log t_a}{(T - T_a)^r}$$

where $P_{(\sigma)}$ is the creep rupture parameter; T is the temperature in Kelvin; t is the time to rupture in hours; σ is the stress in N/mm^2; r is a temperature exponent; and a, b, c, d and e are constants

a = -108856.8984, b = 252363.5625, c = -182577.3125, d = 57694.46875, e = -6863.740723, r = -1, T_a = 0, $\log t_a$ = -14.445973396

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X6CrNiNb 18-10 (1.4550, Type 347, Solution Annealed 950-1070°C)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.034	0.11	-	0.08
	Si	wt%	0.12	0.94	-	1.00
	Mn	wt%	0.41	1.92	-	2.00
	P	wt%	0.008	0.025	-	0.045
	S	wt%	0.004	0.030	-	0.015
	Cr	wt%	16.85	19.00	17.0	19.0
	Ni	wt%	9.14	13.55	9.0	12.0
	Nb	wt%	0.47	1.22	10 x % C	1.00
Product	Form		Plates, sections and bars, forgings, bars for bolting, tubes/pipes			
	Section size	mm	-	-	-	-
Heat treatment	Solution Anneal	°C	950	1066	950	1070
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	700

Source references of analysed data used in assessment

Source references	Scope of data
PD 6525: Part 1: 1990	See below

Description of method used to assess data

Standard ISO method. The stress rupture values were approved in 1988.

Quantity and duration of data used in assessment

Temps	No. of Heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
600°C		54	4	1 (1)	1 (1)	-	-	1
649/650°C		173 (1)	10 (1)	3	2	(1)	1	-
700/704°C		93	6	1	-	-	-	-
Totals		320 (1)	20 (1)	5 (1)	3 (1)	(1)	1	1

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	50,000h	100,000h	150,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
540	258	214*	196*	174*	162*	154*	147*
550	236	197*	181*	161*	149*	142*	136*
560	218	182*	167*	148*	138*	131*	125*
570	202	169*	155*	137*	127*	120*	115*
580	187	157	144	127*	117*	110*	105*
590	174	145	133	117*	108*	101*	96*
600	162	135	123	107*	98*	92*	86*
610	151	125	114	98*	89*	82*	77*
620	140	116	105	89*	80*	72*	66*
630	131	107	96	80*	70*	61*	-
640	121	98	87	71*	57*	-	-
650	113	90	78	58*	-	-	-
660	104	81	69	-	-	-	-
670	96	72	56	-	-	-	-
680	88	62	-	-	-	-	-
690	80	-	-	-	-	-	-
700	71	-	-	-	-	-	-
710	61	-	-	-	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

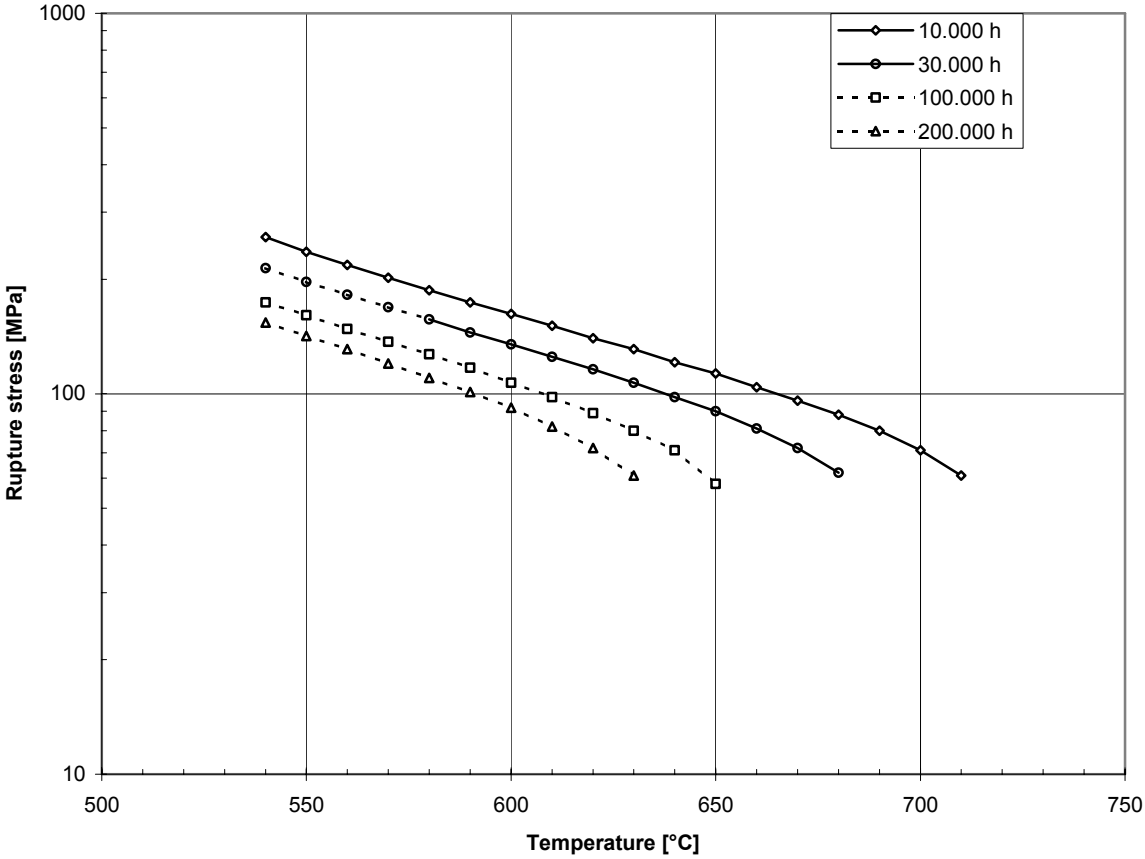
Michael Spindler
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X6CrNiNb 18-10 (1.4550, Type 347, Solution Annealed 950-1070°C)

Working group: WG3.3
Year: 1999



Master equation

Standard ISO method used to fit data. The master curve is described by:

$$P_{(\sigma)} = a + b(\log\sigma) + c(\log\sigma)^2 + d(\log\sigma)^3 + e(\log\sigma)^4 = \frac{\log t - \log t_a}{(T - T_a)^r}$$

where $P_{(\sigma)}$ is the creep rupture parameter; T is the temperature in Kelvin; t is the time to rupture in hours; σ is the stress in N/mm^2; r is a temperature exponent; and a, b, c, d and e are constants

a = 0.02552033961, b = -0.1317141056, c = 0.1342087686, d = -0.05484899506, e = 0.007650834508, r = 1, T_a = 340, $\log t_a$ = 14.446140289

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X8CrNiNb16-13 (1.4961, 16-13Nb)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges in EN 10028-7	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.05	0.1	0.04	0.1
	Si	wt%	0.07	0.88	0.30	0.60
	Mn	wt%	0.11	1.45	-	1.50
	P	wt%	0.005	0.043	-	0.035
	S	wt%	0.005	0.02	-	0.015
	Cr	wt%	15.77	17.16	15.00	17.00
	Mo	wt%	0.02	0.62	-	-
	Ni	wt%	12.0	13.55	12.00	14.00
	V	wt%	0.02	0.1	-	-
	Nb	wt%	0.55	0.95	10x(%C)	1.20
	Al	wt%	0.00	0.04	-	-
	N	wt%	0.017	0.044	-	-
Product	Form	Plate			EN 10028-7	
	Section size	mm	-	25	-	75
	Form	Tube			EN 10216-5	
	Section size	mm	14	18	-	60
	Form	Bar & Forging			-	
	Section size	mm	15	215	-	-
Heat treatment	Solution	°C	1050	1150	1050	1110
Tensile Properties	$R_{P,0.2}$	N/mm²	206	320	200	-
	R_M	N/mm²	534	624	510	690

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17459, DIN 17460 Ergebnisse deutscher Zeitstandversuche langer Dauer, Verlag Stahleisen, Düsseldorf, 1969.	See below
Description of method used to assess data The assessment was made by the German Creep Committee in 1969 by using the manual method	

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
500	1		1					
550	3	1	1	1				
600	20	43	7	6	5	4 (3)	(1)	(1)
650	24	67	12	5	5	5 (2)	(2)	1 (2)
700	20	83	5	3	2	3	(2)	(1)
750	3	13	2	2	1		(2)	
800	1	2						
Totals	28	209	28	17	13	12 (5)	(7)	1 (4)
( ) Figures in parentheses denote unbroken tests								

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X8CrNiNb16-13 (1.4961, 16-13Nb)

Average rupture ☒creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
580	182	129	115 *
590	170	119	105 *
600	157	108	94 *
610	145	98	85 *
620	134	89	77 *
630	124	80	69 *
640	113	72	61 *
650	103	64	53 *
660	93	57 *	47 *
670	84	50 *	41 *
680	76	44 *	36 *
690	70	39 *	31 *
700	64	34 *	27 *
710	59 *	30 *	25 *
720	55 *	27 *	22 *
730	51 *	25 *	19 *
740	47 *	22 *	17 *
750	44 *	20 *	15 *

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Michael Spindler

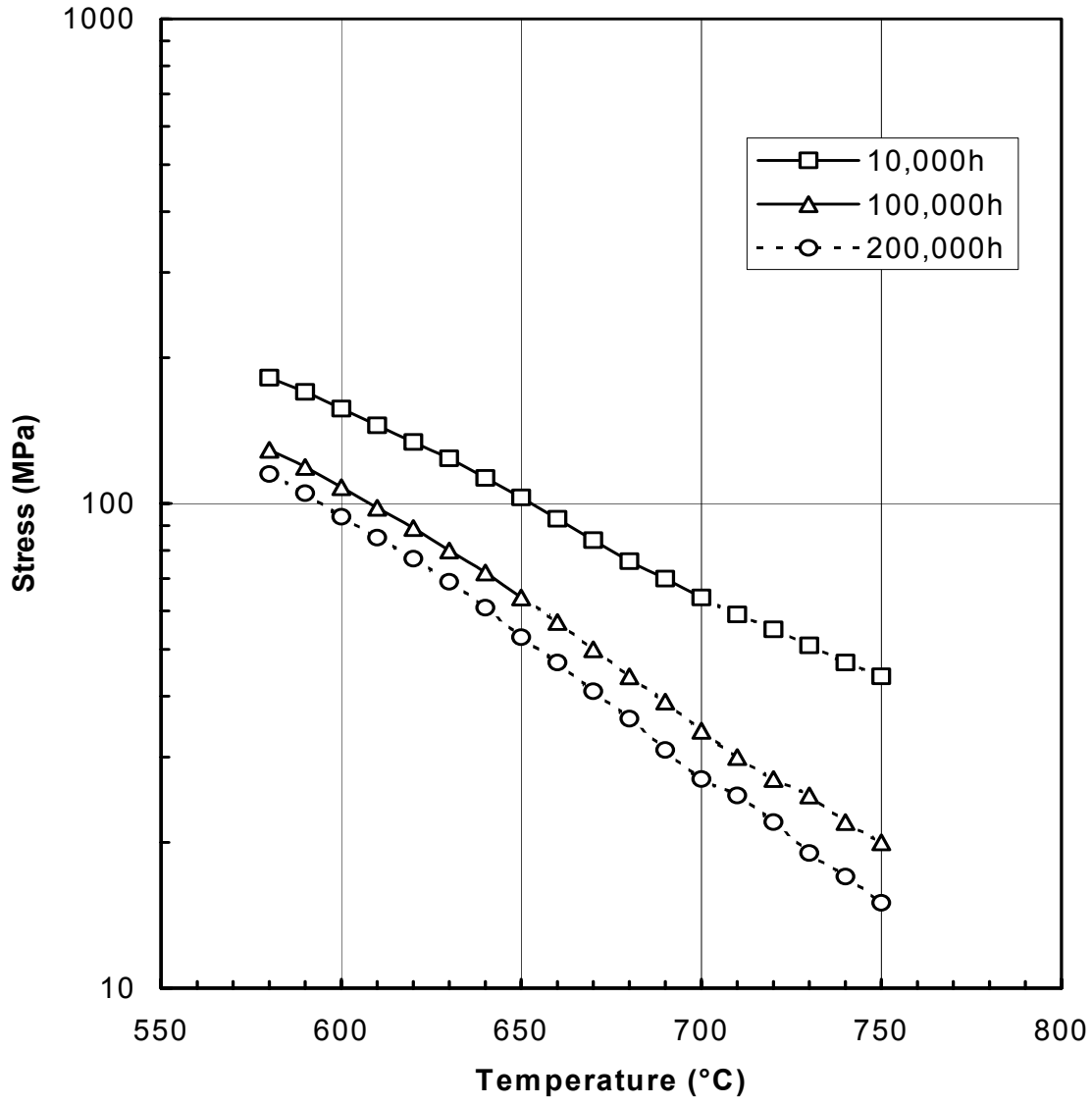
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X8CrNiNb16-13 (1.4961, 16-13Nb)

Working group: WG3.3
Year: 1999



Master equation
Not Applicable (graphical assessment)

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ECCC data sheet

Rupture ☒ Creep ☒ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X5 NiCrAlTi 31- 20 (1.4958, Alloy 800)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.03	0.08
	Si	wt%	-	-	-	0.70
	Mn	wt%	-	-	-	1.5
	P	wt%	-	-	-	0.015
	S	wt%	-	-	-	0.010
	Cr	wt%	-	-	19.0	22.0
	Ni	wt%	-	-	30.0	32.5
	Co	wt%	-	-	-	0.5
	(Ni + Co)	wt%	-	-	30.0	32.5
	Cu	wt%	-	-	-	0.5
	Nb	wt%	-	-	-	0.1
	Al	wt%	-	-	0.20	0.50
	Ti	wt%	-	-	0.20	0.50
	(Al + Ti)	wt%	-	-	-	0.70
	N	wt%	-	-	-	0.03
Product	Form		Pipe, wall thickness ≤ 50			
	Section size	mm	Plate, forgings, see DIN 17460			
Heat treatment	Solution annealed	°C			1100	1200
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	170	-
	$R_{P,1.0\ (min)}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	750

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17459	High temperature seamless circular steel tubes; technical delivery conditions
DIN 17460	High temperature austenitic steels; technical delivery conditions for plate, cold and hot rolled strip, bars and forgings

Description of method used to assess data
Not specified

Average rupture ☒ strength

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
500	290	215	(196)
510	279	205	(186)
520	267	195	(176)
530	254	184	(166)
540	240	172	(155)
550	225	160	(143)
560	208	147	(130)
570	190	133	(117)
580	172	119	(105)
590	155	106	(93)
600	140	95	(83)
610	128	85	(74)
620	118	78	(68)
630	109	72	(63)
640	103	67	(59)
650	97	63	(55)
660	91	59	(52)
670	85	55	(48)
680	80	52	(45)
690	74	48	(41)
700	69	44	(38)

() Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

Average creep ☒ strength (1.00% strain)

Temps	10.000h	100.000h
°C	-	-
500	-	-
510	-	-
520	-	-
530	-	-
540	-	-
550	-	-
560	-	-
570	-	-
580	-	-
590	-	-
600	115	(85)
610	109	(79)
620	102	(74)
630	96	(69)
640	90	(64)
650	84	(59)
660	78	(55)
670	73	(51)
680	68	(47)
690	63	(43)
700	58	(40)

() Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

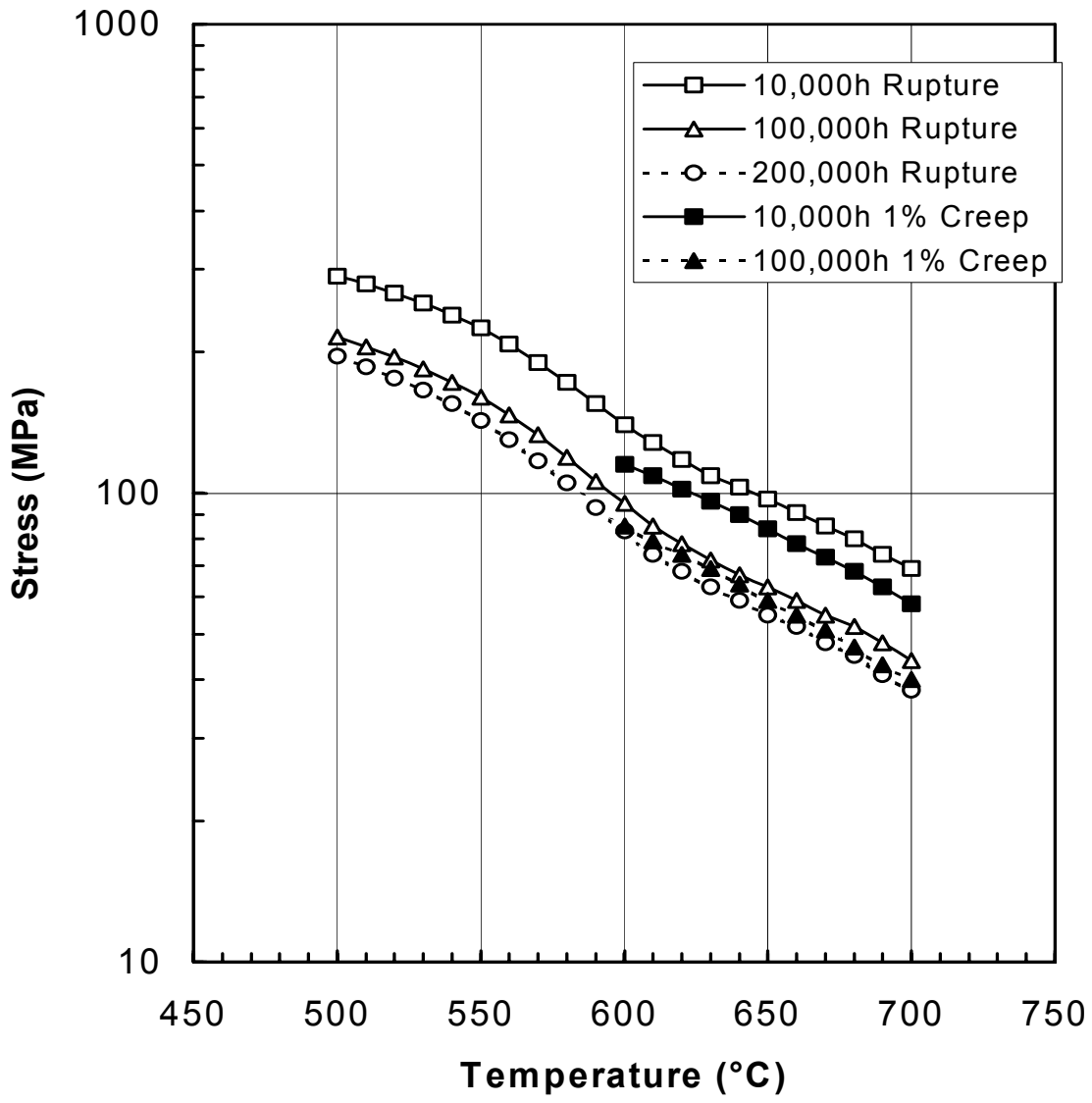
Signed: Michael Spindler WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☒ Relaxation ☐ strength
Formal assessment: ☐

Steel X5 NiCrAlTi 31- 20 (1.4958, Alloy 800)

Working group: WG3.3
Year: 1999



Master equation
Unknown

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.3
Year: 1998

Steel X8NiCrAlTi 32-21 (1.4959, Alloy 800H)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges* Min	Max
Chemical composition	C	wt%	0.05	0.10	0.05	0.10
	Si	wt%	0.32	0.74	-	0.70
	Mn	wt%	0.50	1.34	-	1.50
	P	wt%	0.007	0.019	-	0.015
	S	wt%	0.001	0.017	-	0.010
	Ti	wt%	0.21	0.59	0.25	0.65
	Al	wt%	0.19	0.58	0.25	0.65
	(Al+Ti)	wt%	0.46	1.07	-	-
	Cr	wt%	19.0	21.5	19.0	22.0
	Ni	wt%	29.4	34.45	30.0	34.0
	Co	wt%	0.028	0.76	-	0.50
	(Ni+Co)	wt%	30.09	34.78	30.0	34.0
	N	wt%	-	-	-	0.03
	Cu	wt%	0.006	0.70	-	0.50
Product	Form		Tubes (≤50mm), plate and sheet, cold and hot rolled strip, bars and forgings			
	Section size	mm	-	-	-	75
Heat treatment	Solution Annealed	°C	1120	1190	1100	1200
		ASTM grain size 5 or coarser				
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	170	-
	$R_{P,1.0}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	750

* Specified ranges according to specification in DIN 17459 and DIN 17460 (Sept. 1992).

