NIMONIC® alloy 105

NIMONIC® alloy 105 (W. Nr. 2.4634) is a wrought nickel-cobalt-chromium-base alloy strengthened by additions of molybdenum, aluminum and titanium. It has been developed for service up to 950°C, and combines the high strength of the age-hardening nickel-base alloys with good creep resistance.

NIMONIC alloy 105 is produced by high frequency melting in air followed by casting in air, or, for more critical applications the alloy is produced by vacuum melting and electroslag refining.

The alloy is used for turbine blades, discs, forgings, ring sections, bolts and fasteners.

Heat Treatment

The heat treatment recommended is dependent on the intended service condition.

Two heat treatments are recommended as follows:

(a) 4 h/1150°C/AC+16 h/1050-1065°C/AC+16 h/850°C/AC
(b) 4 h/1125°C/AC+16 h/850°/AC

In general, heat treatment (a) is intended for optimum long-term creep strength and ductility at operating temperatures in the range 850-950°C. Heat-treatment (b) may be used where long-term properties are not of paramount importance and tensile strength, elongation and impact strength may be enhanced for operating temperatures up to 700°C. When applying heat-treatment (b) it is essential to ensure that cooling from 1125°C takes place freely and is not delayed due to close packing of components.

Examples of the use of these heat treatments are as follows:

(a) turbine blades, discs, forgings and ring sections, all of which may be produced from as-extruded, as-forged or subsequently cold worked starting stock

(b) bolts and fasteners for which extruded and cold worked bar or section is recommended as starting stock.

Composition, %

The composition stated in BS HR 3 is as follows:

Carbon	0.17 max
Silicon	1.0 max
Copper	0.2 max
Iron	1.0 max
Manganese	1.0 max
Chromium	14.0-15.7
Titanium	0.9-1.5
Aluminum	4.5-4.9
Cobalt	18.0-22.0
Molybdenum	4.5-5.5
Lead	0.0015 max
Sulfur	0.010 max
Boron	0.003-0.010
Zirconium	0.15 max
Nickel	Balance*

*Reference to the 'balance' of an alloy's composition does not guarantee this is exclusively of the element mentioned, but that it predominates and others are present only in minimal quantities.

Physical Properties

Density 8.01 g/cm³
0.289 lb/in³

The exact density is dependent on compositional variation within the release specification.

Melting Range Liquidus temperature 1345°C
Solidus temperature 1290°C

The liquidus temperature was determined by inverse cooling techniques and the solidus temperature obtained by metallographic examination. The accuracy of determination was ± 5°C for the liquidus temperature and +0, -10°C for the solidus temperature.

Table 1 - Specific Heat

Temperature, °C	Specific Heat, J/kg•°C
20	419
100	461
200	502
300	502
400	544
500	544
600	586
700	628
800	628
900	670
1000	670

Table 2 - Thermal Conductivity

Temperature ,°C	Thermal Conductivity, W/m •°C
20	10.89
100	12.10
200	13.57
300	14.99
400	16.33
500	17.67
600	18.63
700	20.56
800	22.23
900	24.03
1000	26.21

These values have been ***calculated*** from electrical resistance measurements on a single 3-stage heat-treated specimen using the modified Wiedemann-Franz equations.

Table 3 - Mean Coefficient of Linear Thermal Expansion

Temperature range, °C	10^{-6}/ °C
20-100	12.2
20-200	12.8
20-300	13.1
20-400	13.4
20-500	13.7
20-600	14.0
20-700	14.5
20-800	15.3
20-900	16.5
20-1000	18.0

Extruded section subsequently cold rolled given heat treatment
4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC.
These data are average and subject to approximately ±5% variation.

Table 4 - Electrical Properties

Electrical resistivity at 20°C = 131 microhm cm

Temperature °C	Relative Resistance
20	1.000
100	1.021
200	1.044
300	1.066
400	1.089
500	1.107
600	1.155
700	1.117
800	1.106
900	1.088
1000	1.055

Hot rolled bar subsequently cold drawn (wire) and given heat treatment 15 min/1150°C/AC + 1 h/1050°C/AC + 16 h/850°C/AC.

Table 5 - Magnetic Properties

Magnetic permeability from 0.02T-0.2T	1.000715

Extruded bar subsequently forged and given heat treatment 4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC.

Table 6 - Dynamic Young's Modulus

Temperature °C	Extruded bar	Extruded bar, subsequently forged	Extruded bar, subsequently cold rolled
	GPa	GPa	GPa
20	188	223	220
100	184	219	216
200	179	212	210
300	174	206	204
400	168	200	198
500	161	193	191
600	154	186	185
700	147	178	177
800	139	168	168
900	129	155	154
1000	110	138	137

Heat treatment 4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC.

Tensile Properties: Extruded Bar

The data given in Table 7 and presented graphically in Figures 1 and 2 represent the tensile properties for extruded bar after the 3-stage heat treatment.

Strain rate 0.005/min to proof stress (at room temperature), 0.002/min to proof stress (at elevated temperatures) and 0.1/min thereafter.

Table 7 - Heat treatment 4 h/1150°C/AC + 16 h/1050-1065°C/AC + 16 h/850°C/AC

Temperature, °C	0.1% proof stress	0.2% proof stress	Tensile strength	Elongation on 5.65 √ So, %	Reduction of area, %
	MPa	MPa	MPa		
20	751	776	1140	22	31
100	739	762	1123	20	31
200	712	735	1084	21	38
300	712	735	1091	20	30
400	718	743	1101	24	39
500	711	740	1064	23	37
600	694	720	1038	25	38
700	706	732	1018	28	36
800	647	677	813	25	37
900	373	400	496	30	47
1000	144	152	175	42	73
1100	26	29	51	172	99

Average results of tests on 15 casts.

