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Influence of Thermal Aging (To 50,000 h) on the Tensile Properties of Modified 9Cr-lMo Steel

C. R. Brinkman
R. H. Baldwin

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INFLUENCE OF THERMAL AGING (TO 50,000 h) ON THE TENSILE PROPERTIES OF MODIFIED 9Cr-1Mo STEEL

C. R. Brinkman and R. H. Baldwin

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INFLUENCE OF THERMAL AGING (to 50,000 h) ON THE TENSILE PROPERTIES OF MODIFIED 9Cr-1Mo STEEL*

C. R. Brinkman and R. H. Baldwin

ABSTRACT

Results of room- and elevated-temperature tensile tests are reported from tests conducted on three heats of Modified 9Cr-1Mo steel. The heats were thermally aged at various temperatures from 482 to 704°C and at aging times to 50,000 h. Tensile strain rates were also varied in order to determine strain rate sensitivity of tensile properties. Changes in the yield and tensile strengths occurred following exposure to these temperatures with decreases noted at the higher temperatures. The material showed a strain-rate sensitivity particularly at temperatures in excess of about 538°C due to the presence of what was believed to be strain aging. The tensile-strength data were parameterized in order to permit estimates of changes in both the room- and elevated-temperature properties to be made following exposure for prolonged periods in service. Estimates are given of the changes in yield and tensile strengths following isothermal exposure at several temperatures for 60 years of service time. Comparisons are also made between estimated degradation in short-term properties of Modified 9Cr-1Mo steel and several other materials due to thermal aging.

INTRODUCTION

Modified 9Cr-1Mo steel is a ferritic steel proposed for use in the normalized and tempered condition. Because of its high hardenability, the resultant steel has a uniform tempered martensitic microstructure with excellent strength and toughness properties. These characteristics, along with favorable physical properties, make it highly advantageous to use this steel in elevated-temperature applications in the range of about 482 to 593°C. However, there is some concern

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that prolonged exposure in this temperature range and higher may significantly alter subsequent mechanical properties due to changes in the microstructure. Because of interest in the use of this steel in certain liquid-metal breeder reactor applications requiring use of ASME Code Case N-47, it was necessary to define thermal aging strength reduction factors that could be applied if appropriate. Accordingly, it was the objective of this effort to thermally age several heats at temperatures ranging from 482 to 704°C and subsequently to perform tensile tests to define changes in tensile properties.[1] This is an interim report giving results of tests conducted on material aged up to 50,000 h. Additional material is still being aged, and plans call for continuation of this effort to 100,000 h of exposure. Results from tests conducted on this material will be given in future reports.

MATERIAL AND SPECIMEN PREPARATION

Three heats in the form of plate material were used in this study. Chemistry of these heats subsequent to fabrication is given in Table 1. All three heats were melted by Cartech, Reading, Pa. and subsequently fabricated into plate as shown in Table 2. The plates were given the standard normaliz-ing and tempering heat treatment consisting of 1 h at 1040°C and 1 h at 760°C, respectively. Resultant hardness values were approximately R_B 95. Hardness values on material aged up to 50,000 h can be found elsewhere.[2] Following heat treatment, the plates were cut into blanks with their major axis perpendicular to the plate rolling direction and aged for various times and at temperatures of 482, 538, 593, 649, and 704°C. Aging times ranged from 10,000 to 50,000 h with the initial goal being to 100,000 h. Information presented in this report will deal with the influence of thermal aging to 50,000 h.