Quantity and duration of data used in assessment

Temps	No. of Heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
500°C	2	2	2	-	-	-	-	-
550°C	2	4	-	1	-	1	-	-
600°C	19	48	9	-	2	1	-	-
650°C	6	15	1	3	-	-	(1)	-
700°C	22	69	14	1	3 (2)	2	3	-
704°C	6	16	1	1	-	-	-	-
732°C	1	1	-	-	-	-	-	-
760°C	5	10	1	-	-	-	-	-
800°C	45	128	25	6	8 (2)	1	(1)	-
816°C	7	16	2	-	-	-	-	-
850°C	1	3	-	-	-	-	-	-
871°C	3	7	-	-	-	-	-	-
900°C	46	145 (1)	10	7	7 (1)	1 (3)	1	-
927°C	4	11	-	-	-	-	-	-
950°C	5	12	2	-	-	-	-	-
982°C	5	9	1	-	-	-	-	-
1000°C	22	72	13	4 (1)	3	-	-	-
1038°C	1	1	-	-	-	-	-	-
1050°C	6	8	1	-	-	-	-	-
1093°C	2	3	-	-	-	-	-	-
Totals	58	580 (1)	82	23 (1)	23 (5)	6 (3)	4 (2)	-

( ) Figures in parentheses denote unbroken tests

Michael Spindler
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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X8NiCrAlTi 32-21 (1.4959, Alloy 800H)

Working group: WG3.3
Year: 1998

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	20,000h	30,000h	50,000h	70,000h	100,000h	150,000h	200,000h	250,000h	300,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
550	234	205	190	172*	160*	149*	137*	129*	123*	119*
560	216	189	175	158*	148*	137*	126*	119*	113*	109*
570	199	174	161	145*	136*	126*	116*	109*	104*	100*
580	183	161	148	134	125*	116*	107*	100*	96*	92*
590	169	148	137	123	115*	107*	98*	93*	88*	85*
600	156	137	126	114	106*	99*	91*	85*	81*	78*
610	145	126	117	105	98*	91*	84*	79*	75*	72*
620	134	117	108	97	91*	84*	77*	72*	69*	66*
630	124	108	100	90	84	78*	71*	67*	64*	61*
640	115	100	92	83	77	72*	66*	62*	59*	56*
650	106	93	85	77	72	66	61*	57*	54*	52*
660	99	86	79	71	66	61	56*	53*	50*	48*
670	91	80	73	66	61	57	52*	48*	46*	44*
680	85	74	68	61	57	52	48	45*	43*	41*
690	79	68	63	56	52	48	44	41*	39*	38*
700	73	63	58	52	49	45	41	38*	36*	35*
710	68	59	54	48	45	41	38	35*	33*	32*
720	63	55	50	45	42	38	35	33*	31*	30*
730	59	51	47	42	39	35	32	30*	28*	27*
740	54	47	43	39	36	33	30	28*	26*	25*
750	51	44	40	36	33	30	28	26*	24*	23*
760	47	41	37	33	31	28	25	24*	22*	21*
770	44	38	34	31	28	26	23	22*	21*	20*
780	41	35	32	28	26	24	22	20*	19*	18*
790	38	33	30	26	24	22	20	19*	17*	17*
800	35	30	27	24	22	20	18	17*	16*	15*
810	33	28	25	23	21	19	17	16*	15*	14*
820	30	26	24	21	19	17	16	14*	14*	13*
830	28	24	22	19	18	16	14	13*	12*	12*
840	26	22	20	18	16	15	13	12*	11*	11*
850	24	21	19	16	15	14	12	11*	10*	9.8*
860	23	19	17	15	14	13	11	10*	9.4*	8.9*
870	21	18	16	14	13	12	10	9.2*	8.6*	8.1*
880	20	16	15	13	12	11	9.2	8.4*	7.8*	7.3*
890	18	15	14	12	11	9.6	8.4	7.6*	7.1*	6.6*
900	17	14	13	11	9.8	8.8	7.7	6.9*	6.4*	5.9*
910	16	13	12	10	9.0	8.0	6.9	6.2*	5.7*	5.3*
920	14	12	11	9.1	8.2	7.3	6.3	5.6*	5.1*	(4.7)*
930	13	11	9.8	8.3	7.5	6.6	5.6*	5.0*	(4.5)*	-
940	12	10	9.0	7.6	6.8	5.9	5.0*	(4.5)*	-	-
950	11	9.3	8.2	6.9	6.1	5.3	(4.5)*	-	-	-
960	11	8.5	7.5	6.3	5.5	(4.8)*	-	-	-	-
970	9.6	7.8	6.8	5.7	4.9	-	-	-	-	-
980	8.9	7.1	6.2	5.1	(4.4)*	-	-	-	-	-
990	8.1	6.5	5.6	(4.5)	-	-	-	-	-	-
1000	7.4	5.9	5.0	-	-	-	-	-	-	-

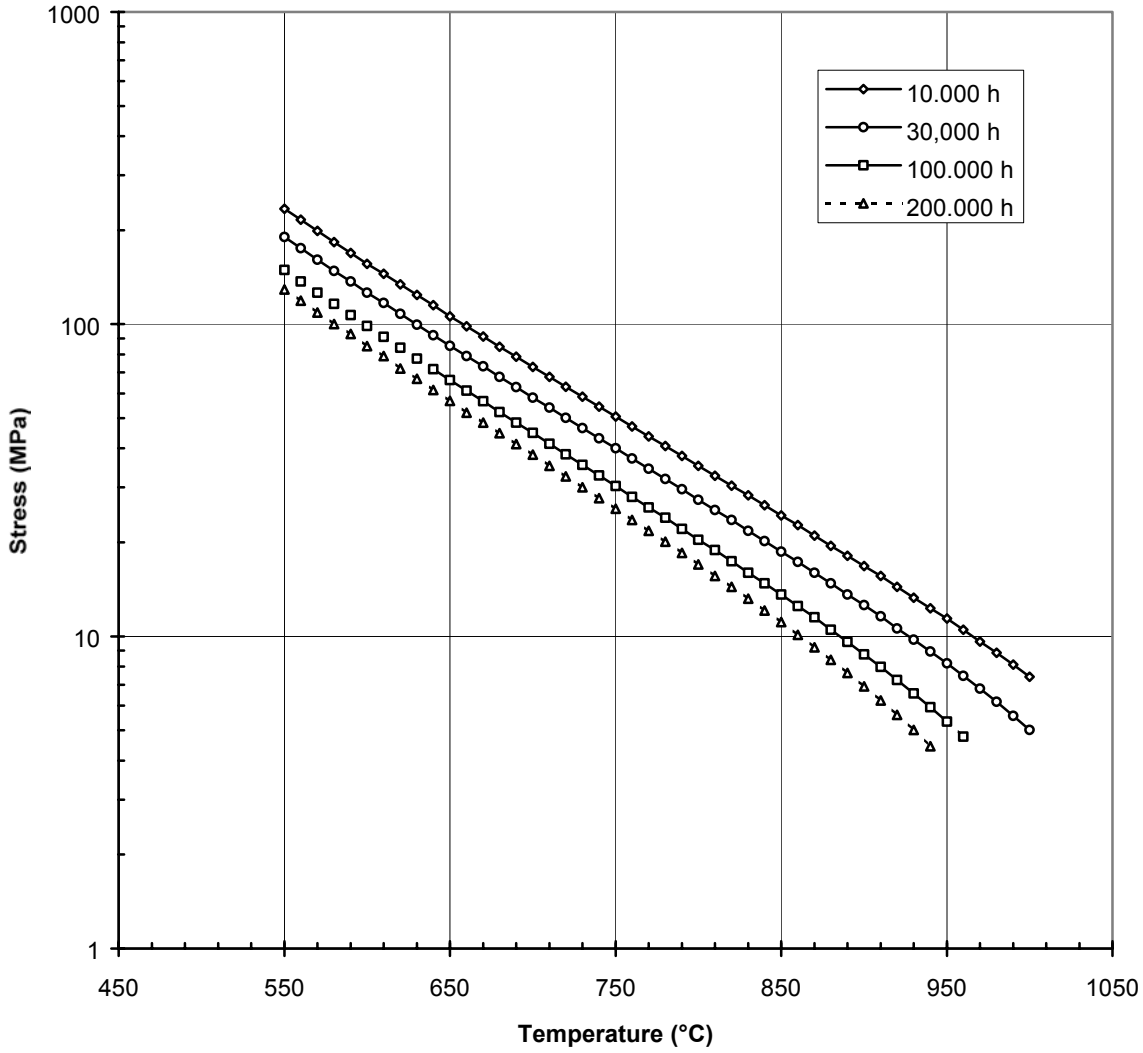
* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X8NiCrAlTi 32-21 (1.4959, Alloy 800H)

Working group: WG3.3
Year: 1998



Master equation

Method used for fitting data was PD6605: 1998, and the resulting master curve is best described by the Manson-Haferd model:

$\log_e(t^*_r) = (\beta_0 + \beta_1 \log_{10}[\sigma] + \beta_2 (\log_{10}[\sigma])^2) \cdot (T-T_0) + \beta_5$

where t^*_r is the predicted time to failure in hours, T is the temperature in Kelvin, σ is the stress in MPa and T_0, β_0, β_1, β_2 and β_5 are coefficients.

$T_0 = 40$, $\beta_0 = -0.025405325$, $\beta_1 = -7.01403478E-5$, $\beta_2 = -0.00328530301$, $\beta_5 = 43.6846733$

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X8NiCrAlTi 32-21 (Alloy 800HT, restr. Al+Ti cont.)

Working group: WG3.3
Year: 1998

Condition of alloy to which the properties apply

	Details of materials tested	Units	Mln	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.05	0.10	0.05	0.10
	Si	wt%	0.32	0.74	-	0.70
	Mn	wt%	0.50	1.34	-	0.15
	P	wt%	0.007	0.019	-	0.015
	S	wt%	0.001	0.017	-	0.010
	Cr	wt%	19.0	21.5	19.0	22.0
	Ni	wt%	29.4	34.45	30.0	34.0
	Co	wt%	0.028	0.76	-	0.5
	(Ni + Co)	wt%	30.09	34.78	30.0	34.0
	Cu	wt%	0.006	0.7	-	0.5
	Al	wt%	0.19	0.58	0.25	0.65
	Ti	wt%	0.21	0.59	0.25	0.65
	(Al + Ti)	wt%	0.85	1.07	0.85	1.20
Product	Form Section size	 mm	Tube Wall Thickness ≤ 50 mm			
Heat treatment	Solution annealed	°C	(>1150°C) ASTM grain size 5 or coarser.			
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	170	-
	$R_{P,1.0}$	N/mm²	-	-	200	-
	R_M	N/mm²	-	-	500	750

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
°C		Number of test points available						
600	4	8	-	-	-	-	-	-
650	4	14	-	1	-	-	-	-
700	7	19	1	-	1 (1)	1	-	-
704	6	16	1	1	-	-	-	-
732	1	1	-	-	-	-	-	-
760	4	9	1	-	-	-	-	-
800	15	39	8	1	4 (2)	-	-	-
816	6	15	2	-	-	-	-	-
871	3	7	-	-	-	-	-	-
900	15	41 (1)	2	4	4 (1)	-	-	-
927	4	11	-	-	-	-	-	-
982	5	9	1	-	-	-	-	-
1000	6	16	4	1 (1)	1	-	-	-
1038	1	1	-	-	-	-	-	-
1050	1	1	1	-	-	-	-	-
1093	2	3	-	-	-	-	-	-
Totals	84	210 (1)	21	8 (1)	10 (4)	1	-	-

() Figures in parentheses denote unbroken tests

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.3
Year: 1998

Steel X8NiCrAlTi 32-21 (Alloy 800HT, restr. Al+Ti cont.)

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	20,000h	30,000h	50,000h	70,000h	100,000h	150,000h	200,000h	250,000h	300,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
600	177	156	145	132*	125*	117*	108*	103*	99*	95*
610	162	143	133	122*	114*	107*	100*	95*	91*	88*
620	149	132	123	112*	105*	99*	92*	87*	84*	81*
630	137	121	113	103*	97*	91*	85*	80*	77*	75*
640	126	112	104	95*	90*	84*	78*	74*	71*	69*
650	117	103	96	88*	83*	78*	72*	68*	66*	64*
660	108	95	89	81	77*	72*	67*	63*	61*	59*
670	99	88	82	75	71*	66*	62*	59*	56*	54*
680	92	82	76	70	66*	62*	57*	54*	52*	50*
690	85	76	71	65	61*	57*	53*	50*	48*	47*
700	79	70	65	60	56*	53*	49*	47*	45*	43*
710	73	65	61	56	52	49*	46*	43*	41*	40*
720	68	61	56	52	49	46*	42*	40*	38*	37*
730	63	56	53	48	45	42*	39*	37*	36*	34*
740	59	52	49	45	42	39*	36*	35*	33*	32*
750	55	49	45	41	39	37	34*	32*	31*	30*
760	51	45	42	39	36	34	31*	30*	29*	28*
770	48	42	39	36	34	32	29*	28*	26*	26*
780	45	39	37	33	31	29	27*	26*	25*	24*
790	42	37	34	31	29	27	25*	24*	23*	22*
800	39	34	32	29	27	25	23*	22*	21*	20*
810	36	32	30	27	25	24	22*	20*	20*	19*
820	34	30	28	25	23	22	20*	19*	18*	17*
830	31	28	26	23	22	20	19*	18*	17*	16*
840	29	26	24	22	20	19	17*	16*	15*	15*
850	27	24	22	20	19	17	16*	15*	14*	14*
860	26	22	21	19	17	16	15*	14*	13*	12*
870	24	21	19	17	16	15	14*	13*	12*	11*
880	22	19	18	16	15	14	12*	12*	11*	10*
890	21	18	17	15	14	13	11*	11*	9.8*	9.3*
900	19	17	15	14	13	12	10*	9.5*	8.9*	8.4*
910	18	15	14	13	12	11	9.4*	8.6*	8.0*	7.5*
920	17	14	13	12	11	9.6	8.5*	7.7*	7.1*	6.6*
930	15	13	12	11	9.6	8.7*	7.6*	6.8*	6.2*	5.7*
940	14	12	11	9.6	8.7	7.8*	6.7*	5.9*	5.3*	(4.7)*
950	13	11	10	8.7	7.8	6.9*	5.8*	5.0*	-	-
960	12	10	9.2	7.8	7.0*	6.0*	(4.8)*	-	-	-
970	11	9.4	8.3	7.0	6.1*	5.1*	-	-	-	-
980	10	8.5	7.4	6.1*	5.2*	-	-	-	-	-
990	9.4	7.6	6.6	5.2*	-	-	-	-	-	-
1000	8.5	6.8	5.7	-	-	-	-	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

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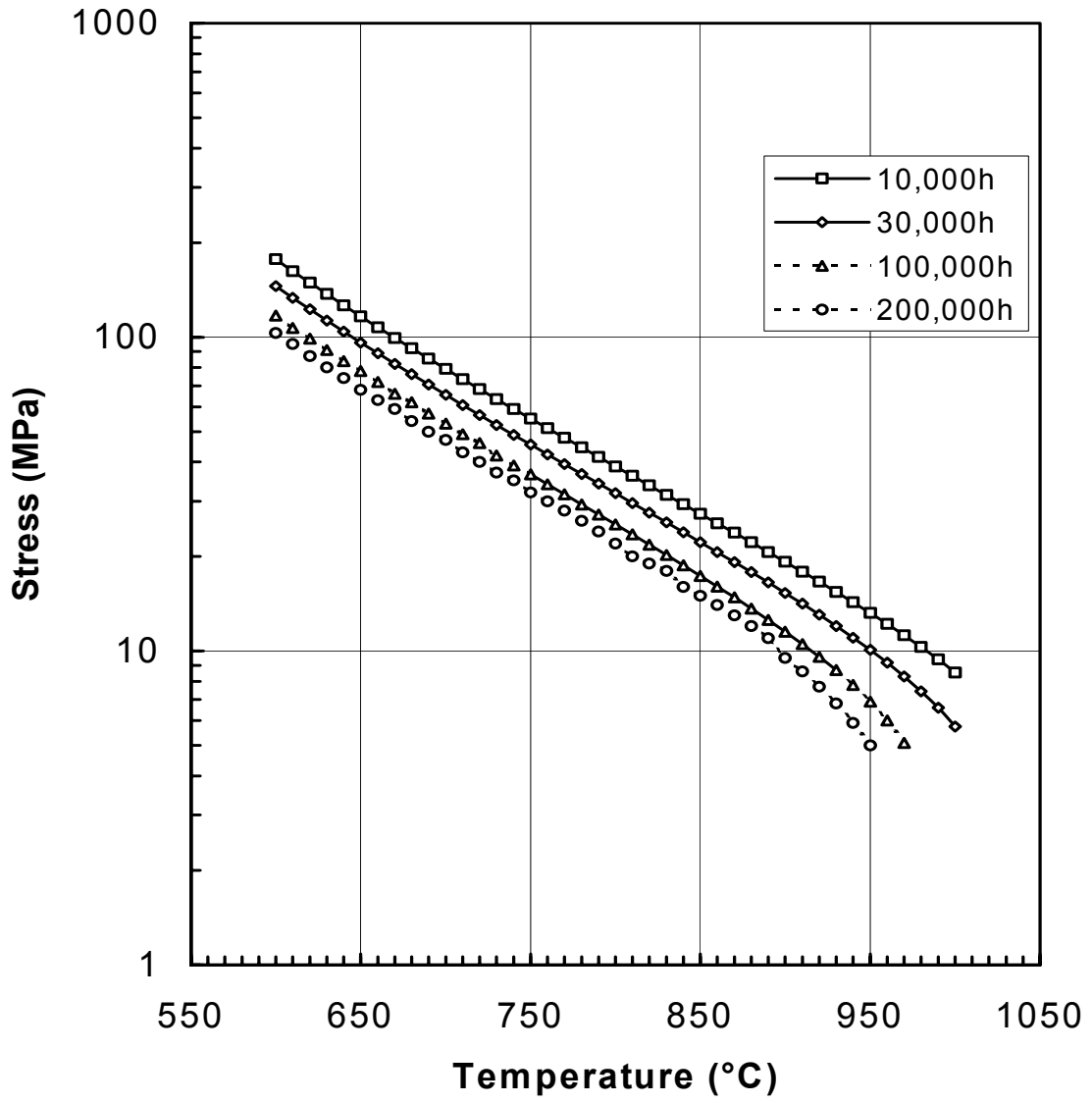
ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X8NiCrAlTi 32-21 (Alloy 800HT, restr. Al+Ti cont.)

Working group: WG3.3
Year: 1998



Master equation

Method used for fitting data was PD6605: 1998, and the resulting master curve is best described by the Manson-Haferd model:

$\log_e(t^*_r) = (\beta_0 + \beta_1 \log_{10}[\sigma] + \beta_2 (\log_{10}[\sigma])^2 + \beta_3 (\log_{10}[\sigma])^3) \cdot (T-T_0) + \beta_5$

where t^*_r is the predicted time to failure in hours, T is the temperature in Kelvin, σ is the stress in MPa and T_0, β_0, β_1, β_2, β_3 and β_5 are coefficients.