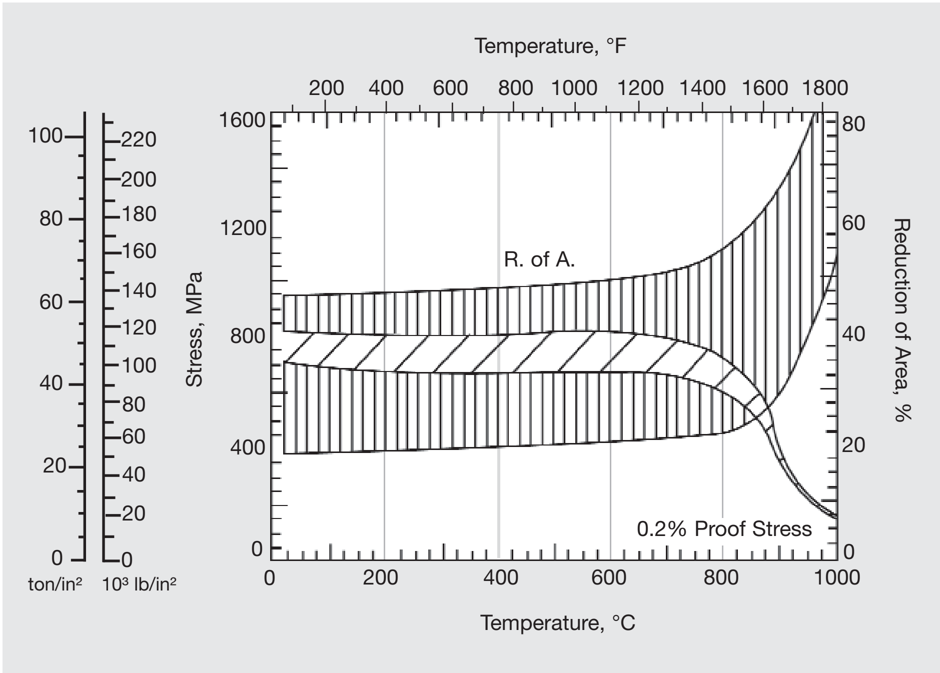

Figure 1. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC

98% confidence region calculated on 15 casts

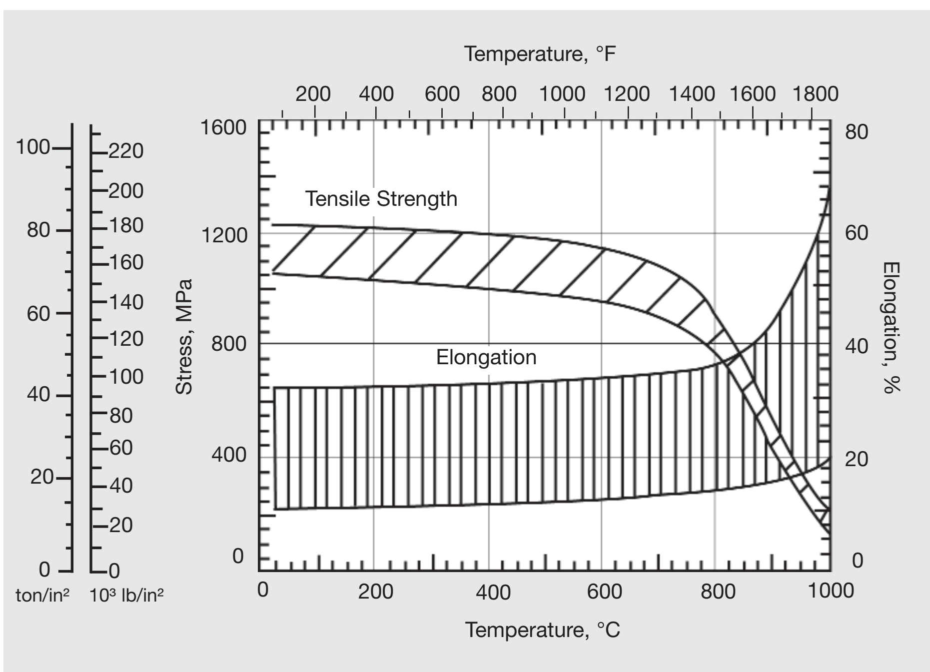

Figure 2. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC

98% confidence region calculated on 15 casts

Tensile Properties: Extruded Bar Subsequently Forged

The data given in Table 8 and presented graphically in Figures 3 and 4 represent the tensile properties for extruded bar subsequently forged after the 3-stage heat treatment.

Strain rate 0.005/min to proof stress (at room temperature), 0.002/min to proof stress (at elevated temperatures) and 0.1/min thereafter.

Table 8 - Heat treatment 4 h/1150°C/AC + 16 h/1050-1065°C/AC + 16 h/850°C/AC

Temperature, °C	0.1% proof stress	0.2% proof stress	Tensile strength	Elongation on 5.65 √ So, %	Reduction of area, %
	MPa	MPa	MPa		
20	796	827	1180	16	16
100	760	793	1185	21	24
200	745	774	1188	24	34
300	739	766	1162	20	24
400	732	763	1126	23	33
500	748	782	1148	23	31
600	735	769	1111	22	32
700	739	768	1075	26	33
800	680	714	836	24	34
900	390	411	491	28	38
1000	152	156	189	43	60
1100	28	31	56	132	99

Average results of tests on 15 casts.

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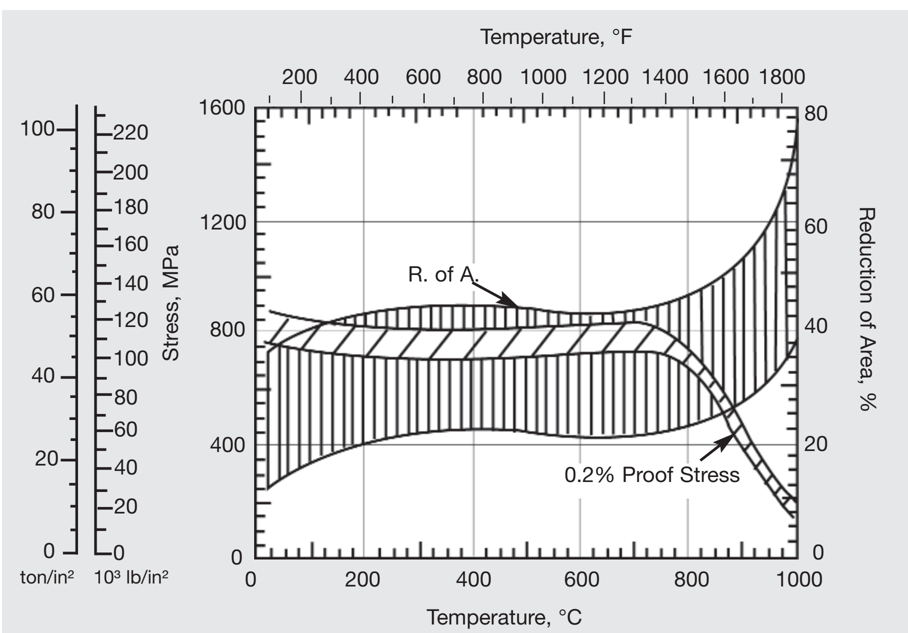


Figure 3. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC
98% confidence region calculated on 15 casts

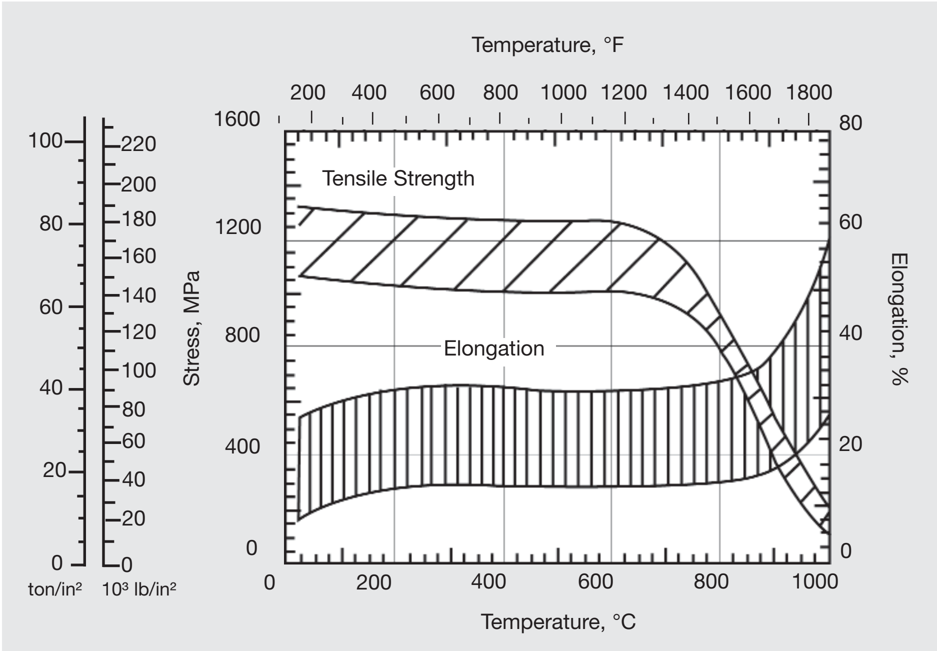


Figure 4. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC
98% confidence region calculated on 15 casts

Tensile Properties: Extruded Section Subsequently Cold Rolled

The data given in Table 9 and presented graphically in Figures 5 and 6 represent the tensile properties for extruded section subsequently cold rolled after the 3-stage heat treatment.

Strain rate 0.005/min to proof stress (at room temperature), 0.002/min to proof stress (at elevated temperatures) and 0.1/min thereafter.

Table 9 - Heat treatment 4 h/1150°C/AC + 16 h/1050-1065°C/AC + 16 h/850°C/AC

Temperature, °C	0.1% proof stress	0.2% proof stress	Tensile strength	Elongation on 5.55 √ So, %	Reduction of area, %
	MPa	MPa	MPa		
20	795	826	1246	25	29
100	780	811	1220	24	30
200	755	785	1234	26	31
300	744	772	1239	26	31
400	744	783	1226	27	31
500	752	785	1195	27	31
600	743	775	1177	25	31
700	744	778	1092	31	31
800	681	718	856	25	31
900	392	420	533	31	39
1000	168	176	221	48	61

Average results of tests on 15 casts.