Following aging, the blanks were machined into tensile bars as shown in Fig. 1. Tensile tests were performed in accordance with ASTM E8 and E151 at a variety of strain rates to failure as follows:

8×10^{-5}/min (1.33×10^{-6} s^{-1})
8×10^{-4}/min (1.33×10^{-5} s^{-1})
4×10^{-3}/min (6.67×10^{-5} s^{-1})
4×10^{-2}/min (6.67×10^{-4} s^{-1})
8×10^{-2}/min (1.33×10^{-3} s^{-1})

Table 1. Chemical analyses of various commercial heats of Modified 9Cr-1Mo steel used in thermal aging program

Element	Content (wt %) for each heat[a]		
	30383 Plate	30394 Plate	30176 Plate
C	0.083	0.084	0.081
Mn	0.46	0.46	0.37
P	0.010	0.010	0.010
S	0.004	0.003	0.003
Si	0.41	0.40	0.11
Ni	0.09	0.09	0.09
Cr	8.46	8.57	8.61
Mo	1.02	1.02	0.89
V	0.198	0.198	0.209
Nb	0.072	0.073	0.072
Ti	0.005	0.055	0.010
Co	0.055	0.055	0.010
Cu	0.03	0.04	0.04
Al	0.002	0.014	0.007
B	<0.001	<0.001	<0.09
W	0.05	0.05	<0.01
As	<0.001	<0.001	0.001
Sn	<0.001	<0.001	0.001
Zr	<0.001	<0.001	<0.001
N	0.051	0.053	0.055

[a]All chemical analysis was carried out at Combustion Engineering, Inc., Chattanooga, Tennessee.

Table 2. Summary of information on commercial heats of Modified 9Cr-1Mo alloy

Heat	Melter	Heat size (tons)	Melting practice[a]	Product	Thickness size (mm)	Fabrication method	Fabricator
30383	Cartech	15	AOD	Plate	51	Hot forged, hot rolled	Jessup
30394	Cartech	15	AOD-ESR	Plate	25	Hot forged, hot rolled	Jessup
30176	Cartech	15	AOD-ESR	Plate	25	Hot forged, hot rolled	Jessup

[a]AOD = argon-oxygen decarburization.
AOD-ESR = argon-oxygen decarburization and elestroslag remelting.

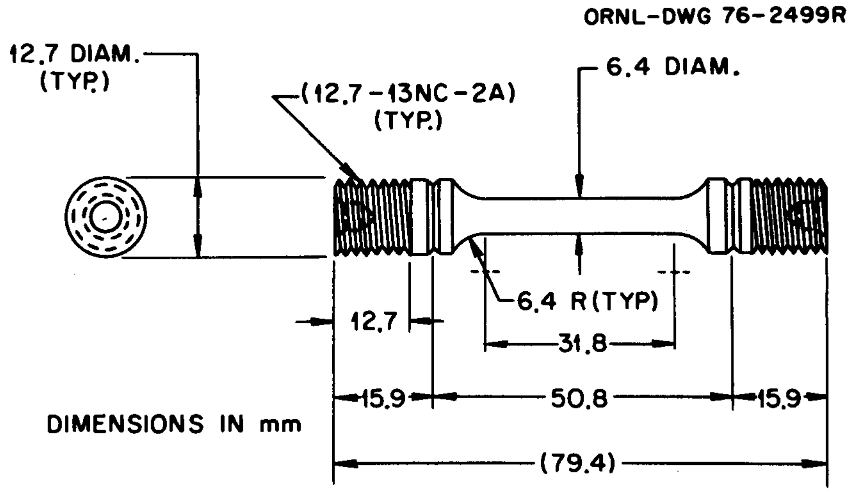


Fig. 1. Schematic drawing of tensile specimen used for characterizing tensile behavior of Modified 9Cr-1Mo steel. Note that actual specimen length was 82.6 mm.

All elevated-temperature tests were conducted using a resistance heated furnace with a specimen soaking time of at least 30 min employed prior to conducting the test.

RESULTS AND DISCUSSION

Results of tensile tests conducted on material aged at different temperatures for various times are tabulated in Appendix A.

Figure 2 compares several tensile properties for heat 30176 aged 50,000 h to unaged material. The strain rate was 0.13/s. Figure 2(*a*) and (*b*) show some reductions in yield and ultimate tensile strengths at temperatures as low as 482°C. This softening of the material also manifests itself as an increase in uniform elongation as shown in Fig. 2(*c*). Figures 3 through 5 compare yield and ultimate tensile strengths of heats 30394, 30176, and 30383 in the aged and unaged condition over the temperature range of 482 to 704°C where the strain rate was $6.7 \times 10^{-5}\ s^{-1}$. Some reduction in both yield and ultimate tensile strengths are apparent, particularly at the higher temperatures.