$T_0 = 0$, $\beta_0 = -0.0343260355$, $\beta_1 = 0.00917885825$, $\beta_2 = -0.0102627706$, $\beta_3 = 0.00147242681$, $\beta_5 = 51.8493652$

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ECCC data sheet

Rupture ☒ Creep ☒ Relaxation ☐ strength
Formal assessment: ☐

Steel X5 NiCrAlTi 31- 20 RK (Alloy 800 - recrystallized)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	-	-	0.03	0.08
	Si	wt%	-	-	-	0.70
	Mn	wt%	-	-	-	1.5
	P	wt%	-	-	-	0.015
	S	wt%	-	-	-	0.010
	Cr	wt%	-	-	19.0	22.0
	Ni	wt%	-	-	30.0	32.5
	Co	wt%	-	-	-	0.5
	(Ni + Co)	wt%	-	-	30.0	32.5
	Cu	wt%	-	-	-	0.5
	Nb	wt%	-	-	-	0.1
	Al	wt%	-	-	0.20	0.50
	Ti	wt%	-	-	0.20	0.50
	(Al + Ti)	wt%	-	-	-	0.70
	N	wt%	-	-	-	0.03
Product	Form		Pipe, wall thickness ≤ 50 mm			
	Section size	mm	Plate, forgings, see DIN 17460			
Heat treatment	Recrystallized	°C			920	1000
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	210	-
	$R_{P,1.0\ (min)}$	N/mm²	-	-	240	-
	R_M	N/mm²	-	-	500	750

Source references of analysed data used in assessment

Source references	Scope of data
DIN 17459	High temperature seamless circular steel tubes; technical delivery conditions
DIN 17460	High temperature austenitic steels; technical delivery conditions for plate, cold and hot rolled strip, bars and forgings

Description of method used to assess data
Not specified

Average rupture ☒ creep ☐ relaxation ☐ strengths (

Temps	10,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²
500	315	258	(242)
510	297	241	(225)
520	280	224	(207)
530	262	206	(190)
540	243	189	(172)
550	224	171	(155)
560	204	153	(138)
570	184	136	(122)
580	165	119	(106)
590	147	104	(92)
600	131	90	(80)
610	117	79	(70)
620	106	70	(62)
630	96	62	(55)
640	87	56	(49)
650	80	51	(44)
660	73	46	(40)
670	67	42	(36)
680	61	38	(33)
690	55	34	(29)
700	50	30	(26)

() Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

% strain) Average 1% strain

Temps	10,000h	100,000h
°C	-	-
500	-	-
510	-	-
520	-	-
530	-	-
540	-	-
550	164	(132)
560	154	(122)
570	144	(111)
580	133	(101)
590	121	(92)
600	113	(82)
610	103	(74)
620	93	(65)
630	84	(58)
640	75	(51)
650	67	(46)
660	60	(41)
670	55	(37)
680	50	(33)
690	45	(30)
700	41	(27)

() Values which have involved extended time and/or stress extrapolation, as indicated in the source reference.

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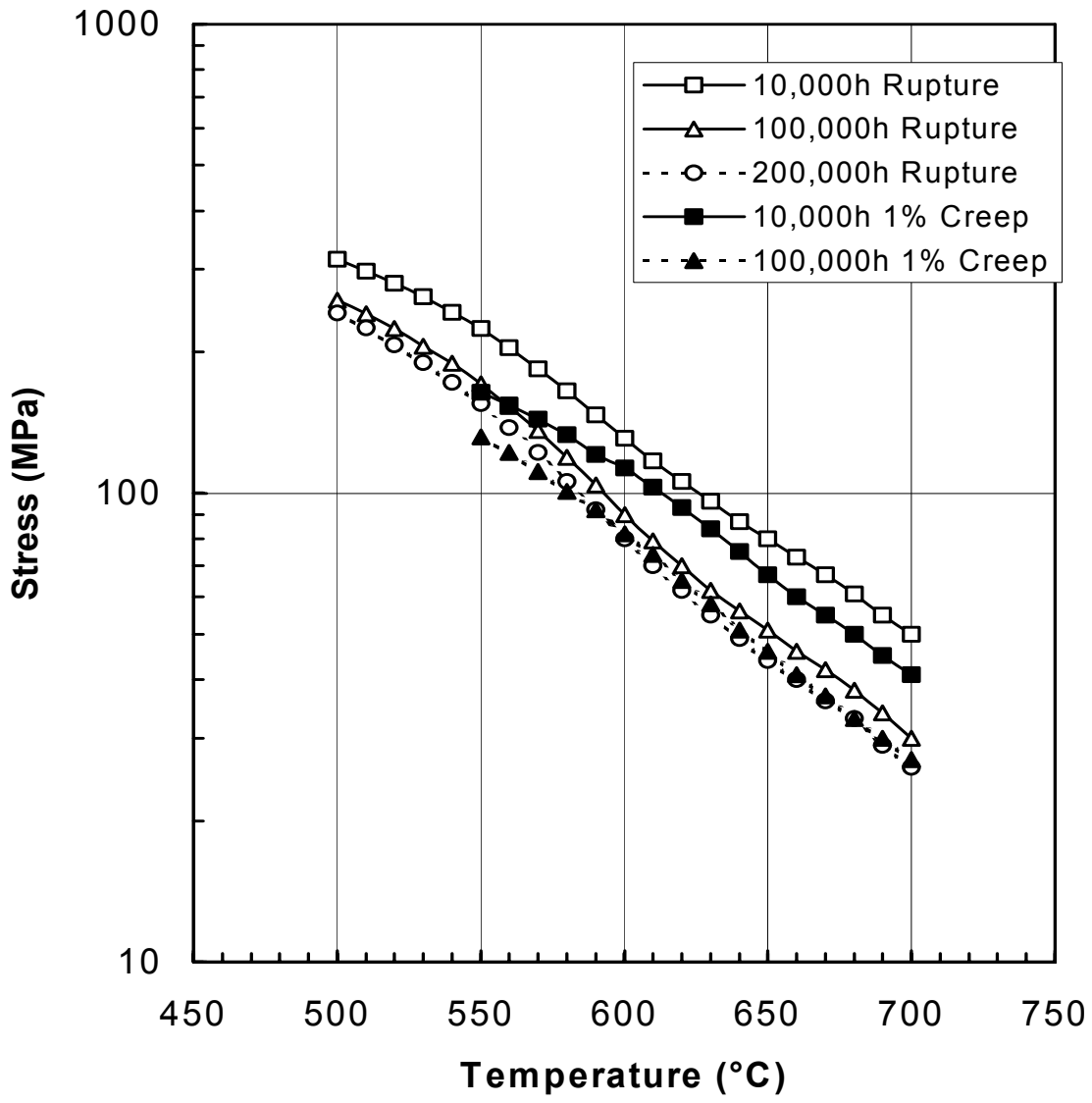
ECCC data sheet

Rupture ☒ Creep ☒ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X5 NiCrAlTi 31- 20 RK (Alloy 800- recrystallized)



Master equation
Unknown

ECCC data sheet

Rupture ☐ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X6NiCrNbCe32-27 (1.4877, Type AC 66)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested		VdTÜV-Werkstoffblatt 497 (06.90)		Specified ranges in EN 10095	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.04	0.08	0.04	0.08
	Si	wt%	-	0.30	-	0.30
	Mn	wt%	-	1.00	-	1.0
	P	wt%	-	0.015	-	0.020
	S	wt%	-	0.010	-	0.010
	Cr	wt%	26.0	28.0	26.0	28.0
	Mo	wt%	-	-	-	-
	Ni	wt%	31.0	33.0	31.0	33.0
	V	wt%	-	-	-	-
	Nb	wt%	0.6	1.0	0.6	1.0
	Al	wt%	-	0.025	-	0.025
	N	wt%	-	-	-	0.11
	Ce	wt%	0.05	0.10	0.05	0.10
Product	Form	Plate				
	Section size	mm	-	30	-	75
	Form	Bar				
	Section size	mm	-	250	-	160
	Form	Tube	Diameter < 180 mm			
	Section size	mm	-	25	-	-
Heat treatment	Solution Anneal	°C	1120	1180	1050	1150
Tensile Properties	$R_{P,0.2}$	N/mm²	185	-	180	-
	R_M	N/mm²	500	750	500	750

Source references of analysed data used in assessment

Source references	Scope of data
VdTÜV-Werkstoffblatt 497 (06.90)	unknown

Description of method used to assess data
Graphical method (manual)

Average rupture ☐ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h	Temps	10,000h	100,000h
°C	N/mm²	N/mm²	°C	N/mm²	N/mm²
580	(199)	(160)	770	(36)	(22)
590	(187)	(150)	780	(32)	(20)
600	(176)	(140)	790	(28)	(18)
610	(163)	(130)	800	(25)	(16)
620	(153)	(120)	810	(23)	(14.5)
630	(142)	(111)	820	(20.5)	(13)
640	(131)	(101)	830	(19)	(11.5)
650	(120)	(92)	840	(17)	(10)
660	(112)	(83)	850	(15.9)	(9)
670	(104)	(74)	860	(14)	(8)
680	(95)	(66)	870	(13)	(7)
690	(87)	(58)	880	(12)	(6.3)
700	(80)	(52)	890	(11)	(5.6)
710	(71)	(45)	900	(10)	(5)
720	(63)	(39)	910	(9)	(4.5)
730	(57)	(34)	920	(8.2)	(4)
740	(51)	(30)	930	(7.9)	(3.6)
750	(46)	(27)	940	(6.8)	(3.3)
760	(40)	(24.5)	950	(6)	(3)

(1) Information concerning which strengths are the results of extended extrapolation is typically unavailable for this type of assessment. Hence, all values should be considered as "qualified".

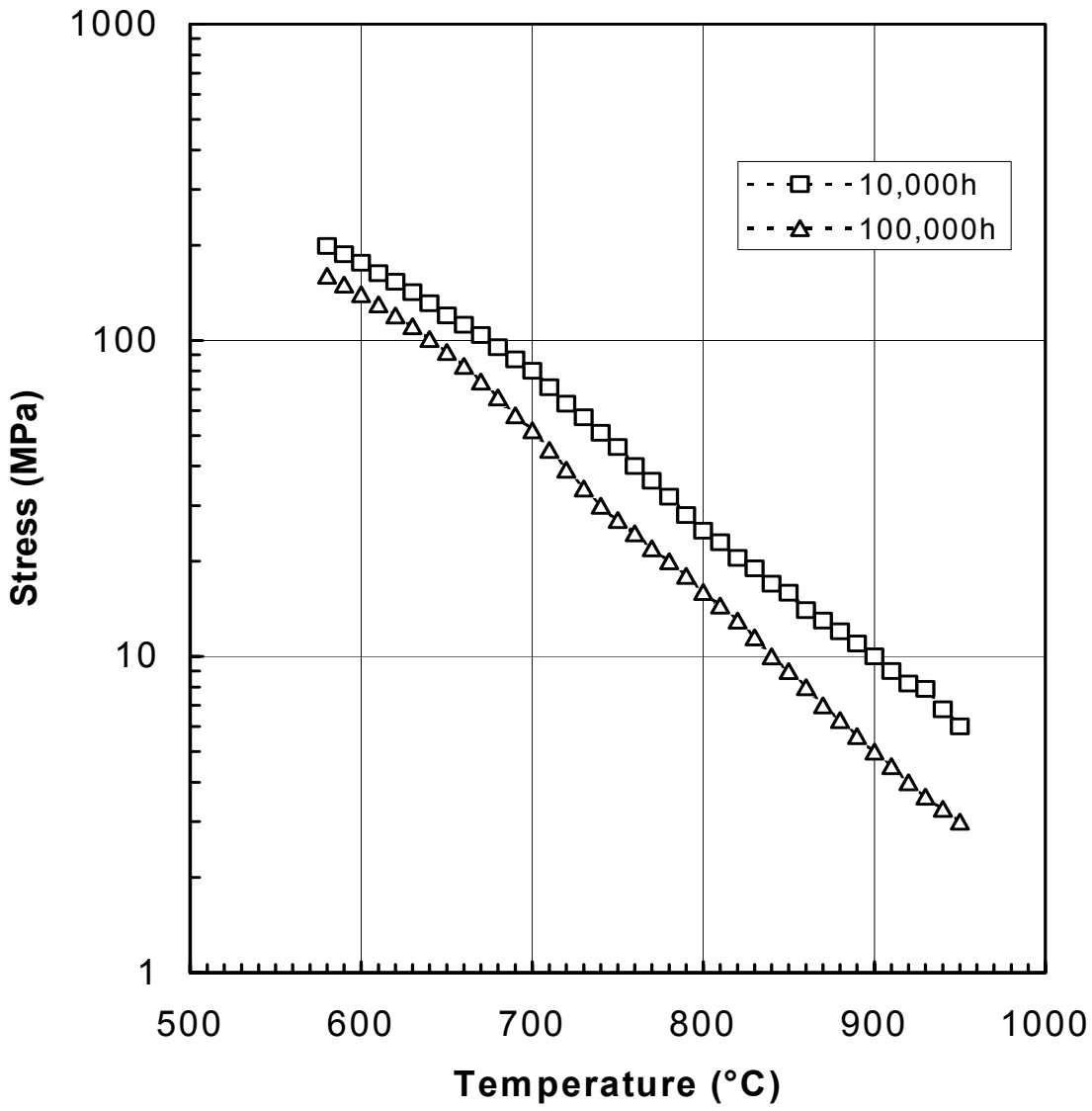
Michael Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☐ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel X6NiCrNbCe32-27 (1.4877, Type AC 66)



Master equation
Not Applicable (graphical assessment).

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel X7CrNiSiNCe 21-11 (253MA)

Working group: WG3.3
Year: 1998

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.062	0.091	0.05	0.10
	Si	wt%	1.54	1.82	1.4	2.0
	Mn	wt%	0.27	0.75	-	0.80
	P	wt%	0.012	0.026	-	0.040
	S	wt%	0.0002	0.004	-	0.030
	Cr	wt%	20.36	21.2	20.0	22.0
	Ni	wt%	10.75	11.08	10.0	12.0
	N	wt%	0.15	0.20	0.14	0.20
	Ce	wt%	0.03	0.08	0.03	0.08
Product	Form	Plate				
	Section size	mm	12	25	-	30
	Form	Tube	(wall thickness)			
	Section size	mm	6	10	-	30
	Form	Bar				
	Section size	mm	18	20	-	50
Heat treatment	Solution	°C	1050	1180	1020	1180
Tensile Properties	$R_{p,0.2}$	N/mm²	297	383	295	-
	$R_{p,1.0}$	N/mm²	381	419	345	-
	R_m	N/mm²	643	726	640	850

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
°C		Number of test points available						
550	7	26	5	-	-	-	-	-
600	12	51	27	7	4	1	-	-
650	1	2	-	-	-	-	-	-
700	9	42	7	1	-	-	-	-
750	4	37	9	-	-	-	-	-
800	9	34	9	3	3	-	-	-
900	14	70	13	7	3	-	-	-
950	1	1	-	-	-	-	-	-
1000	6	30	4	1	-	-	-	-
1100	4	23	-	-	-	-	-	-
Totals	15	316	74	19	10	1	-	-

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.3
Year: 1998

Steel X7CrNiSiNCe 21-11 (253MA)

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
550	208	178	149*	135*
560	192	162	134*	120*
570	177	147	120*	107*
580	163	134	108	96*
590	150	122	98	86*
600	138	112	88	77*
610	127	102	80	69*
620	117	93	72	63*
630	108	85*	66*	57*
640	100	78*	60*	51*
650	92	72*	54*	47*
660	85	66*	50*	42*
670	78	60*	45*	39*
680	72	55	42*	35*
690	66	51	38*	32*
700	61	47	35*	30*
710	57	43	32*	27*
720	52	40	30*	25*
730	48	37	27*	23*
740	45	34	25*	21*
750	41	32	23*	20*
760	38	29	22*	18*
770	35	27	20*	17*
780	33	25	19	16*
790	30	23	18	15*
800	28	22	16	14*
810	26	20	15	13*
820	24	19	14	12*
830	23	18	13	11*
840	21	16	13	11*
850	20	15	12	10*
860	18	14	11	9.5*
870	17	13	10	9.0*
880	16	13	10	8.5*
890	15	12	9.2	8.0*
900	14	11	8.7	7.6*
910	13	11	8.3	7.2*
920	12	9.9*	7.8*	6.8*
930	12	9.4*	7.4*	6.5*
940	11	8.8*	7.0*	6.2*
950	10	8.4*	6.7*	5.9*
960	9.7	7.9*	6.4*	5.6*
970	9.1	7.5*	6.1*	5.3*
980	8.6	7.1	5.8*	5.1*
990	8.2	6.8	5.5*	4.9*
1000	7.8	6.4	5.3*	4.7*
1010	7.4	6.1	5.0*	4.5*
1020	7.0	5.9	4.8*	(4.3)*
1030	6.7	5.6*	4.6*	-
1040	6.4	5.3*	4.4*	-
1050	6.1	5.1*	(4.2)*	-
1060	5.8	4.9*	(4.1)*	-
1070	5.6	4.7*	-	-
1080	5.4	4.5*	-	-
1090	5.2	4.4*	-	-
1100	5.0	(4.2)*	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

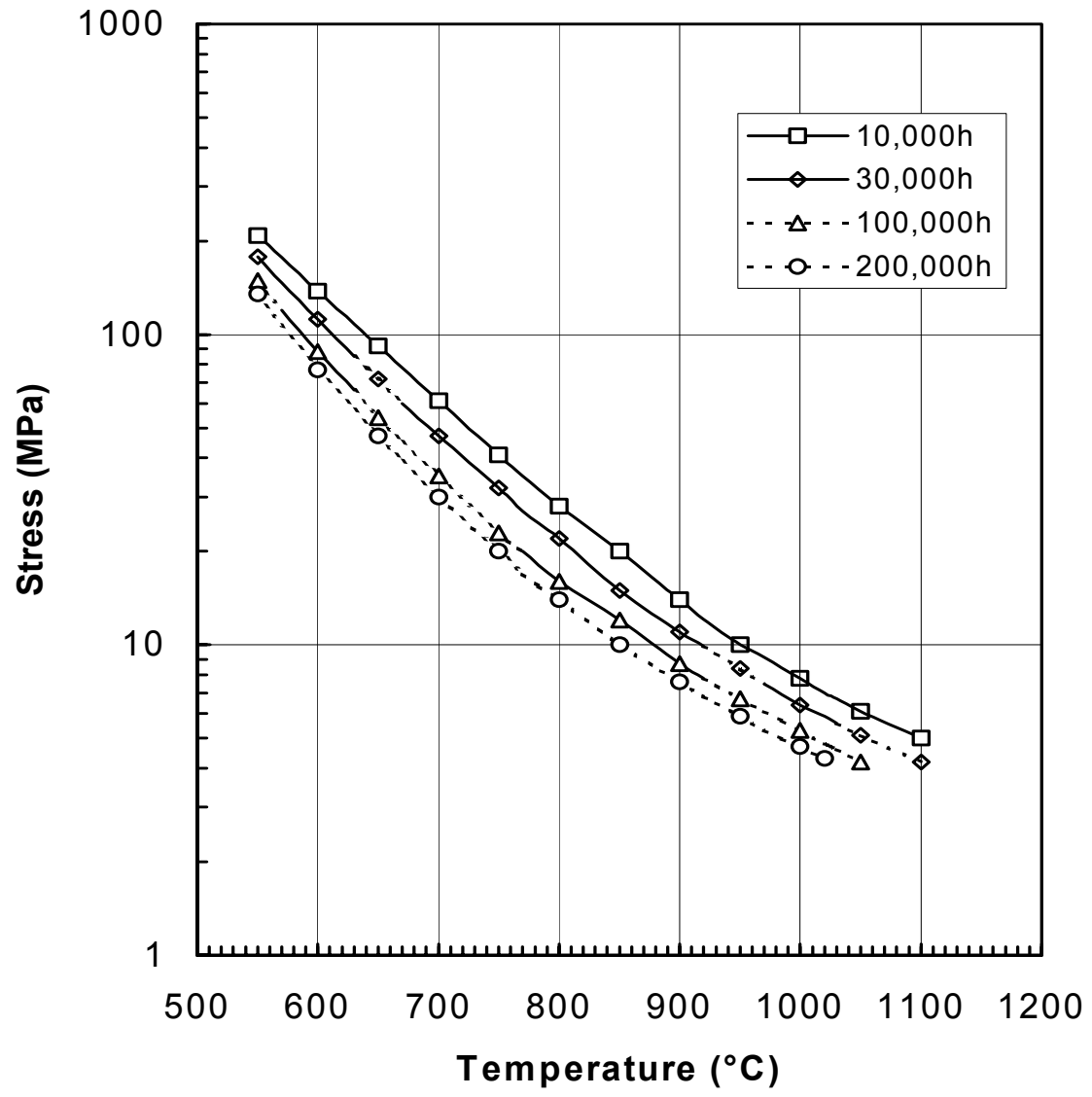
M Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Steel X7CrNiSiNCe 21-11 (253MA)

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.3
Year: 1998



Master equation

$$\log_{10}(t_r^*) = \frac{\log_{10}(\sigma) - f_2(T)}{f_1(T)}$$

where t_r^* is the predicted time to failure in hours, T is the temperature in °C and σ is the stress in MPa.