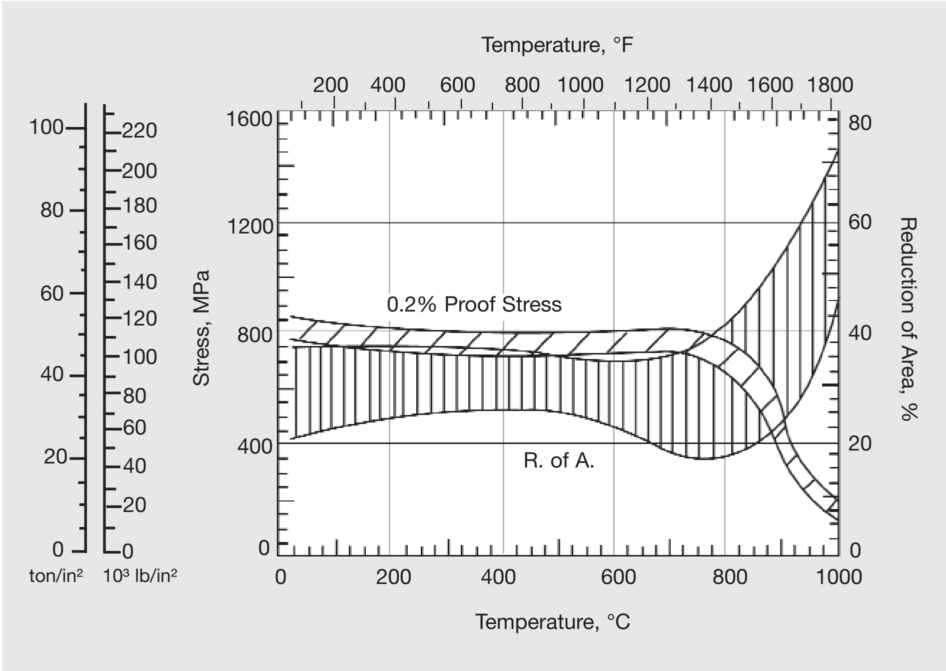


Figure 5. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC
98% confidence region calculated on 15 casts

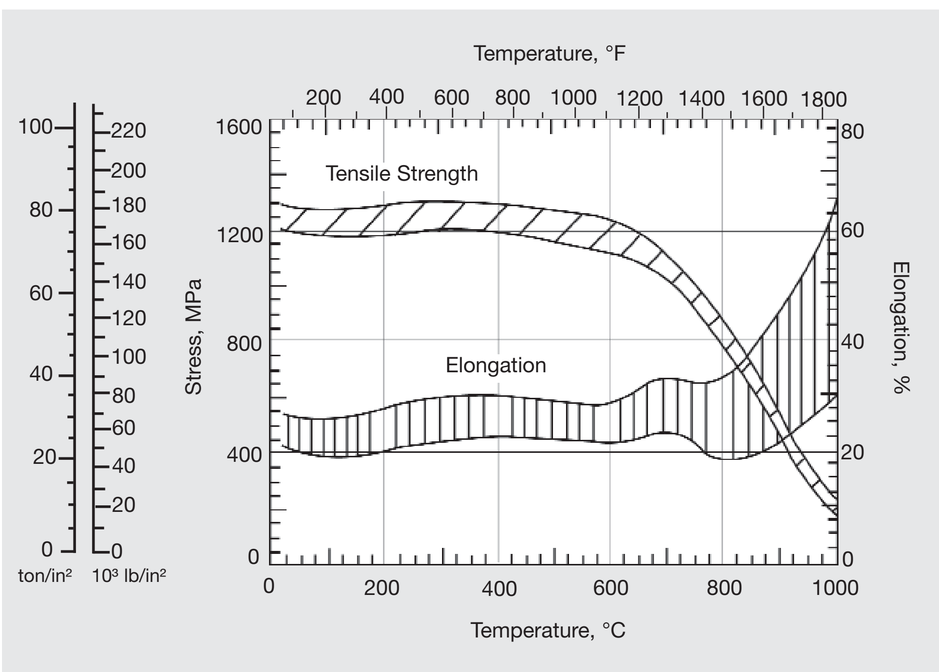


Figure 6. Heat treatment 4h/1150°C/AC + 16h/1050-1065°C/AC + 16h/850°C/AC
98% confidence region calculated on 15 casts

Tensile Properties: Extruded Bar Subsequently Cold Stretched

The data given in Table 10 and presented graphically in Figure 7 represent the tensile properties for extruded bar subsequently cold stretched after the 2-stage heat treatment.

Strain rate 0.005/min to proof stress (at room temperature), 0.002/min to proof stress (at elevated temperatures) and 0.1/min thereafter.

Table 10 - Heat treatment 4 h/1125°C/AC + 16 h/850°C/AC

Temperature, °C	0.1% proof stress	0.2% proof stress	Tensile strength	Elongation on 5.55 √ So, %	Reduction of area, %
	MPa	MPa	MPa		
20	791	811	1220	25	35
100	749	777	1177	24	39
200	731	757	1186	27	34
300	732	752	1183	25	36
400	740	760	1143	28	35
500	740	771	1140	28	35
600	726	759	1106	26	35
700	723	752	1060	30	33
800	678	706	817	27	35
900	407	430	496	27	35
1000	155	161	210	46	59

Test on 1 cast.

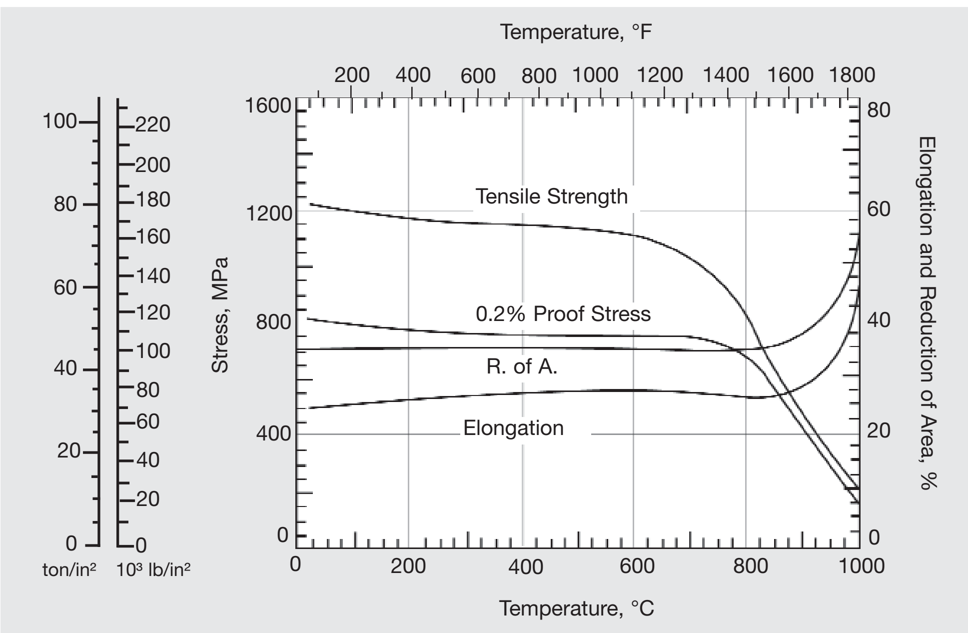


Figure 7. Heat treatment 4h/1125°C/AC + 16h/850°C/AC

Creep Properties

The creep characteristics for NIMONIC alloy 105 have been determined for bar after the 3-stage heat treatment.

Creep-rupture properties for extruded bar subsequently forged are shown in Table 11 and Figures 8 and 9, by Larson-Miller presentation and Graham and Walles technique.

Creep-rupture properties for extruded bar subsequently cold stretched are shown in Table 12 and Figures 10 and 11.

Derived total plastic strain data were created from test specimens 9.1 - 11.7 mm diameter x 76 mm gauge length (0.357 - 0.461 in diameter x 3 in gauge length) and are shown in Table 13.

Creep-Rupture Properties: Extruded Bar Subsequently Forged

The data given in Table 11 and presented graphically in Figures 8 and 9 represent the average results of 15 casts of extruded bar subsequently forged.