Figure 6 shows the influence of strain rate and temperature on several tensile properties of aged and unaged heat 30176. Note that as the strain rate is increased, both the yield and ultimate tensile strengths increase at elevated temperatures for both aged and unaged material. A peak value of strength is indicated at a strain rate of about 1/min ($1.67 \times 10^{-1}\ s^{-1}$) at temperatures above 538°C. This peak, which is probably due to dynamic strain aging, is particularly apparent at 593°C in the aged heats 30394 (high silicon) and 30176 (low silicon), as shown in Fig. 7. Figure 6(*c*) shows that the reduced strength of the aged material shown in Fig. 6(*a*) and (*b*) is accompanied by a slight increase in reduction of area for the material aged and tested at 649°C.

Figures 8 through 11 contain plots of ratios of yield or ultimate tensile strengths as a function of a time-temperature parameter P, where P is given by the following expression:

$$\begin{aligned} P &= T(\log t + 10)/1000 , \\ T &= \text{temperature (K)} , \\ t &= \text{time (h)} . \end{aligned} \tag{1}$$

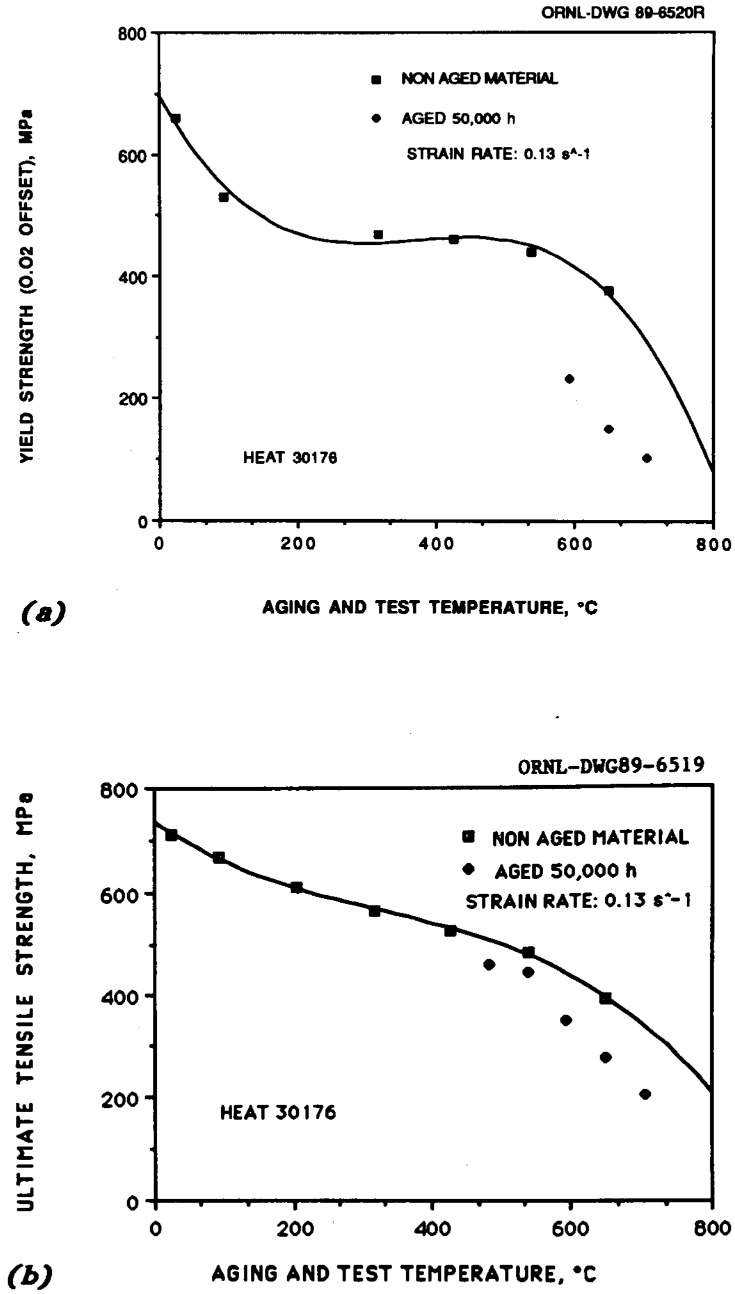
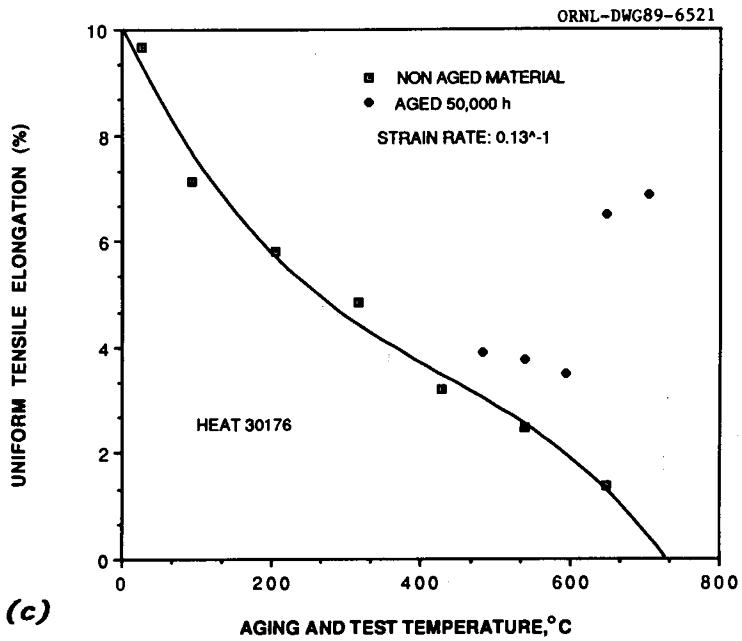
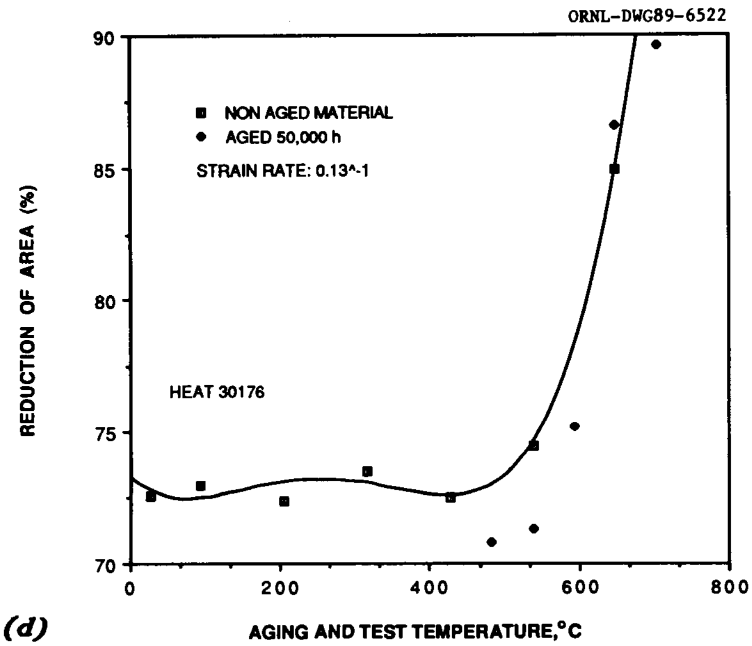


Fig. 2. Tensile properties as a function of temperature for heat 30176 aged for 50,000 h compared to unaged material. (*a*) Yield strength, (*b*) ultimate strength, (*c*) uniform elongation, and (*d*) reduction of area.