$f_1(T) = 2.578156379 - (0.009927722923 \cdot T) + (0.00001133695177 \cdot T^2) - (0.000000004157213537 \cdot T^3)$

$f_2(T) = -6.596117608 + (0.03898383604 \cdot T) - (0.00005011376056 \cdot T^2) + (0.00000001929547878 \cdot T^3)$

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X10CrNiMoMnNbVB 15-10-1 (1.4982, Esshete 1250)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.074	0.14	0.06	0.15
	Si	wt%	0.25	0.73	0.20	1.00
	Mn	wt%	5.75	6.75	5.50	7.00
	P	wt%	0.015	0.037	-	0.04
	S	wt%	0.005	0.026	-	0.03
	Cr	wt%	14.40	16.00	14.00	16.00
	Mo	wt%	0.77	1.20	0.80	1.20
	Ni	wt%	8.94	11.00	9.00	11.00
	V	wt%	0.20	0.57	0.15	0.40
	Nb	wt%	0.75	1.20	0.75	1.25
	B	wt%	0.0025	0.009	0.003	0.009
Product	Form		Tube, Bar & Plate			
	Section size	mm	19	41	-	250
Heat treatment	Solution annealed	°C	1040	1150	1050	1150
Tensile Properties	$R_{P,0.2}$	N/mm²	220	410	220	-
	R_M	N/mm²	-	-	540	740

Source references of analysed data used in assessment

Source references	Scope of data
D Burton, J Orr & D Dulieu, An Assessment of The Stress Rupture Properties of Esshete 1250, British Steel Report No. S/RSC/S1122/2/88/E, 1988.	See below
Description of method used to assess data Standard ISO method.	

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
600	97	313(4)	28(1)	8(2)	20(8)	9(6)	7(23)	7
650	164	593(13)	62(2)	40	16(9)	6(1)	4(2)	1
700	64	199	10	7	15(1)	2(2)	2	1
750	18	44	1	3	-	-	-	-
800	32	78	1	-	-	-	-	-
Totals	-	1227(17)	102(3)	58(2)	51(18)	17(9)	13(25)	9
( ) Figures in parentheses denote unbroken tests								

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
600	241	222	199	183
610	231	211	185	165
620	221	200	167	143
630	210	185	147	118
640	198	168	122	97
650	184	148	100	82
660	167	124	84	72
670	147	102	74	64
680	124	86	66	58
690	102	75	59	52
700	86	67	54	48
710	75	60	49	43
720	67	55	45	39
730	61	50	40*	35*
740	55	46	36*	-
750	51	41	30*	-
760	46	37	-	-
770	42	32	-	-
780	38	-	-	-
790	34	-	-	-
* Values which have involved extended time extrapolation () Values which have involved extended stress extrapolation				

M Spindler

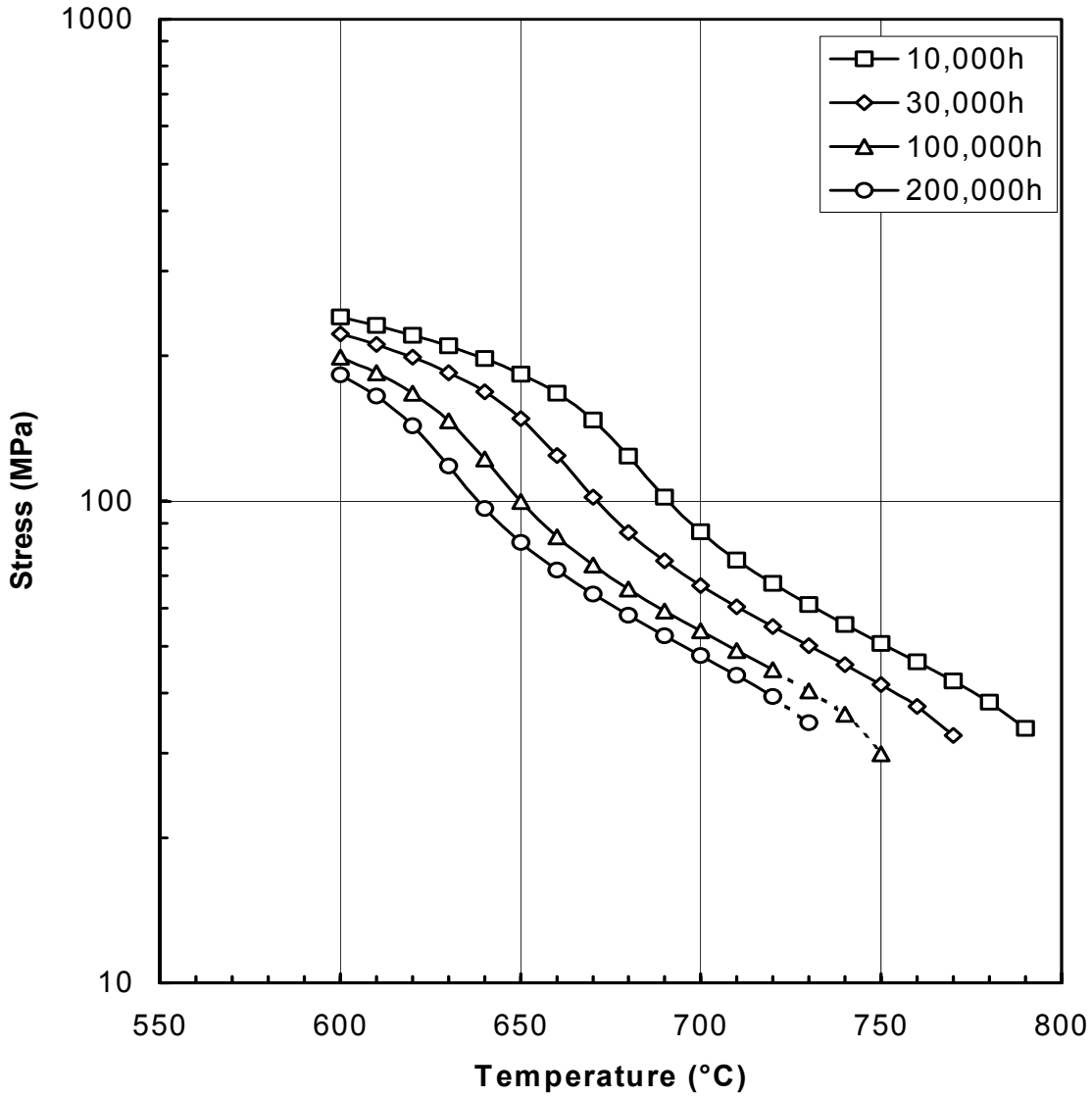
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel X10CrNiMoMnNbVB 15-10-1 (1.4982, Esshete 1250)

Working group: WG3.3
Year: 1999



Master equation

Standard ISO 6303 method used to fit data. The master curve is described by:

$$P_{(\sigma)} = a + b(\log\sigma) + c(\log\sigma)^2 + d(\log\sigma)^3 + e(\log\sigma)^4 = \frac{\log t - \log t_a}{(T - T_a)^r}$$

where $P_{(\sigma)}$ is the creep rupture parameter; T is the temperature in Kelvin; t is the time to rupture in hours; σ is the stress in N/mm^2; r is a temperature exponent; and a, b, c, d and e are constants

a = -336414.5313, b = 799872.0625, c =-654687.0625, d =234517.4219, e =-31193.5293, r = -1, T_a = 0, $\log t_a$ =-18.431352615

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel BS1503 310S31 (Type 310)

Working group: WG3.3
Year: 1999

Condition of alloy to which the properties apply

	Details of materials tested	Units	Mln	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.018	0.20	-	0.15
	Si	wt%	0.26	1.78	-	1.50
	Mn	wt%	0.93	2.00	-	2.00
	P	wt%	0.009	0.035	-	0.045
	S	wt%	0.001	0.025	-	0.030
	Cr	wt%	22.30	25.93	23.00	26.00
	Ni	wt%	19.54	23.00	19.00	22.00
Product	Form		-			
	Section size	mm	-			
Heat treatment	Solution annealed	°C	1050 + hot finish	1130 + hot finish	1000	1120
Tensile Properties	$R_{P,1.0}$	N/mm²	-	-	240	-
	R_M	N/mm²	-	-	510	710

Source references of analysed data used in assessment

Source references	Scope of data
BS PD 6525: Part 1: 1990	See below

Description of method used to assess data
The method used for the fitting was the standard ISO extrapolation method.

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
°C		Number of test points available						
600	-	10 (3)	1	-	-	-	1	-
650	-	46 (2)	3 (1)	-	-	-	-	-
700	-	72 (2)	1 (2)	(1)	-	-	(1)	-
800	-	39	-	-	-	-	-	-
900	-	30 (3)	2	-	-	-	-	-
Totals	-	197 (10)	7 (3)	(1)	-	-	1 (1)	-

() Figures in parentheses denote unbroken tests

ECCC data sheet

Steel BS1503 310S31 (Type 310)

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	50,000h	100,000h	150,000h	200,000h	250,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
600	137	113	104*	92*	86*	82*	79*
610	120	98	90*	79*	74*	71*	68*
620	105	85	78*	69*	64*	61*	59*
630	92	75	68*	60*	56*	54*	52*
640	81	66	60*	53*	50*	47*	46*
650	72	58	53*	47*	44*	42*	41*
660	64	52	47*	42*	39*	38*	36*
670	57	46	42*	38*	35*	34*	33*
680	51	42	38	34*	32*	31*	29*
690	47	38	35	31*	29*	28*	27*
700	42	34	32	28*	26*	25*	24*
710	39	31	29	26*	24*	23*	22*
720	35	29	26	23.5*	22*	21*	20*
730	32	27	24.5*	22*	20*	19.5*	18.5*
740	30	24.5	22.5*	20*	18.5*	18*	17*
750	28	22.5	21*	18.5*	17*	16.5*	16*
760	26	21	19*	17*	16*	15*	14.5*
770	24	19.5	18*	15.5*	14.5*	14*	13.5*
780	22	18	16.5*	14.5*	13.5*	13*	12.5*
790	21	17	15.5*	13.5*	12.5*	12*	11.5*
800	19.5	15.5	14*	12.5*	11.5*	11*	10.5*
810	18	14.5	13*	11.5*	10.5*	10*	9.5*
820	17	13.5	12*	10.5*	10*	9.5*	(9)*
830	16	12.5	11.5*	10*	(9)*	-	-
840	15	12	10.5*	(9)*	-	-	-
850	14	11	10*	-	-	-	-
860	13	10	(9)*	-	-	-	-
870	12	9.5	-	-	-	-	-
880	11.5	(9)	-	-	-	-	-
890	10.5	-	-	-	-	-	-
900	10	-	-	-	-	-	-
910	9.5	-	-	-	-	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

M Spindler

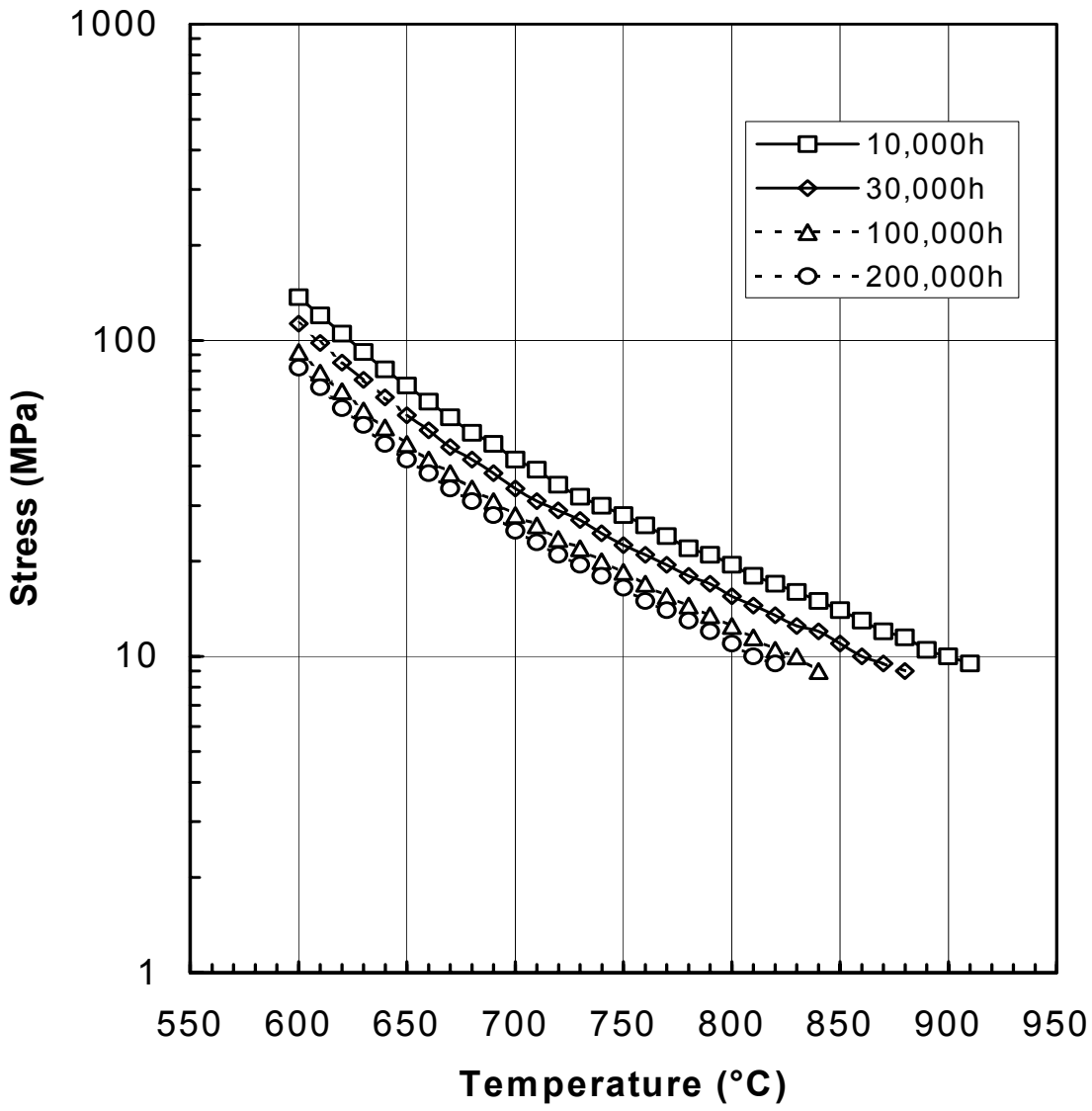
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel BS1503 310S31 (Type 310)

Working group: WG3.3
Year: 1999



Master equation

Standard ISO method used to fit data. The master curve is described by:

$$P_{(\sigma)} = a + b(\log\sigma) + c(\log\sigma)^2 + d(\log\sigma)^3 + e(\log\sigma)^4 = \frac{\log t - \log t_a}{(T - T_a)^r}$$

where $P_{(\sigma)}$ is the creep rupture parameter; T is the temperature in Kelvin; t is the time to rupture in hours; σ is the stress in N/mm^2; r is a temperature exponent; and a, b, c, d and e are constants

a = 2380.403320, b = 4522.662109, c = -7219.988281, d = 3388.112793, e = -539.2338867, r = -1, T_a = 710, $\log t_a$ = -1.4756911993

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel Fine grained TP347H (Sumitomo Report)

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges in Sumitomo data sheets 1993	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.06	0.09	0.06	0.10
	Si	wt%	0.49	0.62	-	0.75
	Mn	wt%	1.46	1.73	-	2.00
	P	wt%	0.020	0.026	-	0.040
	S	wt%	0.001	0.007	-	0.030
	Cr	wt%	17.50	18.65	17.00	20.00
	Mo	wt%	-	-	-	-
	Ni	wt%	11.35	12.55	9.00	13.00
	V	wt%	-	-	-	-
	Nb	wt%	0.72	0.97	8*(%C)	1.0
	Al	wt%	-	-	-	-
	N	wt%	-	-	-	-
Product	Form	Tubes	Outer Diameter 54 mm Wall thickness			
	Section size	mm	6	8	6	8
	Form	Plate				
	Section size	mm	-	-	6	15
Heat treatment	Solution	°C	1200	1250	-	-
Tensile Properties	$R_{P,0.2}$	N/mm²	220	270	205	-
	R_M	N/mm²	750	830	522	-

Source references of analysed data used in assessment

Source references	Scope of data
1) Sumitomo Data Sheets, 1993. 2) Fine-Grained TP347H Steel Tubing with High Elevated Temperature Strength and Corrosion Resistance for Boiler Applications; by H. Teranishi, Y. Sawaragi, M. Kubota, Y. Hayase; The Sumitomo Search No. 38, May 1989, pp.63-74.	1) 15 casts. Further information not available. 2) Nine casts were tested in two different heat treatment conditions. The fine grained modification of the steel is produced only when the softening heat treatment temperature before cold-forming was about 70°C higher, e. g. 1300°C, than the solution heat treatment after cold-forming. Creep rupture tests in the range between 600°C and 800°C with test durations up to 50.000 hrs. Cold working up to 10% had no effect on creep rupture properties. In addition creep rupture tests on weldments at test temperatures between 600°C and 700°C.
Description of method used to assess data Unknown.	