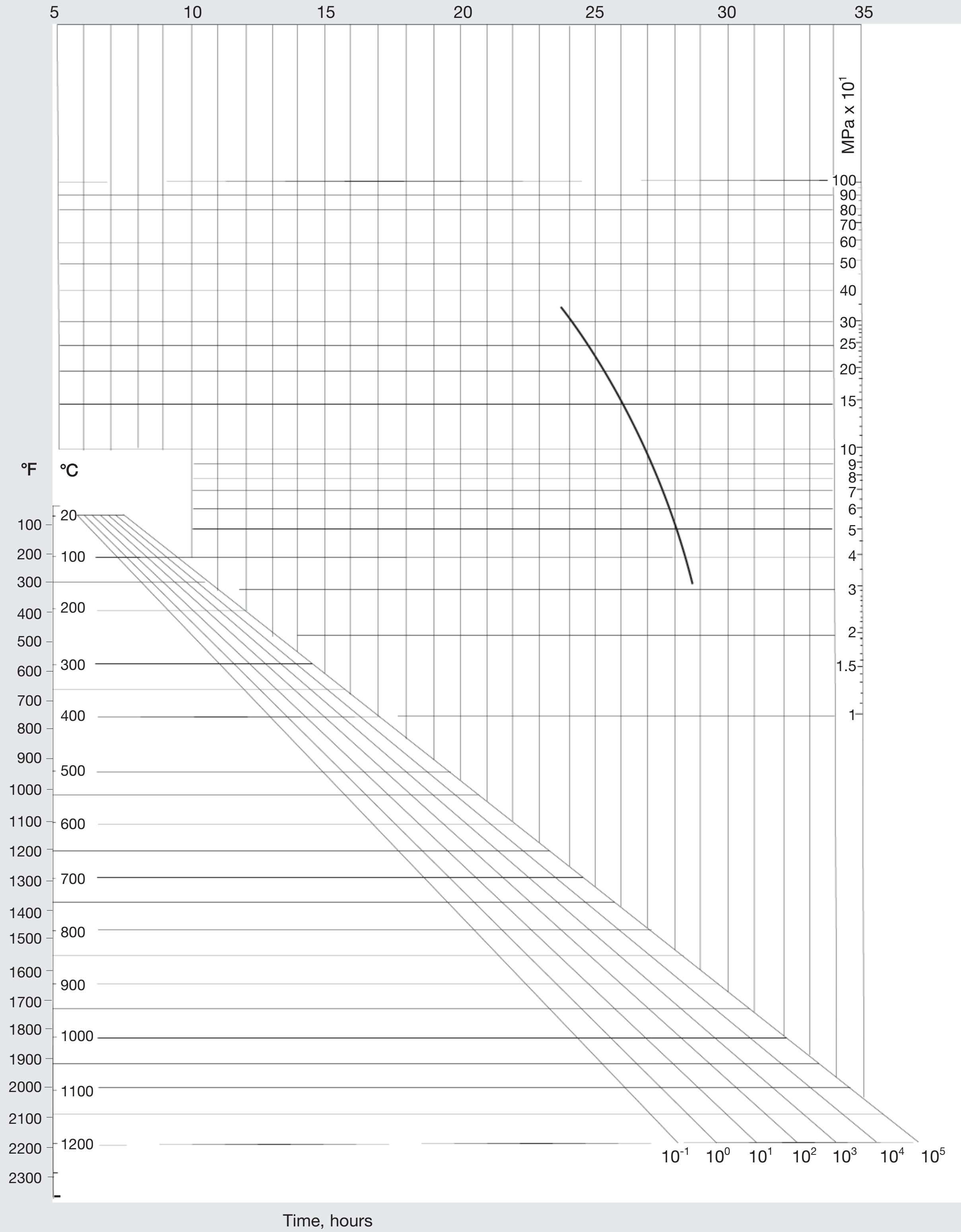
Table 11 - Heat treatment 4 h/1150°C/AC + 16 h/1050-1065°C/AC + 16 h/850°C/AC

Test temperature °C		Stress to produce rupture in 100 h MPa	300 h MPa	1000 h MPa	3000 h MPa	10 000 h MPa	30 000 h MPa	100 000 h MPa	Elongation at fracture on 5.65 √ So, %
750	GW	456	394	340	270	(201)	(154)	(83)	12-18
	LM	448	417	363	317	(263)	(224)	(178)	
815	GW	324	278	232	178	(130)	(77)	(42)	8-21
	LM	324	270	224	185	(144)	(116)	(85)	
870	GW	208	178	131	99	(54)	(31)	(17)	7-17
	LM	208	173	134	102	(77)	(54)	(39)	
940	GW	108	82	(60)	(36)	(20)	—	—	10-21
	LM	108	85	(62)	(39)	(25)	—	—	
980	GW	68	51	31	(17)	—	—	—	12-22
	LM	68	51	32	(19)	—	—	—	

GW=Graham and Walles analysis. LM=Larson-Miller analysis. ( ) =Outside range of determination.

Creep-Rupture Properties: Extruded Bar Subsequently Forged

Figure 8 - Larson-Miller Parameter, T(20 + log t) x10^{-3}; T in °K, t in hours; Heat treatment 4 h/1150°C/AC + 16 h/1050-1065°C/AC + 16 h/850°C/AC



1MPa x 10^1 = 10^7 N/m^2 ; 1 N/mm^2 (1 MN/m^2) = 0.1 hbar = 1.02 kgf/mm^2 = 0.0647 tonf/in^2

Creep-Rupture Properties: Extruded Bar Subsequently Forged

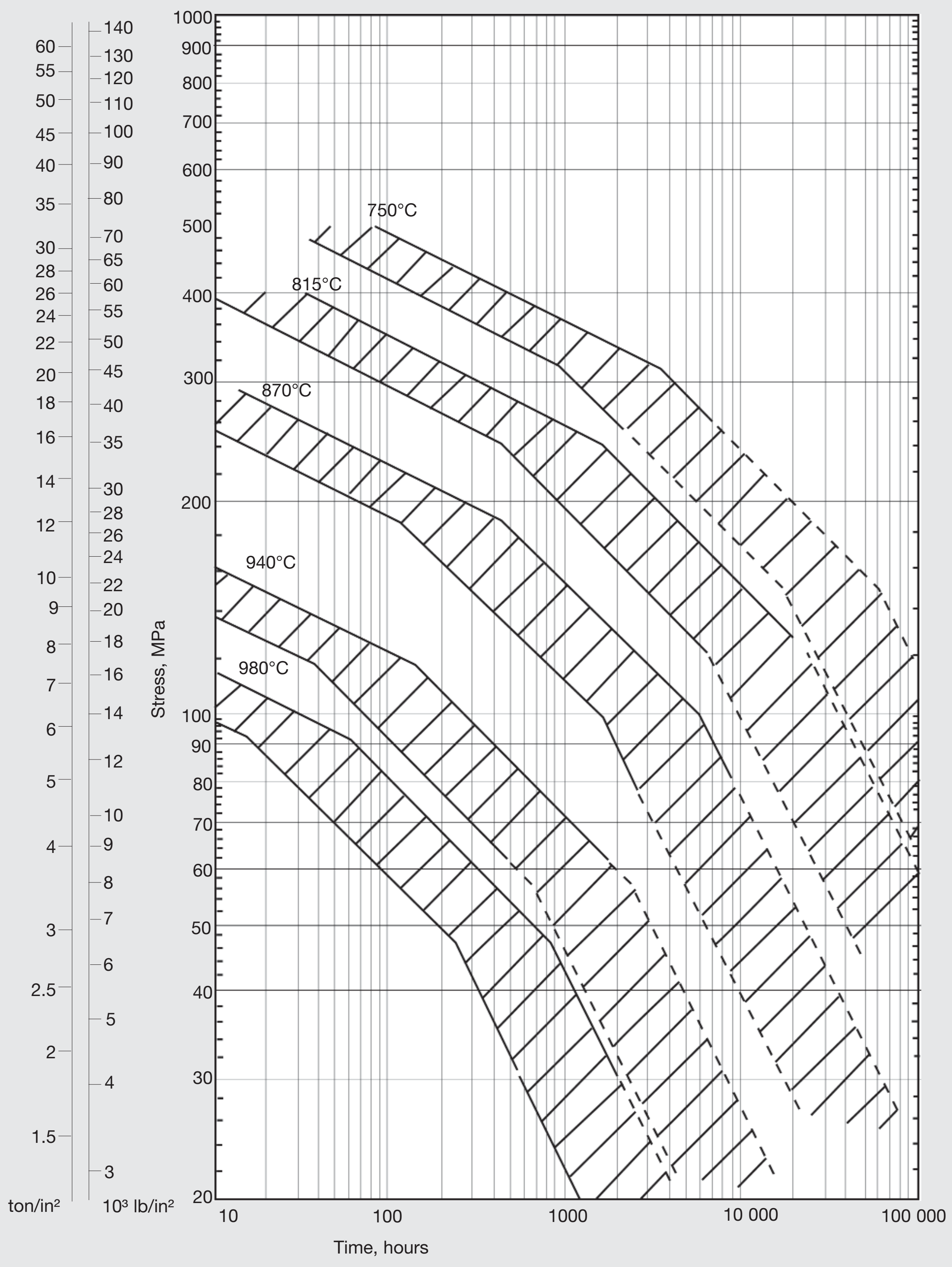


Figure 9. Heat-treatment 4 h/1150°C/AC + 16h/1050-1065°C/AC + 16 h/850°C/AC

Creep-Rupture Properties: Extruded Bar Subsequently Cold Stretched

The data given in Table 12 and presented graphically in Figure 10 represent the creep-rupture properties of extruded bar subsequently cold stretched.