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h
°C	N/mm²	N/mm²
600	215	159 *
650	143	100 *
700	90	58 *
750	53	29 *

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

M Spindler

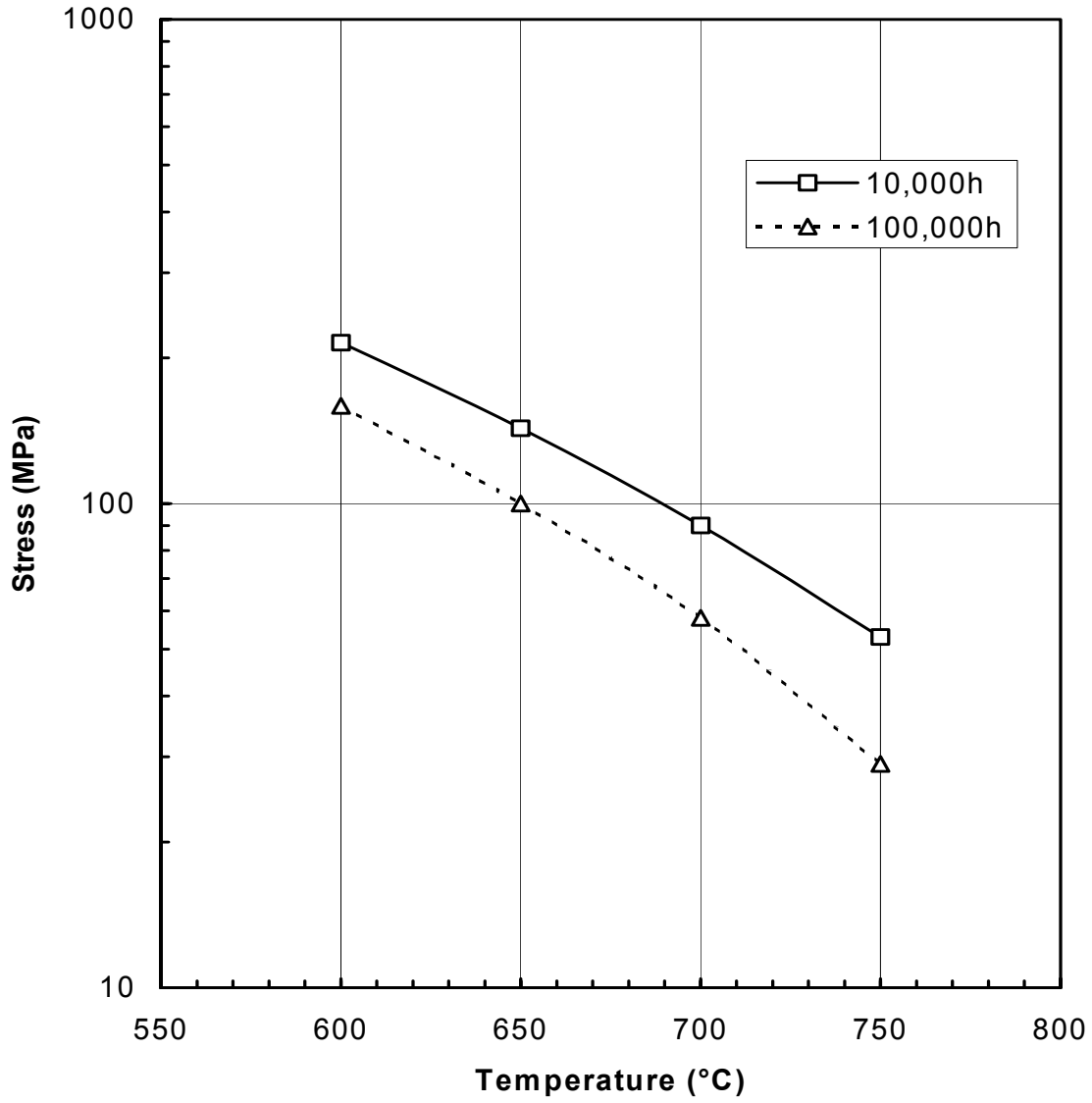
Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐

Steel Fine grained TP347H (Sumitomo Report)

Working group: WG3.3
Year: 1999



Master equation
Unknown.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel Super 304H (Sumitomo Report)

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges in Sumitomo Data sheets 1993	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.09	0.11	0.07	0.13
	Si	wt%	0.11	0.27	-	0.30
	Mn	wt%	0.69	0.80	-	1.00
	P	wt%	0.018	0.027	-	0.040
	S	wt%	0.001	0.002	-	0.010
	Cr	wt%	17.75	18.35	17.00	19.00
	Mo	wt%	0.17	-	-	-
	Ni	wt%	8.87	10.05	7.50	10.50
	Cu	wt%	2.71	3.03	2.50	3.50
	Nb	wt%	0.20	0.56	0.30	0.60
	Al	wt%	-	-	-	-
	N	wt%	0.051	0.114	0.05	0.12
Product	Form	Tubes	Outer diameter < 55 mm Wall thickness			
	Section size	mm	9	13	-	-
	Form	Plate				
	Section size	mm	-	10.5	-	-
Heat treatment	Solution	°C	-	-	-	-
Tensile Properties	$R_{P,0.2}$	N/mm²	272	319	235	-
	R_M	N/mm²	601	650	588	-

Source references of analysed data used in assessment

Source references	Scope of data
Sumitomo Seamless Tubes and Pipe Creep Data Sheets, 1993	This part of the information was not available except that 11 casts had been tested. In a separate publication "Welding Materials for Super 304H Steel; Filler Metal for GTAW and Covered Electrode for SMAW" published by Sumitomo Metal Industries, Ltd., Report 904 F-No. 2801 R 1, May 1996, 10 pages, results of creep rupture tests on the base metal are presented in a figure. The test data cover the temperature range between 600°C and 750°C, the maximum test duration is about 30.000 hrs.
Description of method used to assess data unknown	

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	100,000h
°C	N/mm²	N/mm²
600	239	184 *
650	165	120 *
700	106	70 *
750	62	33 *

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

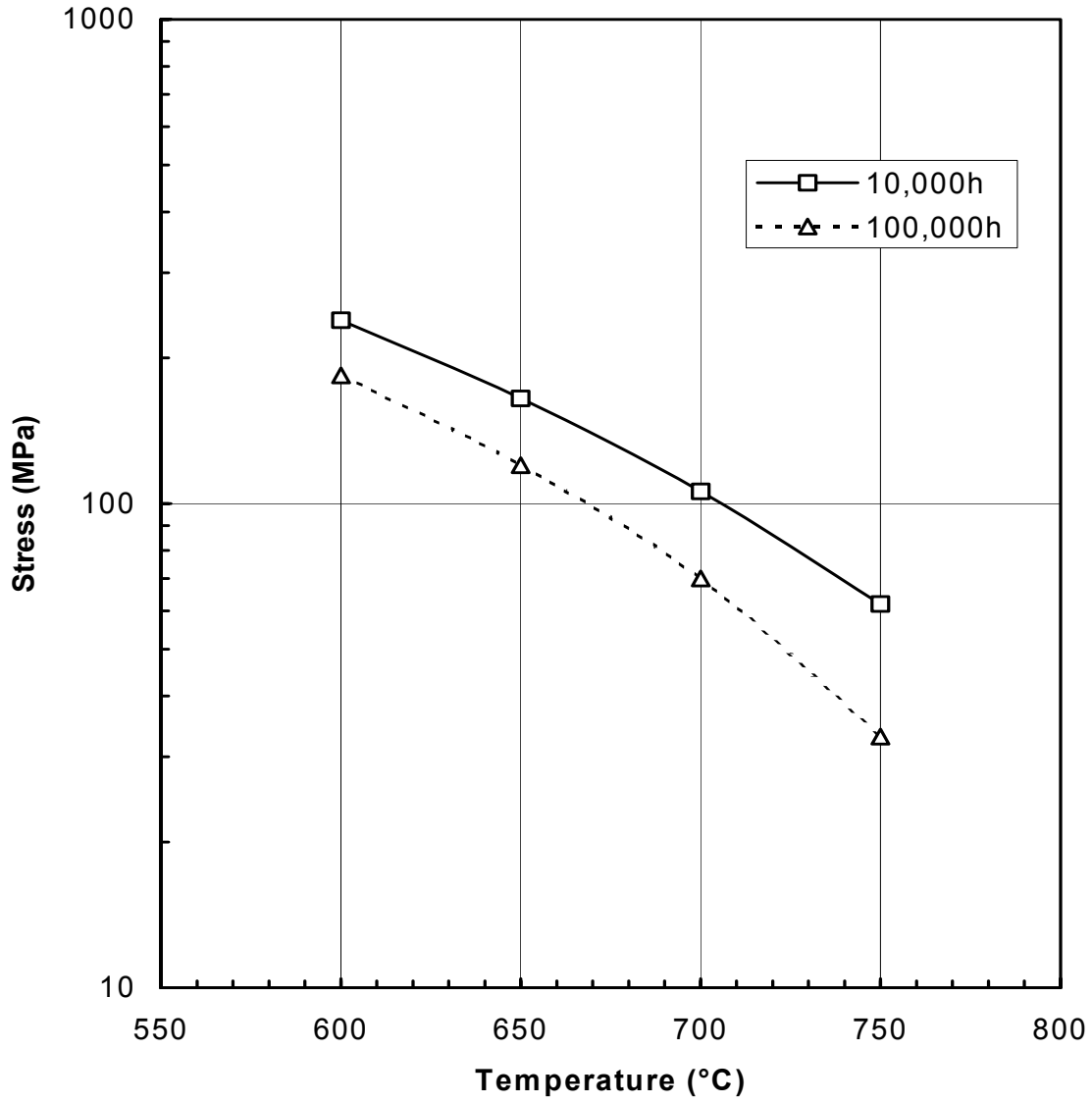
M Spindler

Signed: WG3.3 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☐
Working group: WG3.3
Year: 1999

Steel Super 304H (Sumitomo Report)



Master equation
In a paper published by Sumitomo (reference unknown) the time-temperature-parameter of a Larson-Miller plot is indicated as :
$P = T * (20.7187 + \log t) * 10^{-3}$.
Further in a paper published by Y.Sawaragi, K. Ogawa, S. Kato, A. Natori and S. Hirano in The Sumitomo Search, No. 48 January 1992, results of creep rupture tests on tubes with 38 – 54 mm O.D x 6 – 8 mm wall thickness and plates with 10,5 mm in thickness, 9 casts in total, with test durations up to about 12.000 hrs at 600° C to 750° C have been reported. The Larson-Miller Parameter is indicated as follows:
$P = T * (21.0276 + \log t) * 10^{-3}$.

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel HR3C

Working group: WG3B
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges In Sumitomo Data sheets 1993	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.05	0.07	-	0.10
	Si	wt%	0.04	0.55	-	1.50
	Mn	wt%	0.08	1.29	-	2.00
	P	wt%	0.003	0.023	-	0.030
	S	wt%	0.001	0.004	-	0.030
	Cr	wt%	24.43	25.62	23.00	27.00
	Ni	wt%	17.03	22.94	17.00	23.00
	Nb	wt%	0.38	0.48	0.20	0.60
	N	wt%	0.18	0.29	0.15	0.35
Product	Form Section size	Tubes mm	Outer diameter 51 mm Wall thickness 5	13	-	-
	Form Section size	Plate mm	10.5	10.5	-	-
Heat treatment Tensile Properties	Solution	°C	1200	1250	-	-
	$R_{P,0.2}$	N/mm²	361	408	295	-
	R_M	N/mm²	733	789	660	-

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
600	7	11	6	4	-	-	-	-
650	14	38	4	2	-	-	-	-
700	22	75(1)	2	4	-	1	2	-
750	22	76(1)	3	-	2	1	-	-
Totals	22	200(2)	15	10	2	2	2	0

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h
°C	N/mm²	N/mm²	N/mm²
580	307	268	221*
590	287	246	199*
600	266	223	179*
610	245	202	161*
620	223	182	145*
630	203	164	130*
640	184	149	118*
650	167	135	107*
660	151	122	97*
670	138	111	88*
680	126	101	80*
690	115	93	72*
700	105	84	65*
710	96	77	59*
720	88	70	53*
730	81	63*	(47.3*)
740	74	58*	-
750	67	52*	-
760	61	(46.7*)	-
770	56	-	-

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

M Spindler

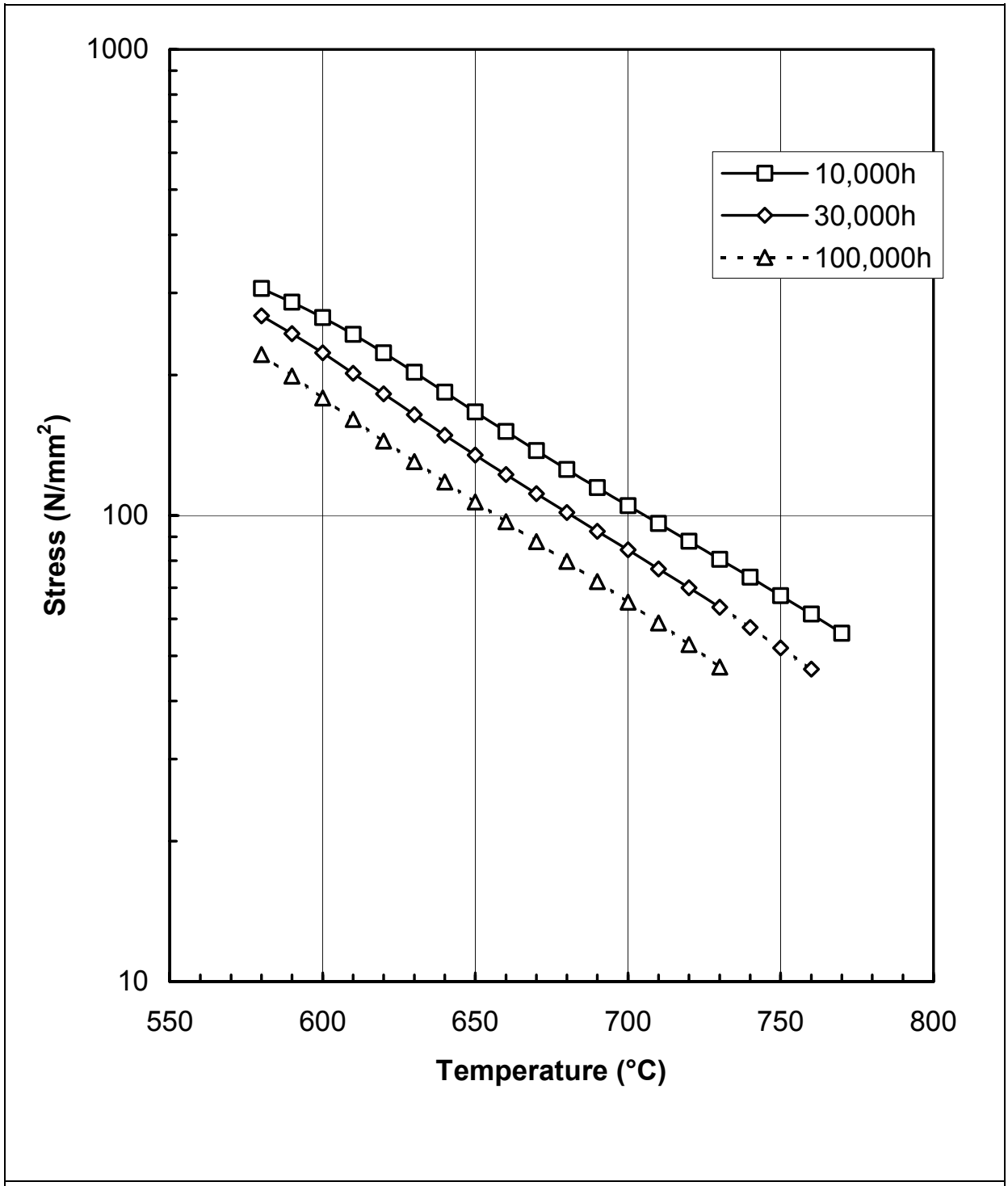
Signed: WG3B Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel HR3C

Working group: WG3B
Year: 2005



Master equation

$$t_U^* = \exp(\beta_0 + \beta_1\sigma_0 + \beta_2{\sigma_0}^2 + \beta_3{\sigma_0}^3 + \beta_4{\sigma_0}^4 + \beta_5/T)$$

where t_u* is the predicted rupture time in hours, σ_0 is the stress in N/mm² and T is the temperature in Kelvin.

β_0	β_1	β_2	β_3	β_4	β_5
-26.7658463	-0.116574839	0.00045779653	-9.44027818E-7	6.22283614E-10	42990.9766

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel NF709 (Nippon Steel)

Working group: WG3B
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges by Nippon Steel 2002	
		Units	Mln	Max	Min	Max
Chemical composition	C	wt%	0.04	0.10	0.05	0.10
	Si	wt%	0.39	0.52	-	1.00
	Mn	wt%	0.96	1.05	-	1.50
	P	wt%	0.002	0.021	-	0.030
	S	wt%	0.0003	0.002	-	0.010
	Cr	wt%	19.29	20.79	19.0	21.0
	Mo	wt%	1.00	1.92	1.0	2.0
	Ni	wt%	23.30	26.90	22.0	28.0
	Ti	wt%	0.04	0.14	-	0.20-
	Nb	wt%	0.20	0.28	0.10	0.40
	B	wt%	0.002	0.007	0.002	0.010
	N	wt%	0.107	0.195	0.10	0.25
Product	Form	Tubes	Outer Diameter 38-76 mm Wall thickness			
	Section size	mm	6.3	10.6	-	-
Product	Form	Plate	Thickness			
	Section size	mm	15	16	-	-
Heat treatment	Solution	°C	1200	1250-	1100	-
Tensile Properties	$R_{P,0.2}$	N/mm²	324	373	270	-
	R_M	N/mm²	686	745	640	-

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	H >100,000
		Number of test points available						
600	3	18(3)	6	-	-	-	-	-
650	9	58(3)	1	3	-	-	-	-
700	17	75(3)	10(3)	5	2	-	-	-
750	17	83(1)	9(1)	1	1	-	-	-
800	7	15(2)	2	-	-	-	-	-
850	3	11	1	-	-	-	-	-
900	2	9(2)	-	-	-	-	-	-
950	1	3	-	-	-	-	-	-
Totals	20	272(14)	29(4)	9	3	0	0	0
( ) Figures in parentheses denote unbroken tests								

ECCC data sheet

Steel NF709 (Nippon Steel)

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3B
Year: 2005

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h
°C	N/mm²	N/mm²	N/mm²
580	302	262*	223*
590	280	242*	206*
600	259	224*	190*
610	240	207*	175*
620	222	191*	161*
630	206	177*	148*
640	191	163*	137*
650	177	151*	126*
660	164	139*	116*
670	151	129*	107*
680	140	119	99*
690	130	110	91*
700	120	102	84*
710	111	94	77*
720	103	87	72*
730	96	80	66*
740	89	74	61*
750	82	69	56*
760	76	64	52*
770	71	59	48.3*

* Values which have involved extended time extrapolation
() Values which have involved extended stress extrapolation

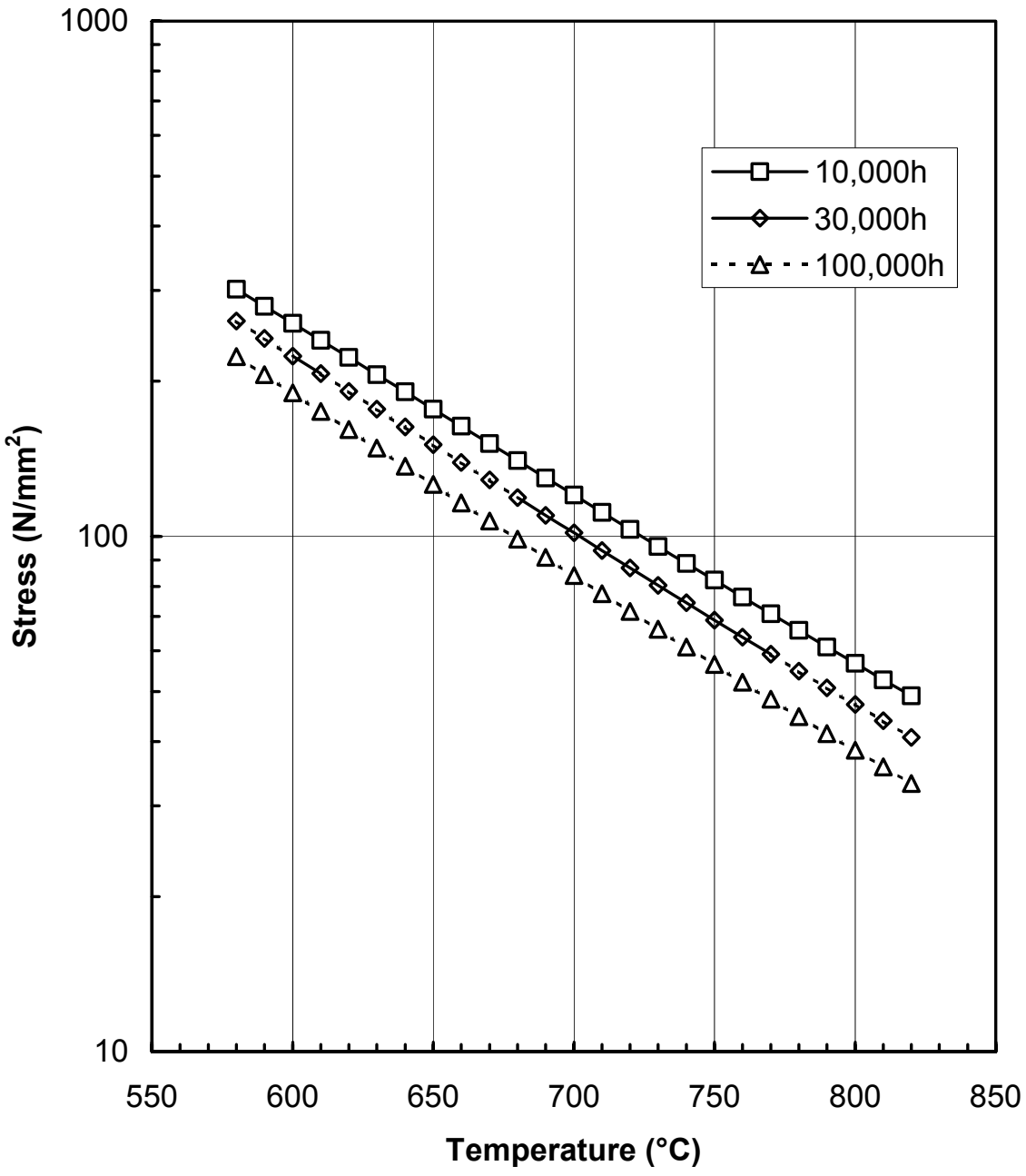
M Spindler

Signed: WG3B Convenor

ECCC data sheet

Steel NF709 (Nippon Steel)

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3B
Year: 2005



Master equation

$$\log_{10}(\sigma_0) = a_1\,TTP^2 + a_2\,TTP + a_3$$

where $TTP = w(T) + v(T).\log_{10}(t_u^*)$

where $w(T) = c_1(T/1000)^3 + c_2(T/1000)^2 + c_3(T/1000) + c_4$

and $v(T) = b_1(T/1000)^2 + b_2(T/1000) + b_3$

where t_u* is the predicted rupture time in hours, σ_0 is the stress in N/mm^2 and T is the temperature in Kelvin.

a_1=-0.180597	a_2=0.989346578	a_3=2.302949701	c_1=-0.766880232	c_2=1.497184302
c_3=2.348259579	c_4=2.127468666	b_1=-0.302426774	b_2=0.597588321	b_3=-0.152279049

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3B
Year: 2005

Steel NF709R (Nippon Steel)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges by Nippon Steel 2002 Min	Max
Chemical composition	C	wt%	0.019	0.035	-	0.04
	Si	wt%	0.29	0.42	-	1.00
	Mn	wt%	0.95	1.18	-	1.50
	P	wt%	0.009	0.022	-	0.030
	S	wt%	0.0001	0.0015	-	0.010
	Cr	wt%	21.87	22.52	21.5	23.0
	Mo	wt%	1.47	1.51	1.0	2.0
	Ni	wt%	24.59	25.36	22.0	28.0
	Ti	wt%	0.02	0.07	-	0.20-
	Nb	wt%	0.15	0.25	0.10	0.40
	B	wt%	0.002	0.0053	0.002	0.010
	N	wt%	0.158	0.223	0.10	0.25
Product	Form	Tubes	Outer Diameter 38-70 mm Wall thickness			
	Section size	mm	-	-	-	-
Heat treatment	Solution	°C	-	-	1100	-
Tensile Properties	$R_{P,0.2}$	N/mm²	-	-	270	-
	R_M	N/mm²	-	-	640	-

Quantity and duration of data used in assessment

Temps °C	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	H >100,000
		Number of test points available						
600	4	8(1)	2	1	-	-	-	-
650	5	21	4(1)	1	0(1)	-	-	-
700	5	20	1(1)	2	1(2)	-	-	-
750	5	21	1(1)	1	-	-	-	-
800	4	9	0(1)	-	-	-	-	-
Totals	5	81(1)	8(4)	5	1(3)	-	-	-

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h
°C	N/mm²	N/mm²	N/mm²
600	277	234*	194*
610	254	214*	177*
620	233	196*	162*
630	214	180	148*
640	196	165	135*
650	180	151	124*
660	165	138	113*
670	151	126	103*
680	139	116	94*
690	127	106	86*
700	116	97	79*
710	107	89	72*
720	98	81	66*
730	90	74*	60*
740	82	68*	55*
750	75	62*	50*
760	69	57*	45.9*
770	63	52*	(42.0*)
780	58	47.9*	-
790	54	(43.9*)	-
800	49.2	-	-
810	45.2	-	-
820	(41.5)	-	-

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

M Spindler

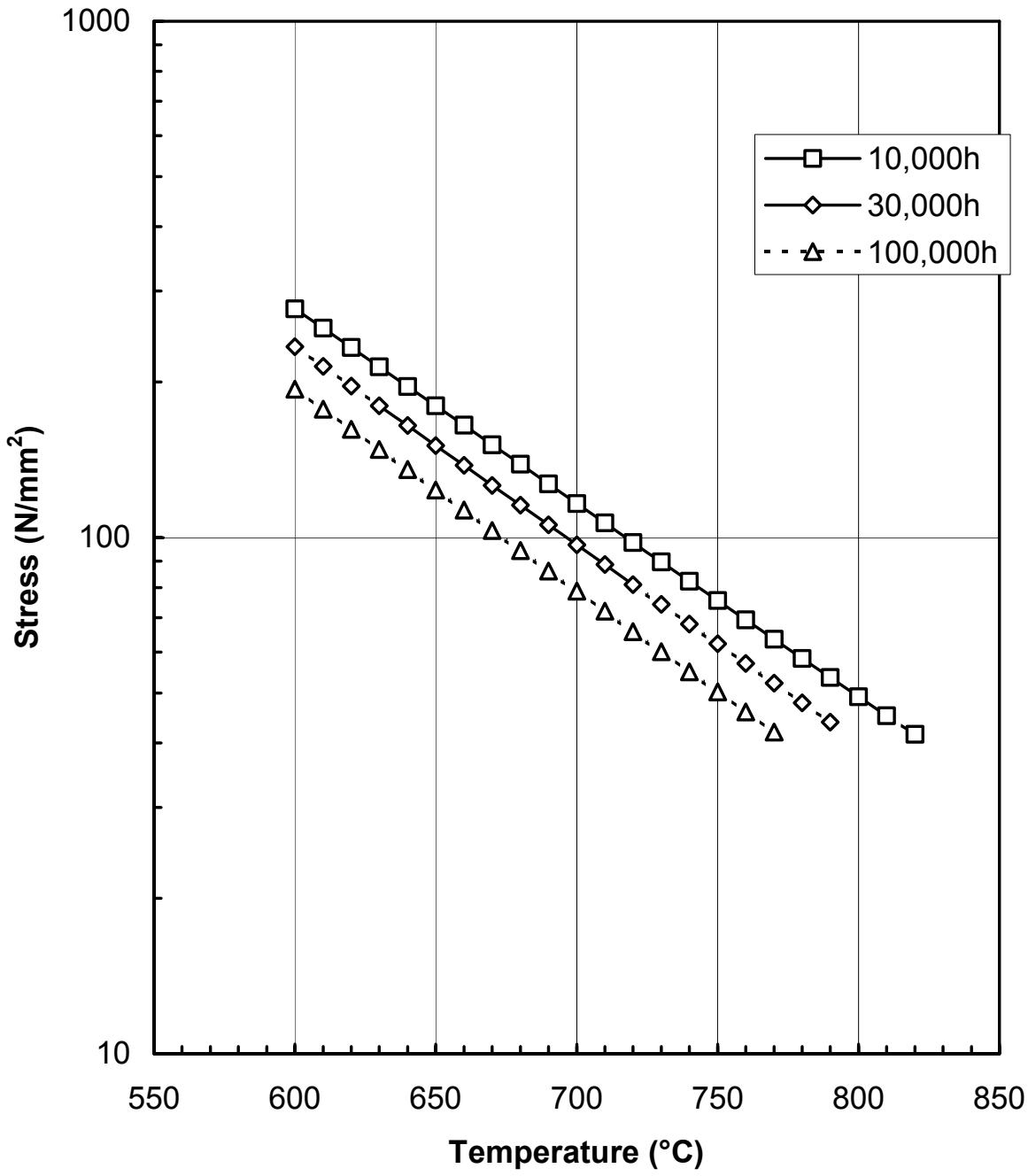
Signed: WG3B Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel NF709R (Nippon Steel)

Working group: WG3B
Year: 2005



Master equation

$$\log_{10}(\sigma_0) = a_1\,TTP^2 + a_2\,TTP + a_3$$

where $TTP = w(T) + v(T).\log_{10}(t_u^*)$

where $w(T) = c_1(T/1000)^3 + c_2(T/1000)^2 + c_3(T/1000) + c_4$

and $v(T) = b_1(T/1000) + b_2$

where t_u^* is the predicted rupture time in hours, σ_0 is the stress in N/mm^2 and T is the temperature in Kelvin.

a_1=-0.2365067	a_2=1.1759746	a_3=2.8337514	c_1=-0.8925620	c_2=1.4333434
c_3=2.3487875	c_4=2.2769370	b_1=0.0003497	b_2=0.1145036	-

ECCC data sheet

Alloy 617

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3C
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.054	0.087	0.05	0.10
	Si	wt%	0.03	0.5	-	0.5
	Mn	wt%	0.01	0.5	-	0.5
	P	wt%	0.002	0.006	-	0.006
	S	wt%	0.001	0.008	-	0.008
	N	wt%	0.015	0.048		
	Al	wt%	0.81	1.23	0.6	1.5
	B	wt%	0.0017	0.003	-	-
	Co	wt%	11.4	12.5	10.0	13.0
	Cr	wt%	21.44	22.5	20.0	23.0
	Cu	wt%	0.01	0.29	-	-
	Mo	wt%	8.49	9.34	8.0	10.0
	Ti	wt%	0.26	0.6	0.2	0.5
	Fe	wt%	0.08	1.9	-	2.00
	Ni	wt%	52	55.57	bal	bal
Product	Form		Strip			
	Section size	mm				
	Form		Plate			
	Section size	mm	6			
	Form		Tube			
	Section size	mm				
	Form		Bar			
	Section size	mm				
	Form		Forging			
	Section size	mm				
Heat treatment	Solution anneal	°C			1140	1200
Tensile Properties	$R_{p0.2}$	N/mm²			300	
	R_m	N/mm²			700	950

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
595	1	5		2				
600	3	6	1					
650	3	21(2)	(1)	(1)	(1)			
700	2	2	1					
750	4	12						
800	2	4						
850	13	55(3)	2	(3)	2(3)	(2)		
900	5	16	1					
950	6	29	2					
1000	7	25	2(1)	1	1(4)			
1100	1	2	(1)					
Totals	16	177(5)	9(3)	3(4)	3(8)	(2)		
( ) Figures in parentheses denote unfailed tests								

ECCC data sheet

Alloy 617

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3C
Year: 2005

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
580	400*	361*	319*	
590	374*	336*	296*	
600	350*	312*	273*	
610	326*	290*	252*	
620	304*	269*	232*	
630	283*	248*	213*	
640	262*	229*	196*	
650	243*	212*	179*	
660	225*	195*	164*	
670	208*	179*	149*	
680	192*	164*	136*	
690	177*	150*	124*	
700	163*	138*	112*	
710	150*	126*	102*	
720	138*	115*	92*	
730	126*	104*	84*	
740	116*	95*	76*	
750	106*	86*	68*	
760	97*	78*	62*	
770	88*	71*	56*	
780	80*	65*	50*	
790	73*	59*	45*	
800	67*	53*	41*	
810	61*	48*	37*	
820	55*	44*	33*	
830	50	40*	30*	
840	46	36*	27*	
850	42	33*	24*	
860	38	29*	22*	
870	35	27*	20*	
880	32*	24*	18.1*	
890	29*	22*	16.4*	
900	26*	20*	14.9*	
910	24*	18.3*	13.5*	
920	22*	16.6*	12.3*	
930	20*	15.2*	11.2*	
940	18.2*	13.8*	10.2*	
950	16.7*	12.6*	-	

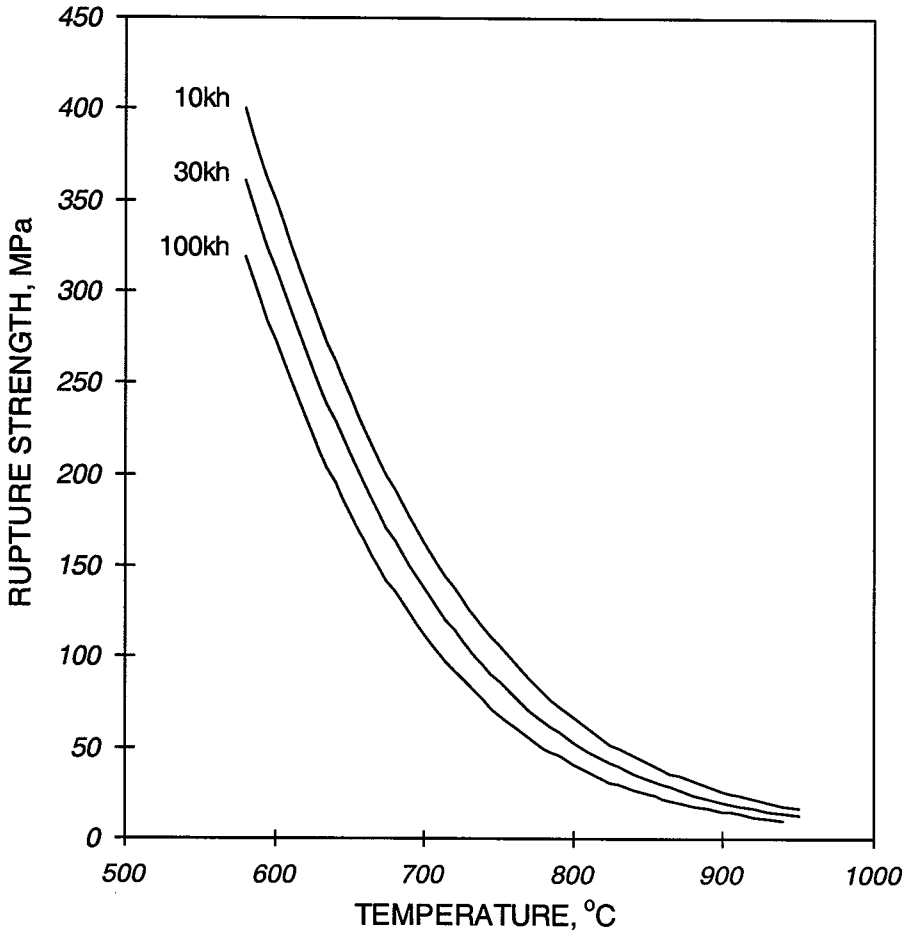
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3C Convenor

ECCC data sheet

Alloy 617

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3C
Year: 2005



Master equation

The data were assessed using the PD-6605 procedure to derive:

$t_u^* = \exp(\beta_0 + \beta_1.\sigma_o + \beta_2.\log(\sigma_o) + \beta_3/T)$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2, and β_0, β_1, β_2 and β_3 are constants, i.e.
β_0 = -23.23283, β_1 = -0.018240476, β_2 = -8.494174, β_3 = 52751.5156.

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (3-stage heat treated)

Working group: WG3C
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	EN 10269 Min	EN 10269 Max
Chemical composition	C	wt%	0.020	0.110	0.04	0.10
	Si	wt%	0.020	0.750	-	1.00
	Mn	wt%	0.001	0.180	-	1.00
	P	wt%	0.005	0.023	-	0.020
	S	wt%	0.001	0.010	-	0.015
	Cr	wt%	18.800	20.900	18.0	21.0
	Mo	wt%	0.030	0.300		
	Ni	wt%	73.300	76.462	65.0	-
	Ti	wt%	2.140	2.800	1.80	2.70
	V	wt%	0.010	0.100	-	-
	B	wt%	0.0018	0.0050	-	0.008
	Co	wt%	0.009	0.810	-	1.00
	Cu	wt%	0.001	0.120	-	0.20
	Fe	wt%	0.080	1.490	-	1.50
	Zr	wt%	0.040	0.090		
	N	wt%	0.020	0.200		
	Al	wt%	1.000	1.800	1.00	1.80
Product	Form	Bar				
	Section size	mm	20	102		
Heat treatment	Solution	°C	1050	1080	1050	1080
	Age-1	°C	850	850	840	860
	Age-2	°C	700	700	690	710
Tensile Properties	$R_{p0.2}$	N/mm²	629	796	600	-
	R_m	N/mm²	1017	1240	1000	1300

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
475	4	4						
500	5	6(4)	1	(1)	2		(1)	
525	4	5	4	(3)				
530	1	1				1		
540	2	5		1				
550	14	30	6(6)	3(3)	5(2)			
560	1	1			1			
600	10	28(3)	7(5)	3(2)	1(5)			
650	2	6(1)	3	2	(3)			
750	9	17		1				
850	1	3(2)						
Totals	31	106(10)	21(11)	10(9)	9(10)	1	(1)	
( ) Figures in parentheses denote unfailed tests								

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (3-stage heat treated)

Working group: WG3C
Year: 2005

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	983*			
460	954*			
470	924*			
480	894*	841*	779*	742*
490	864*	809*	746*	709*
500	834	778	713*	675*
510	804	746	680*	640*
520	773	714	646*	606*
530	742	682	613*	
540	711	649	579	
550	680	617	544	
560	648	584	510	
570	616	550	475	
580	584	517	440*	
590	552	483	406*	
600	519	449	372*	
610	486	416	338*	
620	453	383	306*	
630	421*	350*	275*	
640	388*	318*	245*	
650	356*	287*	217*	
660	325*	257*	191*	
670	294*	229*	168*	
680				
690				
700				

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

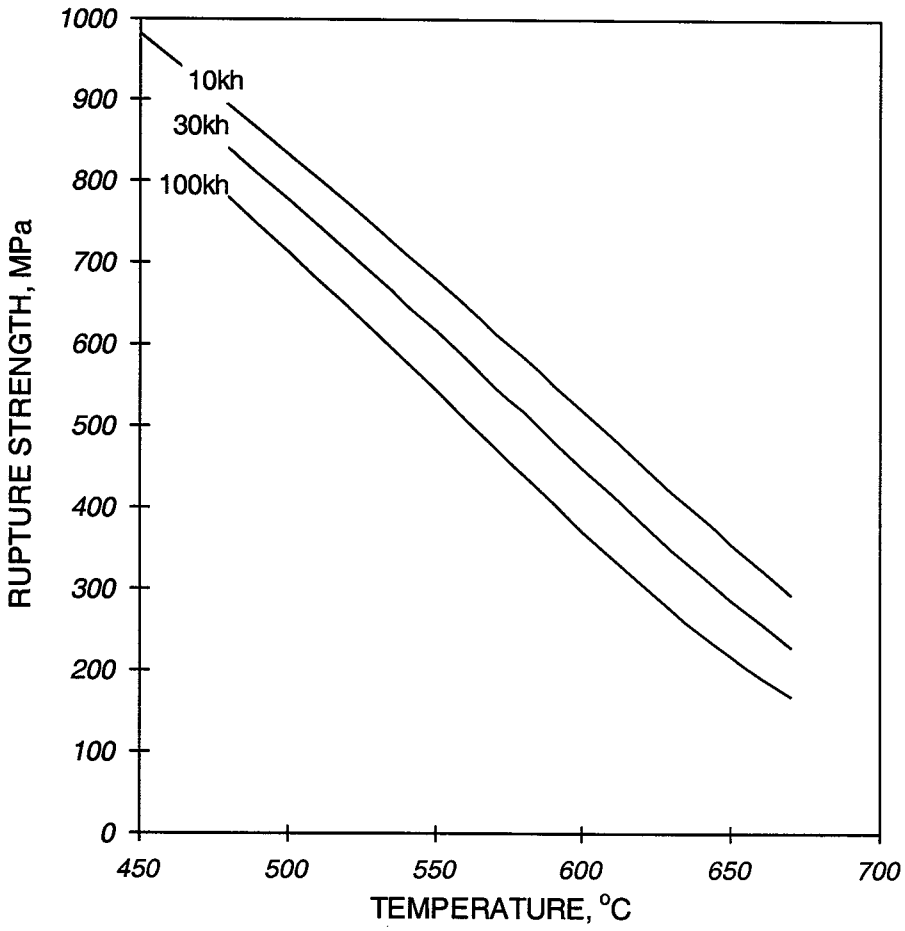
Signed: WG3C Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (3-stage heat treated)

Working group: WG3C
Year: 2005



Master equation

The data were assessed using the PD-6605 procedure to derive:

$t_u^* = \exp(\beta_0 + \beta_1.\log(\sigma_o) + \beta_2.\sigma_o + \beta_3.\sigma_o^2 + \beta_4.T + \beta_5/T)$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2, and β_0, β_1, β_2, β_3, β_4 and β_3 are constants, i.e.
β_0 = 27.5598965, β_1 = -7.06952095, β_2 = -0.00005583, β_3 = -0.000009697, β_4 = -0.024236055, β_5 = 21514.3164.