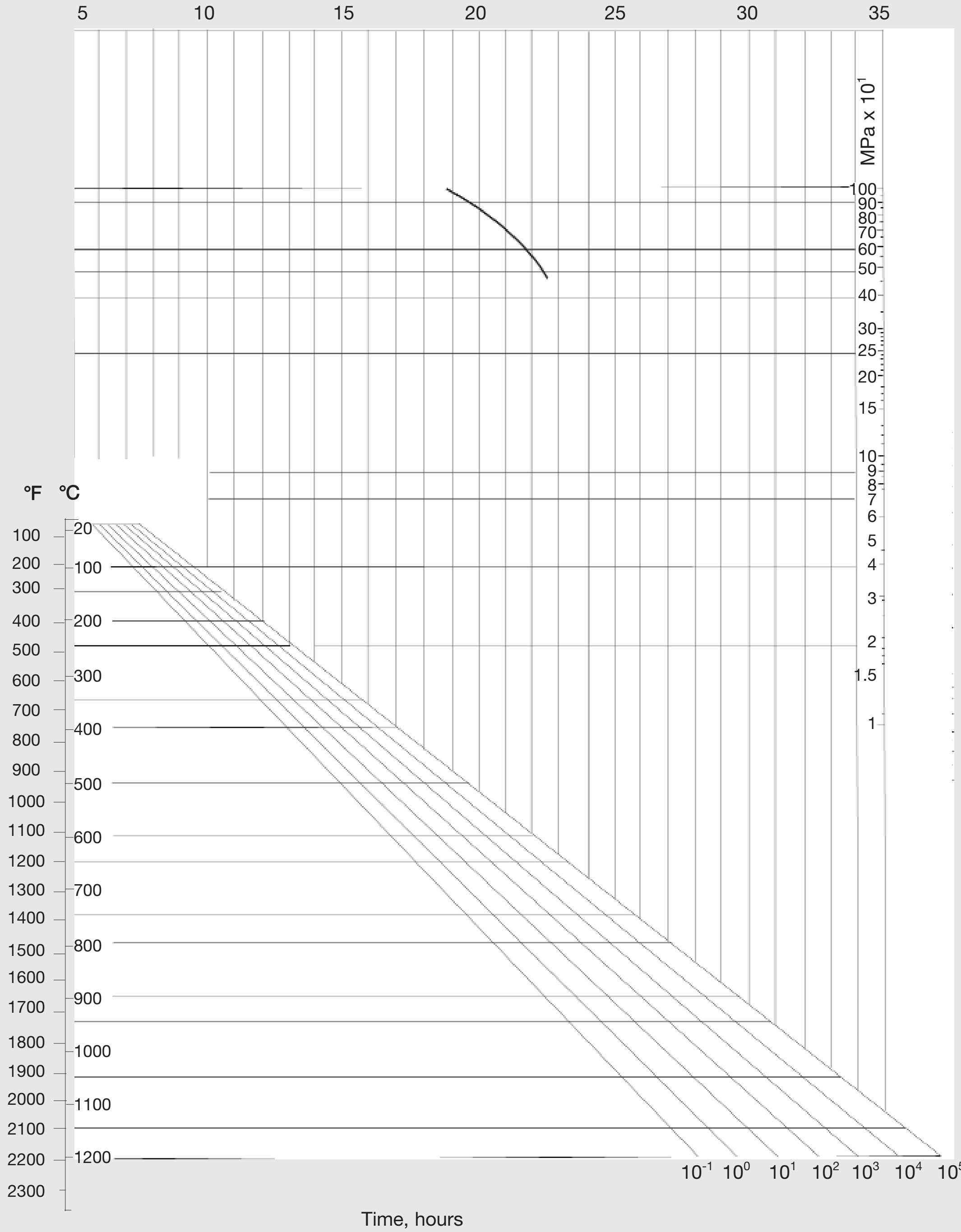
Table 12 - Heat treatment 4 h/1125°C/AC + 16 h/850°C/AC

Test temperature, °C	Stress to produce rupture in			Elongation at fracture on 5.65 √ So, %
	100h	300h	1000h	
	MPa	MPa	MPa	
550	1050	1020	989	18-21
600	958	911	865	8-17
650	819	742	680	9-13
700	634	572	495	13-19

Test on 1 cast.

Creep-Rupture Properties: Extruded Bar Subsequently Cold Stretched

Figure 10 - Larson-Miller Parameter, T(20 + log t) x10^{-3}; T in °K, t in hours.
Heat treatment 4 h/1125°C/AC +16 h/850°C/AC



1MPa x 10^1 = 10^7 N/m^2

1 N/mm^2 (1 MN/m^2) = 0.1 hbar = 1.02 kgf/mm^2 = 0.0647 tonf/in^2

Creep-Rupture Properties: Extruded Bar Subsequently Cold Stretched

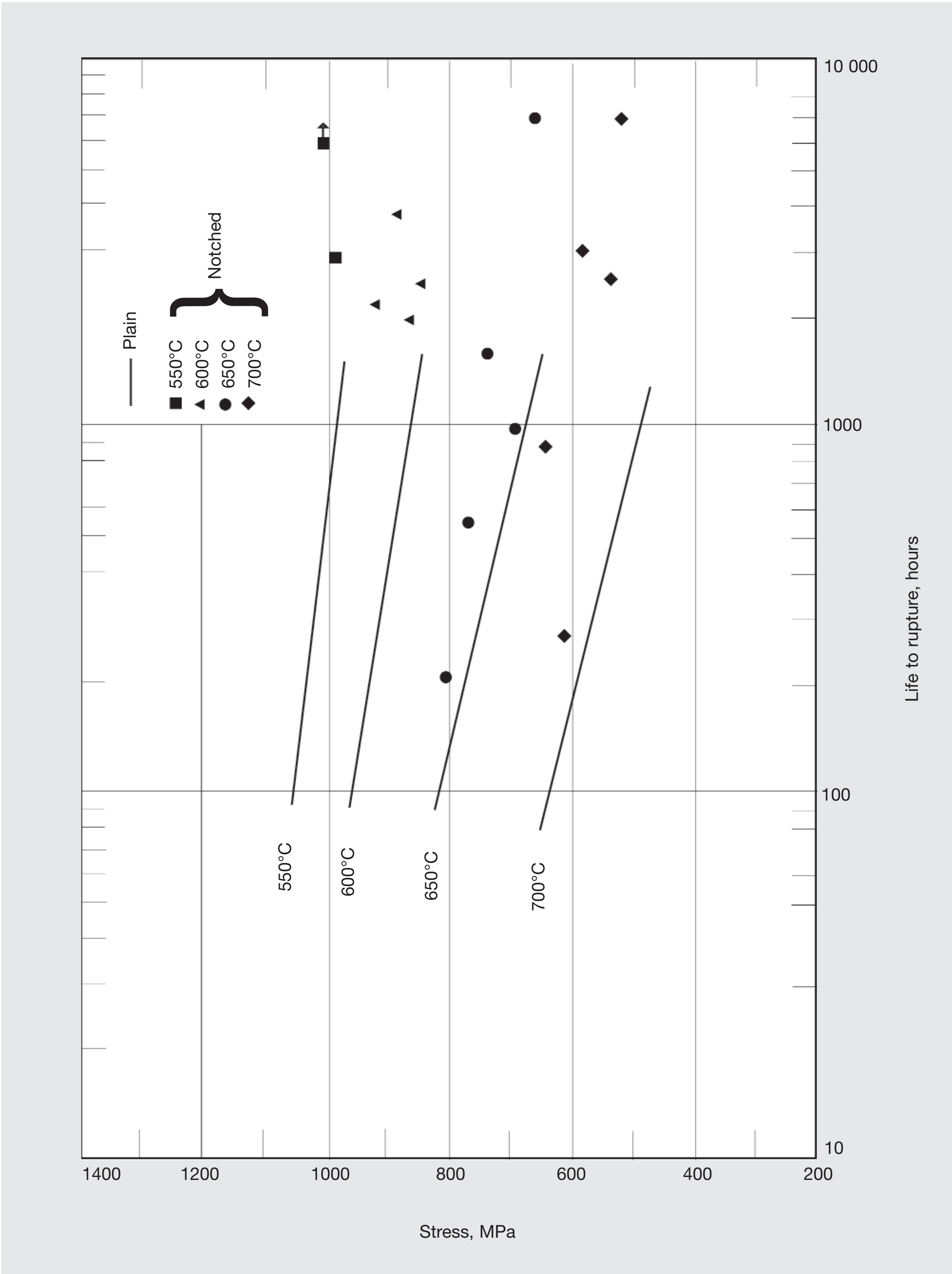


Figure 11. Heat-treatment 4 h/1125°C/AC + 16 h/850°C/AC

Total Plastic Strain Data

This data has been determined on ‘as extruded bar’ and ‘extruded section’ subsequently cold worked.