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (2-stage heat treated)

Working group: WG3C
Year: 2005

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.040	0.084	0.04	0.10
	Si	wt%	0.200	0.690	-	1.00
	Mn	wt%	0.030	0.380		
	P	wt%	0.005	0.012	-	0.015
	S	wt%	0.004	0.005		
	Cr	wt%	19.100	20.700	18.0	21.0
	Mo	wt%	0.030	0.240		
	Ni	wt%	73.290	76.195	bal	bal
	Ti	wt%	2.000	2.520	1.80	2.70
	V	wt%	0.050	0.050	-	-
	B	wt%	0.0020	0.0030	-	0.008
	Co	wt%	0.100	0.680	-	2.00
	Cu	wt%	0.030	0.030	-	0.20
	Fe	wt%	0.340	1.600	-	1.50
	Zr	wt%	0.090	0.090		
	N	wt%	0.012	0.160		
	Al	wt%	0.800	1.690	1.00	1.80
Product	Form	Bar				
	Section size	mm	20			
Heat treatment	Solution	°C	1080	1080	1080	1080
	Age-1	°C	700	700	700	700
Tensile Properties	$R_{p0.2}$	N/mm²	668	806	620	-
	R_m	N/mm²	1056	1330	1000	-

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
500	1	2	1			1		
550	1	1			1			
625	1	1	(1)		(1)			
700	2	6(1)	4(2)	2(2)	(2)	1	1	(1)
750	5	9	3		1			
760	1	7						
800	3	14	1	1(1)	1(1)	1	1	
815	2	10	1					
820	6	56						
900	1	3(1)			1			
Totals	13	109(2)	10(3)	3(3)	4(4)	3	2	(1)
( ) Figures in parentheses denote unfailed tests								

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (2-stage heat treated)

Working group: WG3C
Year: 2005

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
600	475*	411*		
610	450*	386*		
620	425*	360*		
630	399*	335*		
640	373*	310*		
650	348*	285*		
660	322*	261*		
670	297*	237*		
680	272*	215*	160*	133*
690	248*	193*	142*	118*
700	225*	173*	126*	104*
710	203*	155*	111*	91*
720	182*	137*	98*	80*
730	163	121*	86*	
740	145	107*	75*	
750	128	94*	66*	
760	113	82*	58*	
770	99	72*	50*	
780	87	63*	44*	
790	76*	55*	38*	
800	66*	48*	33*	
810	58*	41*	29*	
820	50*	36*	25*	
830	44*	31*	21*	
840	38*	27*	18.6*	
850	33*	23*	16.1*	
860	28*	20*	13.9*	
870	25*	17.5*	12.0*	
880	21*	15.2*	10.4*	
890	18.4*	13.1*		
900	15.9*	11.3*		

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

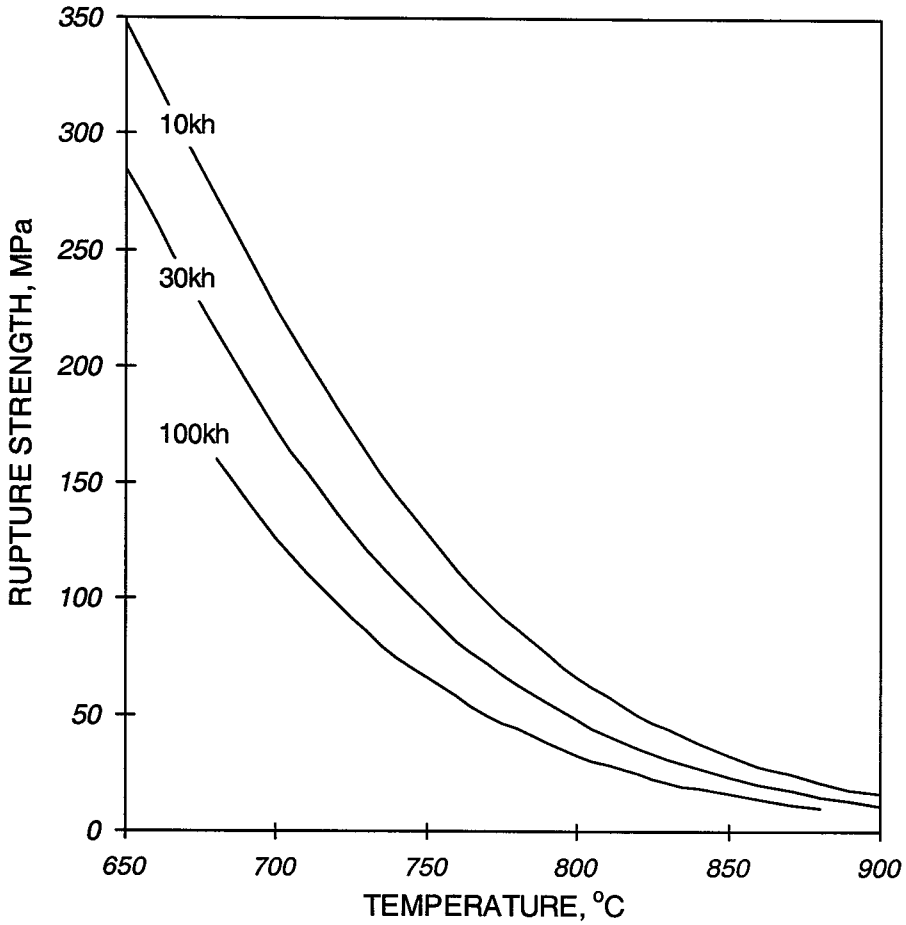
Signed: WG3C Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Nimonic 80A (2-stage heat treated)

Working group: WG3C
Year: 2005



Master equation

The data were assessed using the PD-6605 procedure to derive:

$t_u^* = \exp(\beta_0 + \beta_1.\log(\sigma_o) + \beta_2.\sigma_o + \beta_3.\sigma_o^2 + \beta_4.T + \beta_5/T)$

where t_u^* is the predicted rupture time in h, T is the absolute temperature in K, σ_o is the stress in N/mm^2, and β_0, β_1, β_2, β_3, β_4 and β_3 are constants, i.e.
β_0 = 84.1700592, β_1 = -7.34312201, β_2 = -0.001103774, β_3 = -0.000009916, β_4 = -0.051610813, β_5 = -6533.78125.

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ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒
Working group: WG3.4
Year: 1998

Steel 42CrMo5-6 (1.7233)

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.36	0.43	0.39	0.45
	Si	wt%	0.24	0.33	-	0.40
	Mn	wt%	0.52	0.68	0.40	0.75
	P	wt%	0.005	0.036	-	0.035
	S	wt%	0.010	0.038	-	0.035
	Cr	wt%	1.11	1.44	1.20	1.50
	Mo	wt%	0.52	0.70	0.50	0.70
	Ni	wt%	*	*	0.09	0.29
	Al	wt%	*	*	0.004	0.026
			* not known for all casts			
Product	Form		Bar			
	Section size	mm	29	136.5	-	150
Heat treatment	Harden / Solution	°C	850	880	840	870
	Temper / Age	°C	640	680	600	700
Tensile Properties	$R_{P,0.2}$	N/mm²	660	830	640	-
	R_M	N/mm²	855	1060	850	1000

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
450	15	20	3	3				
500	23	78	10	4 (11)	3			
550	21	53	5	2	1 (1)			
Totals	26	151	18	9 (11)	4 (1)			
( ) Figures in parentheses denote unbroken tests								

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	495	457 *	410 *	381 *
460	450	403 *	346 *	310*
470	399	342	276 *	242 *
480	342	278	219 *	193 *
490	281	223	176	158 *
500	229	183	148	131 *
510	190	153	124	109 *
520	160	130	102	84 *
530	137	110	-	-
540	118	89	-	-
550	99	-	-	-
* Values which have involved extended time extrapolation				
( ) Values which have involved extended stress extrapolation				

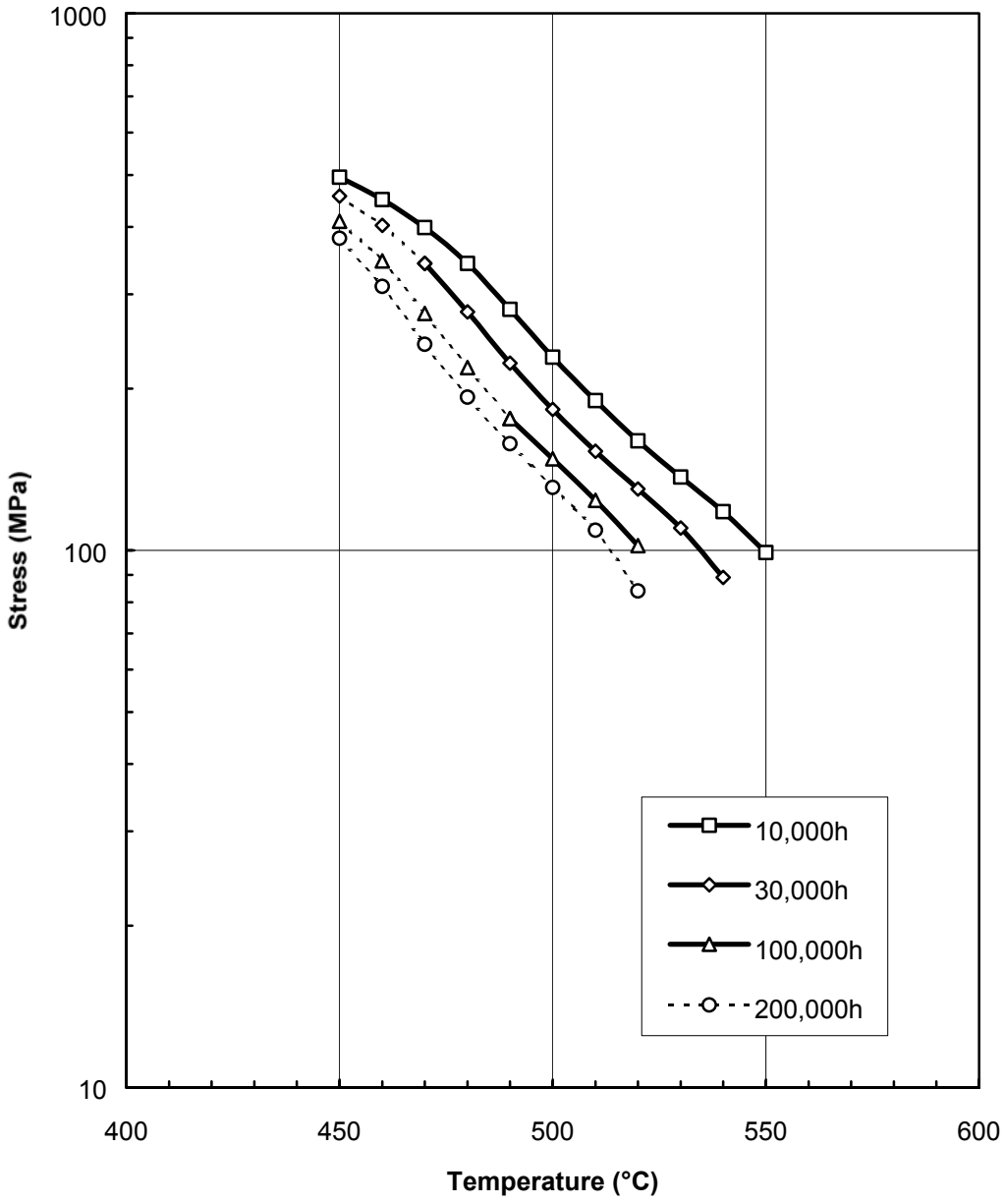
Signed: WG3.4 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel 42CrMo5-6 (1.7233)

Working group: WG3.4
Year: 1998



Master equation

The data were assessed using the ISO 6303 procedure, and the following master curve was derived:

$P(\sigma) = (\log t_r^* - \log t_a) / (T-T_a)^r = a + b (\log \sigma_0) + c (\log \sigma_0)^2 + d (\log \sigma_0)^3 + e (\log \sigma_0)^4$

Where $P(\sigma)$ is the creep rupture parameter, t_r^* is the predicted rupture time in hours, T is the absolute temperature, σ_0 is the stress in N/mm^2, and $\log t_a$, T_a, r, a, b, c, d and e are constants.
$\log t_a$ = -2.4880708599, T_a = 600, r = -1, a = -136047.7656, b = 247130.3594, c = -164831.9531, d = 48477.22266, e = -5323.73877

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel 20CrMoVTiB4-10 (1.7729)

Working group: WG3.4
Year: 1996

Condition of alloy to which the properties apply

	Details of materials tested	Units	Min	Max	Specified ranges Min	Max
Chemical composition	C	wt%	0.18	0.22	0.17	0.23
	Si	wt%	0.12	0.88	-	0.40
	Mn	wt%	0.36	0.60	0.35	0.75
	P	wt%	0.004	0.030	-	0.020
	S	wt%	0.005	0.032	-	0.020
	Cr	wt%	0.90	1.10	0.90	1.20
	Mo	wt%	0.92	1.02	0.90	1.10
	Ni	wt%	0.01	0.27	-	0.20
	V	wt%	0.60	0.77	0.60	0.80
	Al	wt%	0.023	0.076	0.015	0.080
	B	wt%	0.0016	0.0047	0.001	0.010
	Ti	wt%	0.05	0.13	0.07	0.15
	As	wt%	*	*	-	0.020
	Sn	wt%	*	*	-	0.020
	Cu	wt%	*	*	-	0.20
			* not known for all casts			
Product	Form		Bar			
	Section size	mm	19	190	-	160
Heat treatment	Pre-harden	°C	-	-	660-700 air cool	
	Harden / Solution	°C	-	-	970-990 water or oil quench	
	Temper / Age	°C	-	-	680	720
Tensile Properties	$R_{P,0.2}$	N/mm²	680	900	660	-
	R_M	N/mm²	830	1040	820	1000

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
450	2	1					(1)	
475	6	16	2 (1)	1	1	4	1	1
500	25	64 (5)	10 (1)	4 (2)	9 (2)	1	(1)	7 (2)
525	-							
550	75	155 (11)	38 (5)	58 (4)	28 (3)	9 (2)		
575	35	102 (5)	19 (4)	25 (5)	5 (3)	1		
600	34	151 (4)	10	5	1			
625	3	14 (1)	2	1				
650	1	5						
675	1	3						
700	1	2						
Totals	75	513 (26)	81 (11)	94 (11)	44 (8)	15 (2)	1 (2)	8 (2)

( ) Figures in parentheses denote unbroken tests

Average rupture ☒ creep ☐ relaxation ☐ strengths (% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
450	520	489	453	430 *
460	491	460	423	399 *
470	463	432	394	369 *
480	437	405	365	338 *
490	412	379	337	307 *
500	388	353	307	274 *
510	364	327	276	237 *
520	340	300	241	198
530	315	271	204	162
540	289	239	169	135
550	261	205	142	114
560	231	173	121	96
570	200	146	103	-
580	170	126	-	-
590	146	109	-	-
600	127	93	-	-

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

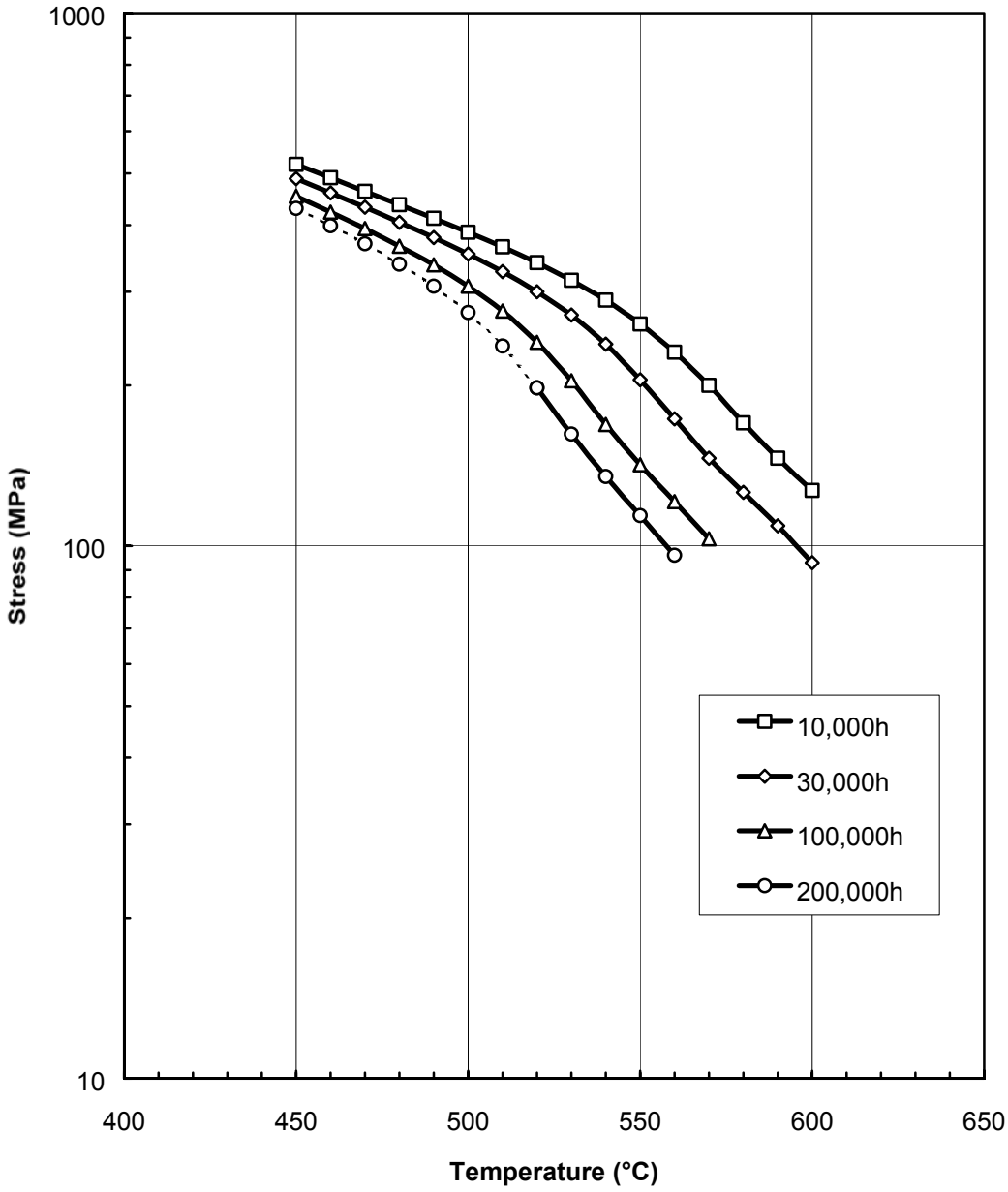
Signed: WG3.4 Convenor

ECCC data sheet

Rupture ☒ Creep ☐ Relaxation ☐ strength
Formal assessment: ☒

Steel 20CrMoVTiB4-10 (1.7729)