Test temperature °C	Strain %	Stress to give total plastic strain in					
		100 h	300 h	1000 h	3000 h	10 000 h	30 000 h
		MPa	MPa	MPa	MPa	MPa	MPa
650	0.1	599	541	479	422	(358)	–
	0.2	625	568	510	456	394	–
	0.5	667	602	539	486	428	(375)
	rupture	772	703	618	549	471	410
750	0.1	314	275	233	196	(154)	–
	0.2	358	317	275	238	196	(159)
	0.5	391	352	310	273	232	(195)
	rupture	479	427	368	314	263	(209)
815	0.1	190	139	97	74	57	–
	0.2	241	190	134	100	74	49
	0.5	–	229	181	136	93	57
	rupture	309	263	218	178	135	99
870	0.1	133	105	76	54	37	–
	0.2	156	128	97	71	46	34
	0.5	170	142	111	83	54	(37)
	rupture	193	164	130	99	65	40
980	0.1	22	–	–	–	–	–
	0.2	28	17	–	–	–	–
	0.5	36	26	15	–	–	–
	rupture	60	43	31	22	12	–

( ) = Outside range of determination *Tests on 3 casts.*

Fatigue Properties: Extruded Section Subsequently Cold Rolled

Fatigue properties for extruded section subsequently cold rolled given the heat treatment 4h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC are given in Table 14.

Gerber Diagrams

Figures 12 to 17 illustrate the fatigue properties of NIMONIC alloy 105 extruded section subsequently cold rolled (heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC) at 20°C, 400°C, 650°C, 750°C, 870°C and 980°C respectively, under conditions of uniaxial stressing with varying mean stress. The abscissae represent the mean stress and the ordinate fluctuating stress. Thus a point on the horizontal axis represents the steady stress which will produce fracture in a specific time in a normal creep rupture test. A point on the vertical axis indicates the fluctuating stress required to produce a pure fatigue failure in the same time at the particular testing frequency adopted. The lines radiating from the origin correspond to stress conditions of the form P ±CP where P is the steady stress and C is a constant for any line. The full lines join points corresponding to lines of 50 and 500 hours for varying stress conditions.

Table 14 - Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

Test temperature °C	Stress form	Stress for lives of 50 h (3×10^7 cycles) MPa	Stress for lives of 500 h (3×10^8 cycles) MPa
20	O ± P	348	248
	P ± 2P	155	116
	P ± P	271	209
	P ± ½P	433	356
	P ± ¼P	618	556
400	O ± P	232	232
	P ± P	193	193
	P ± ½P	371	371
	P ± ¼P	618	618
	P ± O	1004	1004
650	O ± P	271	271
	P ± P	240	240
	P ± ½P	417	417
	P ± ¼P	711	688
	P ± O	834	688
750	O ± P	263	248
	P ± P	232	209
	P ± ½P	417	371
	P ± ¼P	502	386
	P ± O	502	386
870	O ± P	240	193
	P ± P	201	155
	P ± ½P	240	155
	P ± ¼P	240	155
	P ± O	240	155
980	O ± P	170	124
	P ± P	84	46
	P ± ½P	84	46
	P ± ¼P	84	46
	P ± O	84	46

Fatigue Properties: Extruded Section Subsequently Cold Rolled

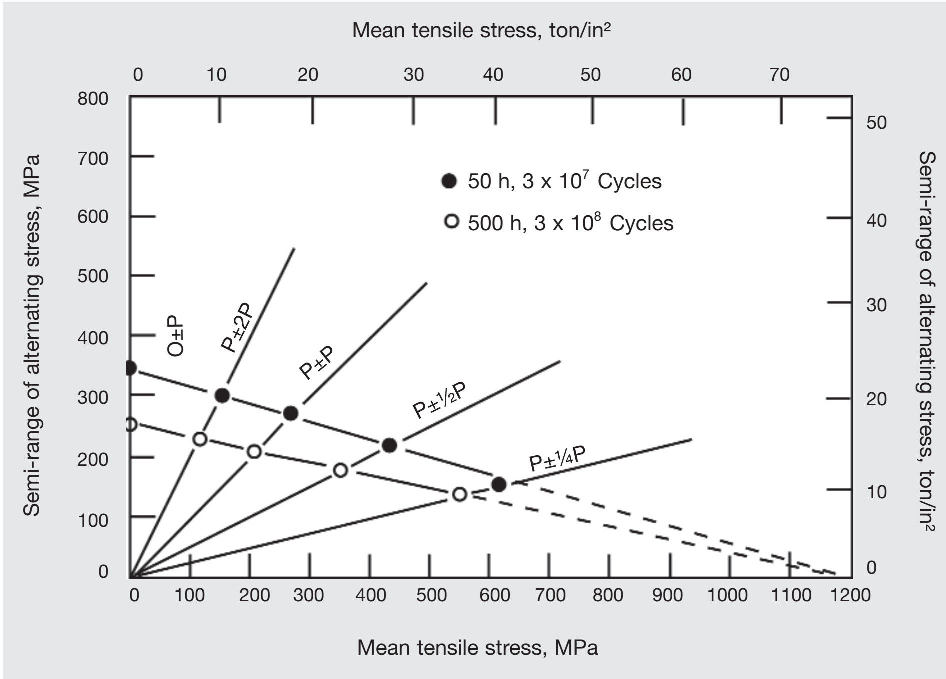


Figure 12. Fatigue properties at room temperature.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

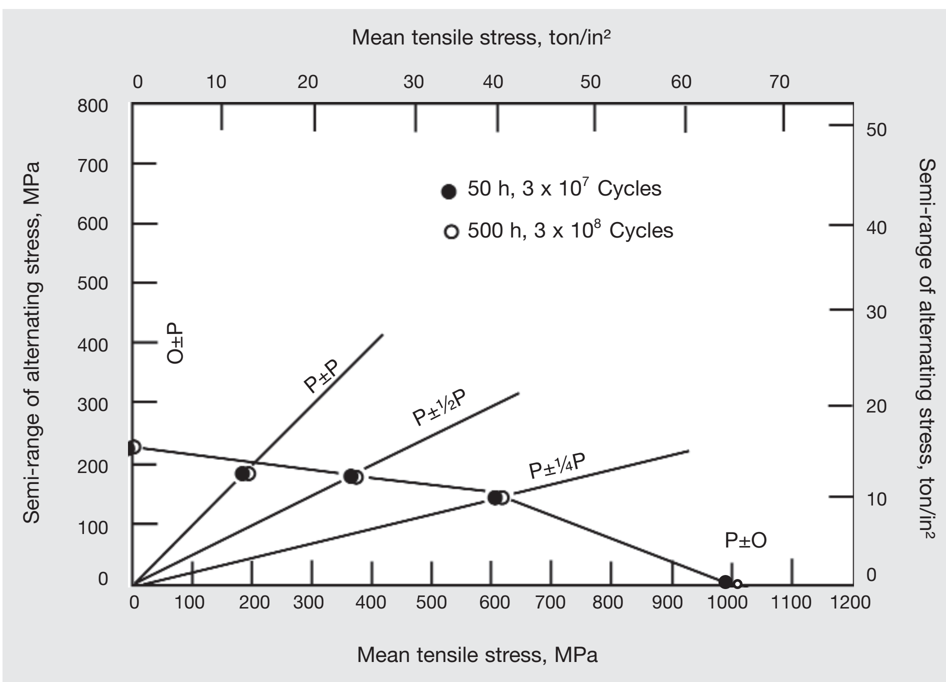


Figure 13. Fatigue properties at 400°C.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

Fatigue Properties: Extruded Section Subsequently Cold Rolled

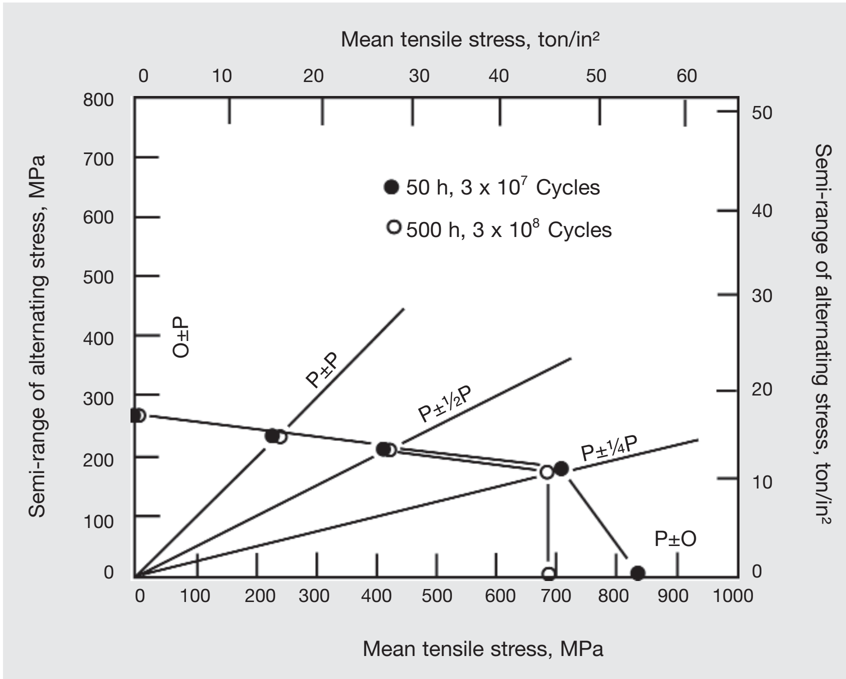


Figure 14. Fatigue properties at 650°C.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

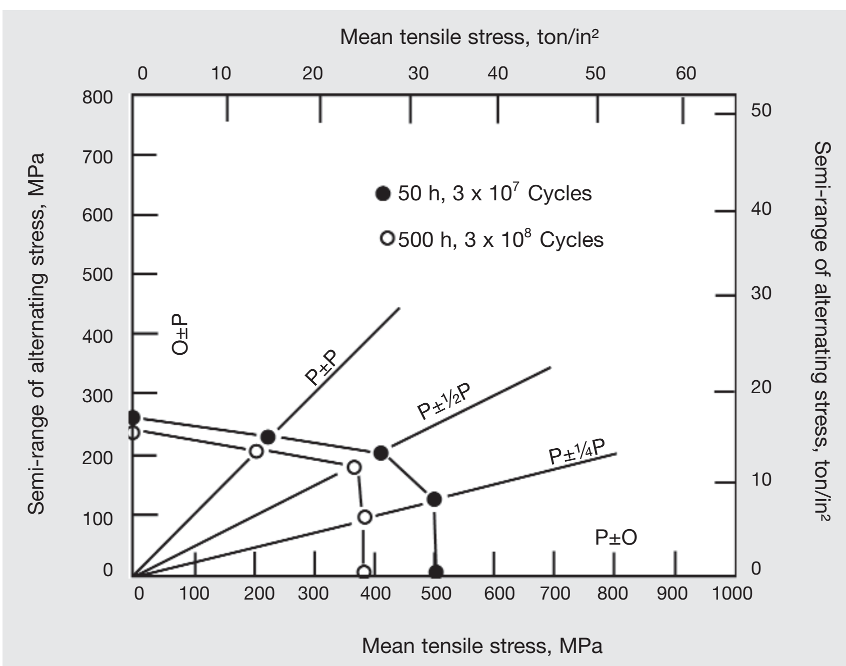


Figure 15 . Fatigue properties at 750°C.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

Fatigue Properties: Extruded Section Subsequently Cold Rolled

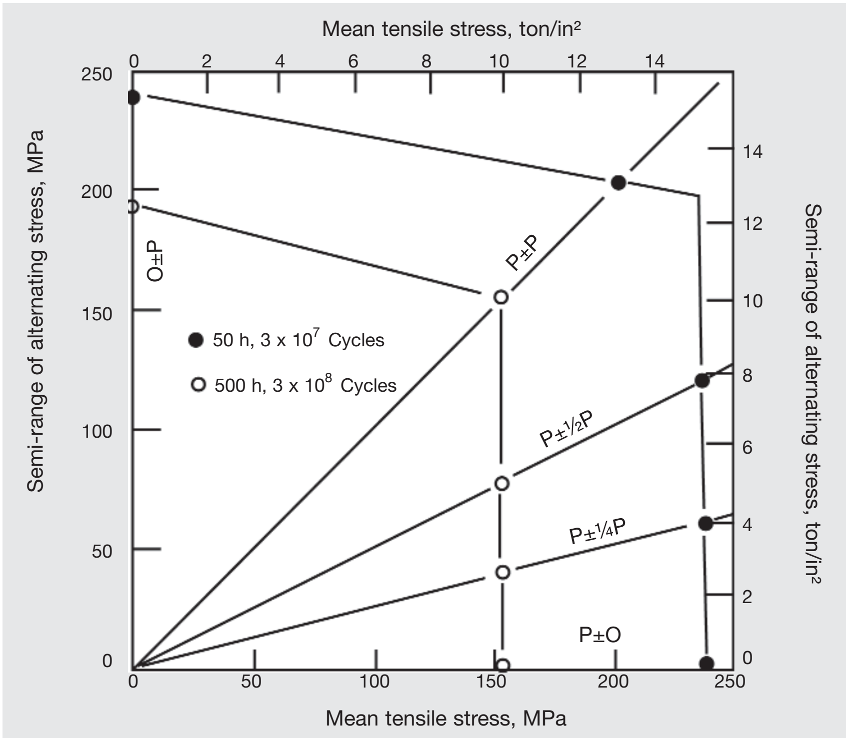


Figure 16. Fatigue properties at 870°C.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

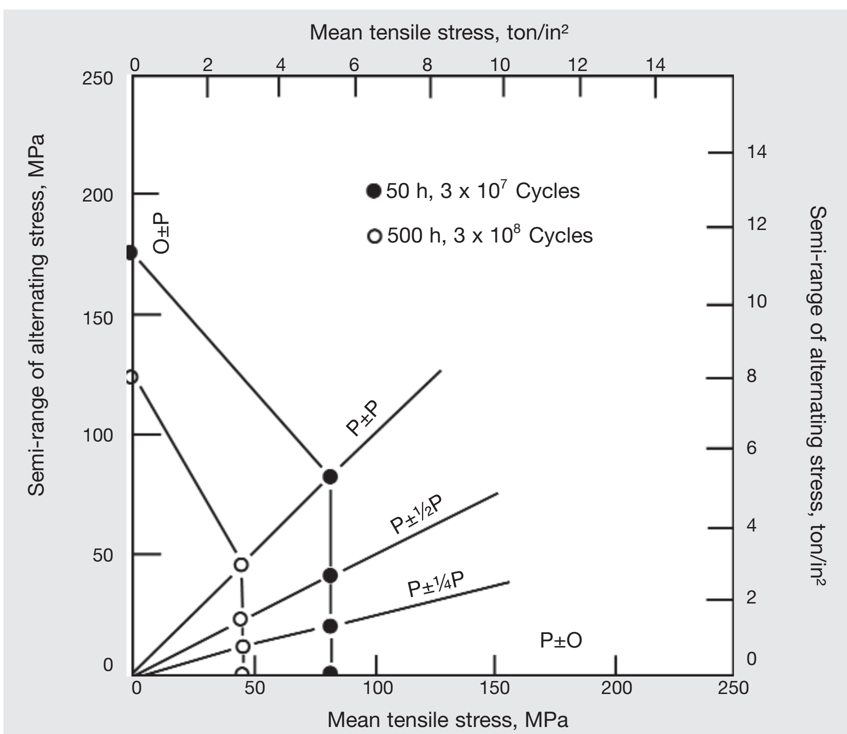


Figure 17. Fatigue properties at 980°C.
Heat treatment 4 h/1150°C/AC + 4 h/1080°C/AC + 8 h/850°C/AC

Stress Relaxation Properties

Stress relaxation data is given for extruded bar given the two recommended heat treatments. It should be noted that only very limited data has been established, and that Tables 15 and 16 only give a general guide to the level of these properties.

Stress Relaxation Properties: Extruded Bar Subsequently Hot Rolled

0.15% Initial Strain **Table 15** - Heat treatment 4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC

Test condition		Time (h) to reach indicated residual stress											Final Reading	
Temp. °C	Stress MPa	232	201	186	170	155	139	124	109	93	77	62	Time h	Stress MPa
600	274	10 000	—	—	—	—	—	—	—	—	—	—	10 000	232
650	280	8000	—	—	—	—	—	—	—	—	—	—	8613	231
700	277	14 000	4600	7400	10 500	—	—	—	—	—	—	—	13 427	161
750	269	17	160	310	600	1120	2100	4000	7200	—	—	—	16 546	99
800	243	—	3	9	20	40	74	130	250	450	810	1750	2014	60
850	223	—	—	—	—	—	10	21	38	70	140	290	698	33

Stress Relaxation Properties: Extruded Bar Subsequently Cold Stretched

0.30% Initial Strain **Table 16** - Heat treatment 4 h/1125°C/AC + 16 h/850°C/AC

Test Condition		Residual Stress at stated time in MPa				Final reading	
Temp. °C	Stress MPa	100 h	300 h	1000 h	3000 h	Time h	Stress MPa
650	539	525	501	445	382	3841	366
700	502	374	325	283	249	4104	238

Impact Data:
Extruded Bar Subsequently Forged

The room temperature Charpy impact strength for NIMONIC alloy 105 extruded bar subsequently forged and given the recommended heat treatment of 4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC is of the order of 16 J.