Working group: WG3.4
Year: 1996



Master equation

The data were assessed using the ISO 6303 procedure, and the following master curve was derived:

$$P(\sigma) = (\log t_r^* - \log t_a) / (T-T_a)^r = a + b (\log \sigma_0) + c (\log \sigma_0)^2 + d (\log \sigma_0)^3 + e (\log \sigma_0)^4$$

Where $P(\sigma)$ is the creep rupture parameter, t_r^* is the predicted rupture time in hours, T is the absolute temperature, σ_0 is the stress in N/mm^2, and $\log t_a$, T_a, r, a, b, c, d and e are constants.
$\log t_a$ = 10.523564339, T_a = 590, r = 1, a = -4.465617180, b = 8.252388000, c = -5.727178097, d = 1.762619853, e = -0.2033182085

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ECCC data sheet

Rupture ☐ Creep ☐ Relaxation ☒ strength
Formal assessment: ☒
Working group: WG3.4
Year: 1998

Steel 20CrMoVTiB4-10 (1.7729)

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.18	0.22	0.17	0.23
	Si	wt%	0.12	0.88	-	0.40
	Mn	wt%	0.36	0.60	0.35	0.75
	P	wt%	0.004	0.030	-	0.020
	S	wt%	0.005	0.032	-	0.020
	Cr	wt%	0.90	1.10	0.90	1.20
	Mo	wt%	0.92	1.02	0.90	1.10
	Ni	wt%	0.01	0.27	-	0.20
	V	wt%	0.60	0.77	0.60	0.80
	Al	wt%	0.023	0.076	0.015	0.080
	B	wt%	0.0016	0.0047	0.001	0.010
	Ti	wt%	0.05	0.13	0.07	0.15
	As	wt%	*	*	-	0.020
	Sn	wt%	*	*	-	0.020
	Cu	wt%	*	*	-	0.20
			* not known for all casts			
Product	Form		Bar			
	Section size	mm	19	190	-	160
Heat treatment	Pre-harden	°C	-	-	660 – 700	AC
	Harden / Solution	°C	-	-	970 – 990	OQ
	Temper / Age	°C	-	-	680 – 720	AC
Tensile Properties	$R_{P,0.2}$	N/mm²	680	870	660	-
	R_M	N/mm²	860	970	820	1000

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
425	7	2	3	1				
475	3			2	1			
500	2				2			
525	3		1	1	1			
550	14	1	5	3	3	1		
565	13	1	6	5	1			
575	3		3					
Totals	40	4	18	12	8	1		

Average rupture ☐ creep ☐ relaxation ☒ strengths (0.15% strain)

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
430	223	207	189	178
440	212	197	178	166
450	202	186	166	154
460	191	175	154	141
470	181	164	142	127
480	170	152	128	111
490	160	140	114	93
500	149	127	97	73
510	137	113	77	55
520	124	97	58	42
530	111	79	45	33
540	95	60	35	-
550	77	47	25	-
560	60	37	-	-
570	47	29	-	-
580	38	-	-	-
590	30	-	-	-

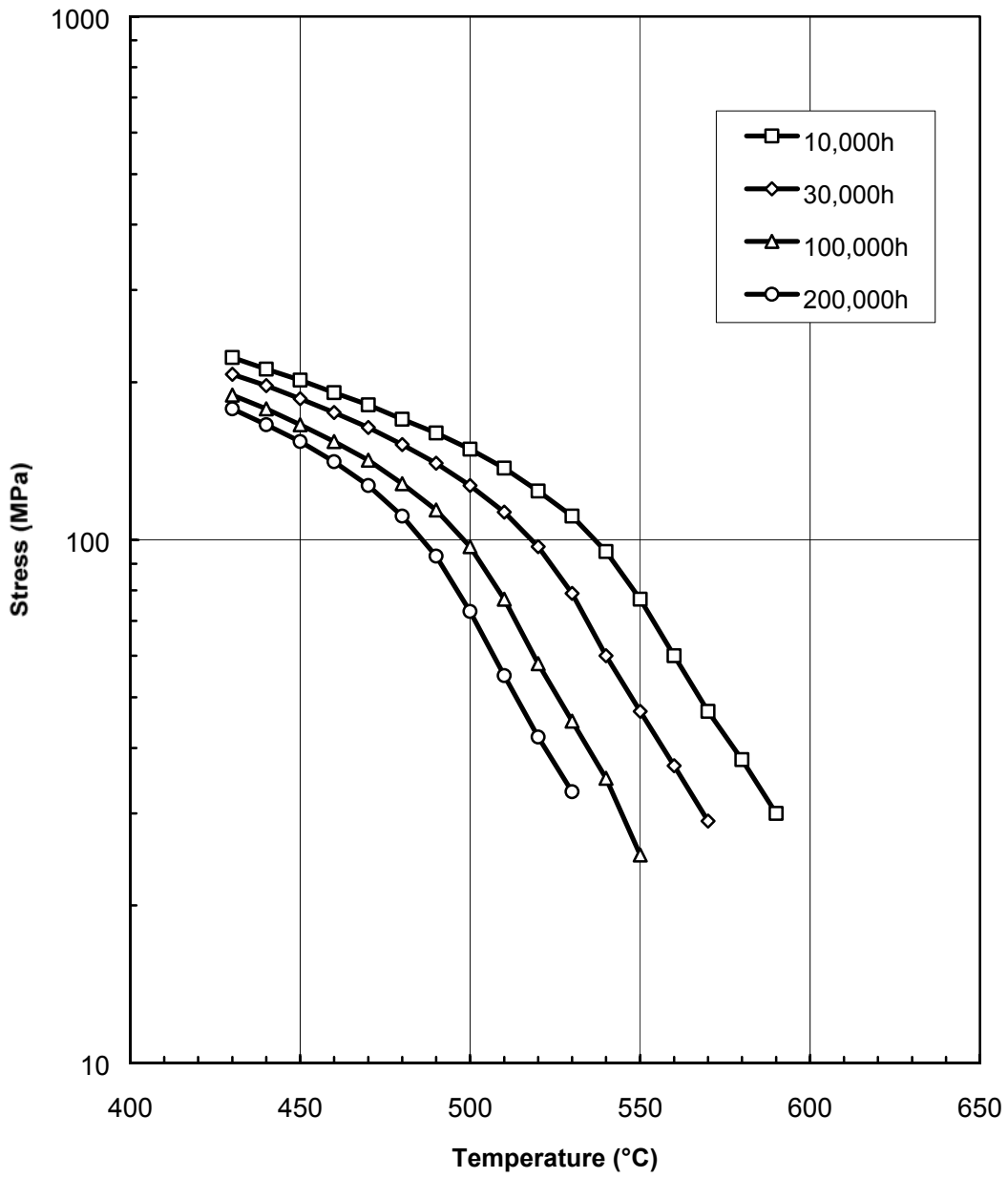
* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

Signed: WG3.4 Convenor

ECCC data sheet

Rupture ☐ Creep ☐ Relaxation ☒ strength
Formal assessment: ☒
Working group: WG3.4
Year: 1998

Steel 20CrMoVTiB4-10 (1.7729)



Master equation

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ECCC data sheet

Steel 21CrMoV 5-7 (1.7709)

Rupture strength
Formal assessment: ☒
Working group: WG3.4
Year: 1996

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.16	0.27	0.16	0.27
	Si	wt%	0.17	0.98	-	0.43
	Mn	wt%	0.38	0.75	0.36	0.84
	P	wt%	0.007	0.024	-	0.035
	S	wt%	0.004	0.023	-	0.035
	Cr	wt%	0.92	1.48	1.15	1.55
	Mo	wt%	0.66	1.16	0.52	0.85
	Ni	wt%	0.11	0.72	-	0.63
	V	wt%	0.19	0.54	0.15	0.38
	Nb	wt%	-	0.03	-	-
	Al	wt%	-	0.025	-	-
Product	Form		Bar			
	Section size	mm	20	525	-	160
Heat treatment	Harden / Solution	°C	920	980	900	950
	Temper / Age	°C	670	740	680	720
Tensile Properties	$R_{P,0.2}$	N/mm²	548	812	550	-
	R_M	N/mm²	680	869	700	850

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
400	6	12 (2)	(1)	(3)	4 (2)	1	2 (1)	2 (1)
450	9	19 (2)	6 (3)	2	5 (2)	(1)		
500	15	57 (1)	12 (6)	4 (1)	7	4 (1)	2 (1)	4 (2)
530	6	10	4	4 (1)	1	4 (2)	2	
550	14	88 (1)	16 (1)	6	10 (1)	6 (1)	1	1
560	3	4						
Totals	33	190 (6)	38 (11)	16 (5)	27 (5)	15 (5)	7 (2)	7 (3)
( ) Figures in parentheses denote unbroken tests								

Average rupture strengths

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
420	466	434	399	379
430	443	411	375	353
440	420	387	350	328
450	396	362	325	303
460	373	338	300	277
470	349	314	274	252
480	325	289	249	226
490	301	264	224	201
500	277	239	199	176
510	253	215	174	151
520	228	191	150	127
530	204	166	126	104
540	180	143	103	82
550	157	120	82	62
* Values which have involved extended time extrapolation				
( ) Values which have involved extended stress extrapolation				

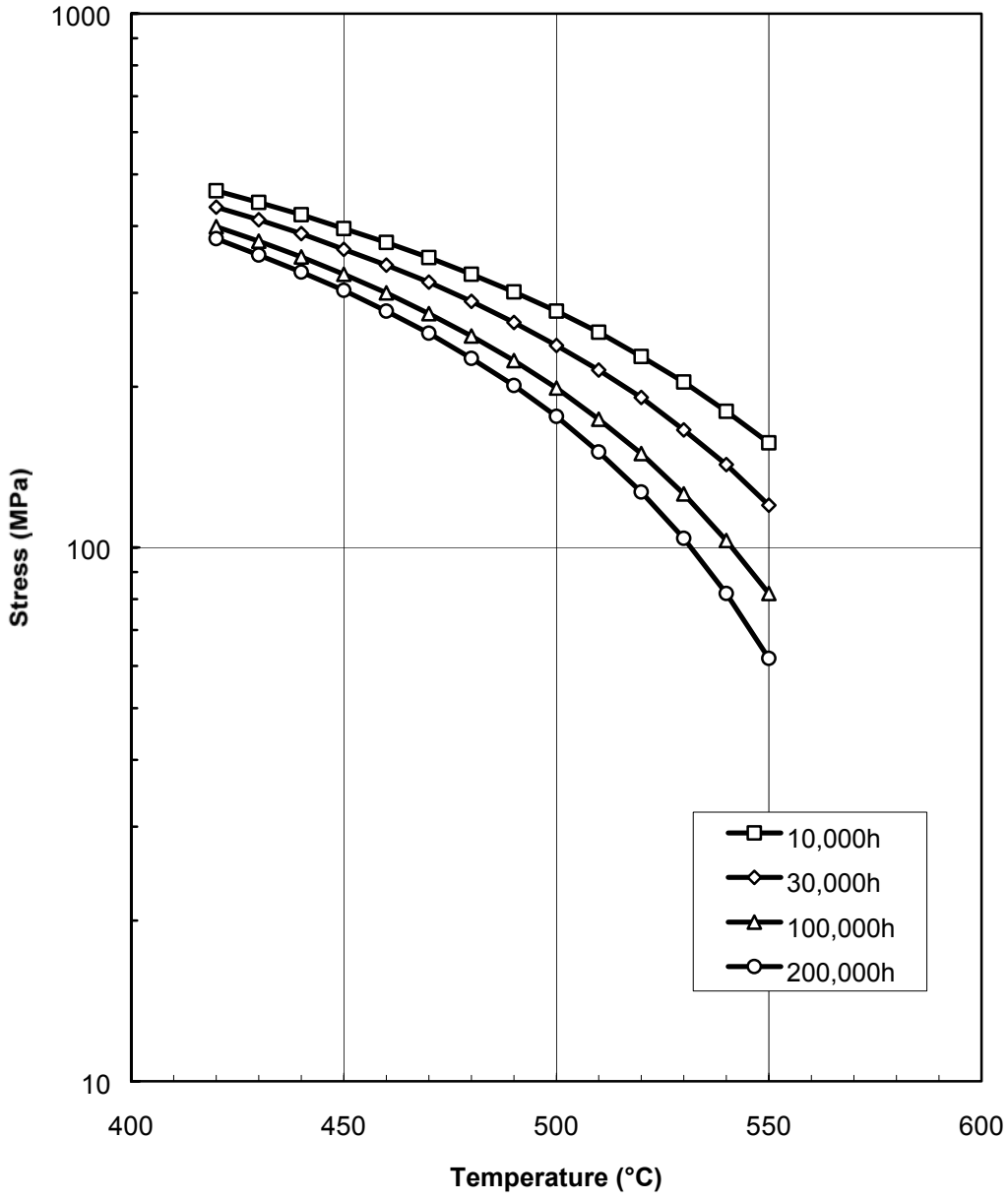
Note: The assessment included the steel grades 21 CrMoNiV 4-7 and 21 CrMoV 5-11

Signed: WG3.4 Convenor

ECCC data sheet

Steel 21CrMoV 5-7 (1.7709)

Rupture strength
Formal assessment: ☒
Working group: WG3.4
Year: 1996



Master equation

The data were modelled using the Larson-Miller parameter and a polynomial stress function:

PLM = T (C + log t_r) , where PLM is the Larson-Miller parameter, T is the absolute temperature, C is a constant and t_r is the rupture time in hours;

Log t_r = - C + B_1 / T + (B_2 / T) f(σ) + (B_3 / T) f(σ) ^{2} + (B_4 / T) f(σ) ^{3} , where f(σ) = $\sigma_0^{0.5}$ and σ_0 is the stress in N/mm^2

C = 20, B_1 = 22349.564, B_2 = -195.449, B_3 = 2.218, and B_4 = -0.251

ECCC data sheet

Steel 21CrMoV 5-7 (1.7709)

1% Creep strength
Formal assessment: ☒
Working group: WG3.4
Year: 1997

Condition of alloy to which the properties apply

	Details of materials tested				Specified ranges	
		Units	Min	Max	Min	Max
Chemical composition	C	wt%	0.16	0.27	0.16	0.27
	Si	wt%	0.17	0.98	-	0.43
	Mn	wt%	0.38	0.75	0.36	0.84
	P	wt%	0.007	0.024	-	0.035
	S	wt%	0.004	0.023	-	0.035
	Cr	wt%	0.92	1.48	1.15	1.55
	Mo	wt%	0.66	1.16	0.52	0.85
	Ni	wt%	0.11	0.72	-	0.63
	V	wt%	0.19	0.54	0.15	0.38
	Nb	wt%	-	0.03	-	-
	Al	wt%	-	0.025	-	-
Product	Form		Bar			
	Section size	mm	20	525	-	160
Heat treatment	Harden / Solution	°C	920	980	900	950
	Temper / Age	°C	670	740	680	720
Tensile Properties	$R_{P,0.2}$	N/mm²	548	812	550	-
	R_M	N/mm²	680	869	700	850

Quantity and duration of data used in assessment

Temps	No. of heats	Test Durations						
		h <10,000	h 10,000 to 20,000	h 20,000 to 30,000	h 30,000 to 50,000	h 50,000 to 70,000	h 70,000 to 100,000	h >100,000
		Number of test points available						
°C								
400	5	3	1	1	1			1
450	4	7	1	1	1			
500	12	40	6	1	5	1		1
530	6	9	1	2	3			
550	12	38	10	2	2			
Totals	33	97	19	7	12	1		2

( ) Figures in parentheses denote unbroken tests

Average 1% creep strengths

Temps	10,000h	30,000h	100,000h	200,000h
°C	N/mm²	N/mm²	N/mm²	N/mm²
420	429	401	365	344
430	407	377	340	319
440	385	353	315	292
450	363	328	288	265
460	339	302	262	238
470	314	277	235	211
480	289	250	208	184
490	263	224	182	158
500	238	198	156	133
510	212	172	132	111*
520	186	148	109	90*
530	161	124	89	72*
540	138	103	71	56*
550	116	84	56	43*

* Values which have involved extended time extrapolation
( ) Values which have involved extended stress extrapolation

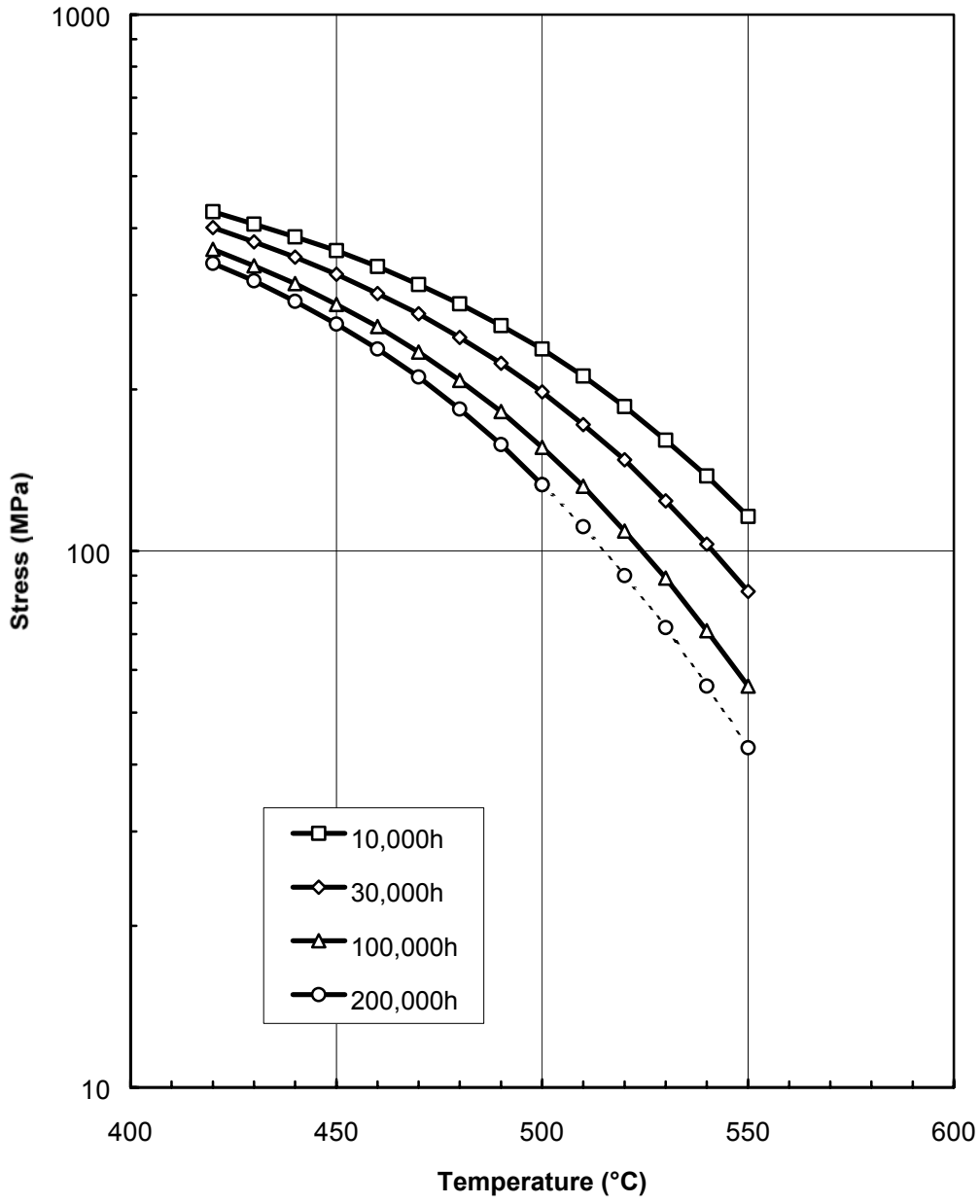
Note: The assessment included the steel grades 21 CrMoNiV 4-7 and 21 CrMoV 5-11

Signed: WG3.4 Convenor

ECCC data sheet

Steel 21CrMoV 5-7 (1.7709)

1% Creep strength
Formal assessment: ☒
Working group: WG3.4
Year: 1997



Master equation

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