Long-term embrittlement of this alloy has been investigated by Charpy impact testing at room and elevated temperatures and the results of duplicate tests are given in Tables 17 and 18 respectively.

Charpy test specimen had square cross-section of 10 mm, test area of 80 mm² and V-notch angle of 45°.

Table 17 - Room Temperature Impact Values

Soaking time, h	Soaking temperature, °C				
	700	750	800	850	900
	J	J	J	J	J
30	11 : 11	9 : 8	14 : 16	23 : 22	22 : 22
100	8 : 11	11 : 12	16 : 16	26 : 19	20 : 19
300	8 : 8	14 : 15	16 : 19	16 : 19	12 : 11
1000	9 : 11	12 : 14	15 : 14	16 : 14	8 : 9
3000	8 : 5	14 : 15	14 : 15	14 : 12	8 : 8
10 000	11 : 8	11 : 11	9 : 11	7 : 9	8 : 5

Table 18 - Elevated Temperature Impact Values

Soaking time, h	Soaking and test temperature, °C				
	700	750	800	850	900
	J	J	J	J	J
0	24 : 30	23 : 22	23 : 22	23 : 24	27 : 27
30	16 : 19	19 : 19	19 : 23	23 : 23	24 : 26
100	18 : 9	15 : 19	23 : 23	22 : 24	23 : 26
300	8 : 11	19 : 20	23 : 20	24 : 23	22 : 26
1000	18 : 14	22 : 19	20 : 20	22 : 20	19 : 19
3000	15 : 15	18 : 19	15 : 23	20 : 19	22 : 20
10 000	14 : 16	20 : 20	18 : 19	16 : 15	27 : 22

Impact Data:
Extruded Section Subsequently Cold Rolled

The room temperature Charpy impact strength of NIMONIC alloy 105 extruded section subsequently cold rolled and given the recommended heat treatment of 4 h/1150°C/AC + 16 h/1050°C/AC + 16 h/850°C/AC is of the order of 20 J.

Long-term embrittlement of this alloy has been investigated by Charpy impact testing at room and elevated temperatures and the results of duplicate tests are given in Tables 19 and 20 respectively.

Charpy test specimen had square cross-section of 10 mm, test area of 80 mm² and V-notch angle of 45°.

Table 19 - Room Temperature Impact Values

Soaking time, h	Soaking temperature, °C				
	700	750	800	850	900
	J	J	J	J	J
30	11 : 11	14 : 14	14 : 19	20 : 20	24 : 26
100	8 : 9	15 : 12	18 : 15	23	22 : 23
300	5 : 8	11	14 : 16	16 : 18	18 : 16
1000	7 : 8	12 : 12	19 : 16	16 : 20	11 : 11
3000	9 : 9	14 : 12	14 : 12	12 : 12	7 : 9
10 000	12 : 12	15 : 14	15 : 14	8 : 9	9 : 5

Table 20 - Elevated Temperature Impact Values

Soaking time, h	Soaking and test temperature, °C				
	700	750	800	850	900
	J	J	J	J	J
0	33 : 30	22 : 22	22 : 19	23 : 22	28 : 30
30	16 : 19	14 : 14	19 : 26	23 : 24	28 : 27
100	20 : 18	12 : 15	24 : 26	24 : 24	30 : 30
300	16 : 16	18 : 20	26 : 26	24 : 24	28 : 26
1000	16 : 15	22 : 24	30 : 27	23 : 23	22 : 24
3000	18 : 18	22 : 24	24 : 24	19 : 19	22 : 20
10 000	20 : 20	23 : 24	23 : 22	15 : 16	18 : 18

Impact Data:
Extruded Bar Subsequently Cold Stretched

The room temperature Charpy impact strength of NIMONIC alloy 105 extruded bar subsequently cold stretched and given the heat treatment of 4h/1125°C/AC + 16h/850°C/AC is of the order of 36 J.

Long-term embrittlement of this alloy has been investigated by Charpy impact testing at room and elevated temperatures and the results of single tests are given in Tables 21 and 22 respectively.

Charpy test specimen had square cross-section of 10 mm, test area of 80 mm² and V-notch angle of 45°.

Table 21 - Room Temperature Impact Values

Soaking time, h	Soaking temperature, °C			
	500	550	600	650
	J	J	J	J
100	31	33	28	24
300	33	33	21	16
1000	24	27	17	8

Table 22 - Elevated Temperature Impact Values

Soaking time, h	Soaking temperature, °C			
	500	550	600	650
	J	J	J	J
0	48	43	47	47
100	45	47	44	41
300	45	48	37	28
1000	44	41	29	15

Corrosion Resistance

Oxidation in Air

Continuous Heating

Descaled weight loss (mg/cm²) after 100 hours at				
800°C	900°C	950°C	1000°C	1100°C
0.11	0.49	0.99	1.43	6.41

Intermittent Heating (Cooling to room temperature every 24 hrs)

Descaled weight loss (mg/cm²) after 100 hours at				
800°C	900°C	950°C	1000°C	1100°C
—	1.19	1.59	1.61	13.3

Cyclic Heating (15 min in furnace, 5 min outside furnace)

Temperature °C	Time to onset of spalling (h) at max cycle temperature of °C	Rate of spalling (mg/cm²/h) at max cycle temperature of °C	Weight change in 100 h (mg/cm²) at max cycle temperature of °C
890	>1000	—	+0.66
910	>1000	—	+1.05
990	600	0.150	-51.9
1010	300	0.408	-229
1090	150	0.946	-748
1110	75	1.170	-955

Resistance to Atmospheres Containing SO_2

Atmosphere	Descaled weight loss (mg/cm²) after 1000 hours at			
	600°C	700°C	800°C	1000°C
3% SO_2-Argon	1.6	8.7	15.0	—
3% SO_2-Air	2.3	1.1	0.6	0.6
3% SO_2-5% O_2-Argon	2.1	0.5	0.6	2.1

Fabrication

Hot working

NIMONIC alloy 105 may be hot worked in the temperature range 1050-1200°C.

Annealing

Interstage annealing of NIMONIC alloy 105 should be carried out at 1150°C followed by air cooling of fluidized bed quenching. Water quenching is not recommended as severe surface cracking may result from thermal shock.

Machining

NIMONIC alloy 105 should be in the fully heat-treated condition for all machining operations. The high hardness range, 320-385 HV, necessitates the use of tungsten carbide tipped tools. High speed steel shock-proof tools can be used if the cut is of an intermittent nature.

Welding

Fusion welding of NIMONIC alloy 105 using conventional processes such as T.I.G. or M.I.G. welding is not recommended as microfissuring can occur both in the weld and heat affected zones. Electron beam welding has been used successfully but the danger of microfissuring still exists and welding trials should always be carried out before the process is specified.

Similar difficulties can be expected with resistance spot, stitch or seam welding. Flash-butt welding is, however, quite satisfactory and in regular use for the production of turbine rings.

High temperature brazing

High temperature brazing in vacuum, dry hydrogen or inert atmospheres is satisfactory for joining NIMONIC alloy 105. However, the brazing cycle chosen should not involve temperatures above the solution treatment temperature (1150°C) as this could adversely affect the properties of the material.

Available Products and Specifications

NIMONIC alloy 105 is generally available in the following forms, subject to minimum order quantities. Other forms are subject to enquiry.

- Bar and billet for forging
- Rod and bar for machining
- Extruded section, rectangular or profiled, for machining, rolling and welding to rings, etc.
- Extruded and cold worked section

NIMONIC alloy 105 is designated W. Nr. 2.4634 and is available to the following specifications:

BS. HR3 billets, bars and forgings
AICMA Ni-P61-HT billets, bars and forgings
Swedish Defence Material Administration MH.14 forged bar
DIN designation NiCo20Cr15MoAlTi forged bar
AFNOR NCKD 20ATv
AECMA PrEn 2179-2181

Units of stress

The primary units for property data are those of the SI system. The unit of stress is the Megapascal. Its relationship with other units is as follows:

$1\text{MPa} = \text{N/mm}^2 = 1\ \text{MN/m}^2 = 0.1\ \text{hbar} = 0.102\ \text{kgf/mm}^2 = 0.0647\ \text{tonf/in}^2$.

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