(c)



(d)

Fig. 2. (continued)

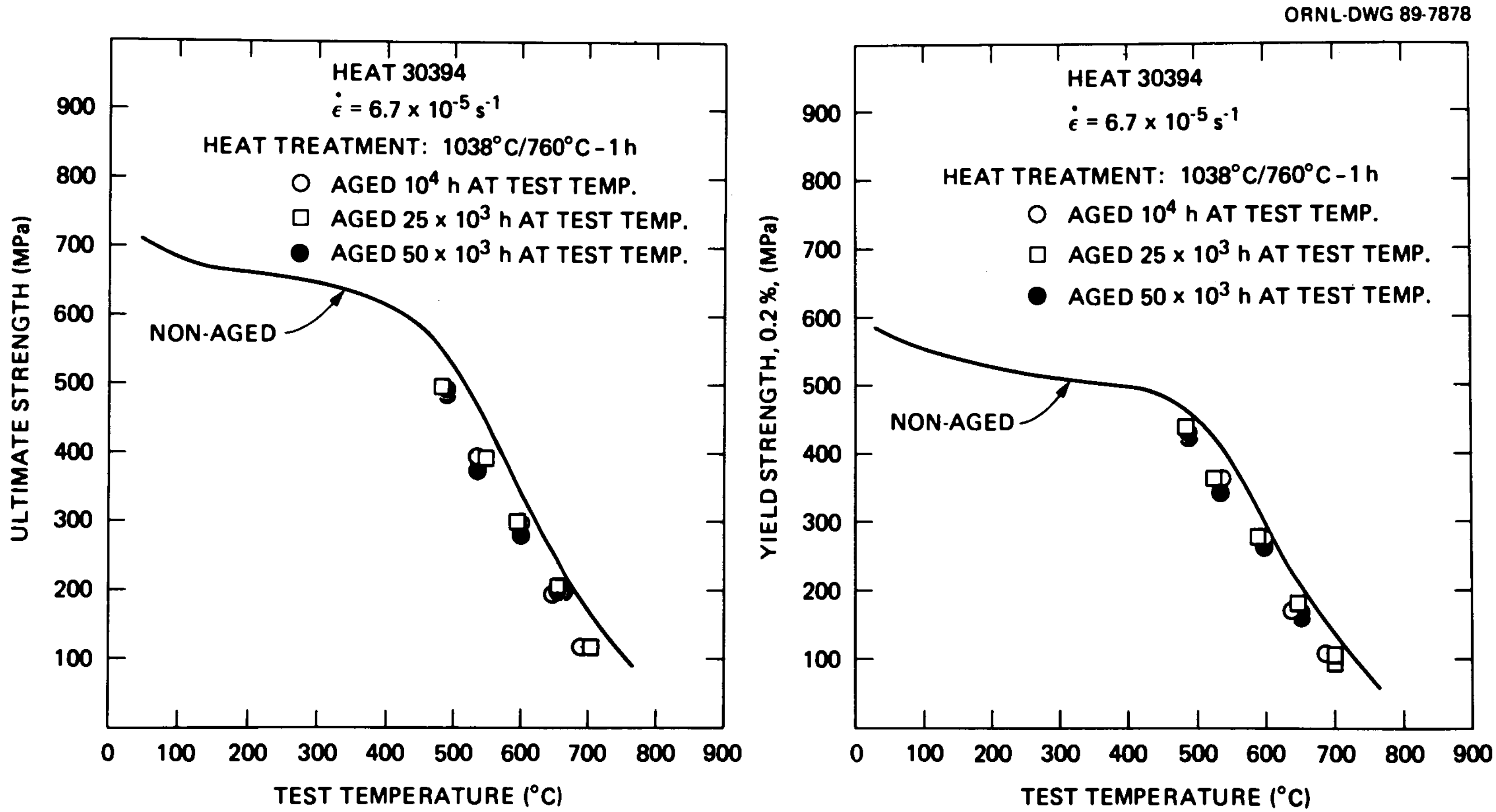


Fig. 3. Influence of aging time on the ultimate and yield strengths of heat 30394 of Modified 9Cr-1Mo steel.

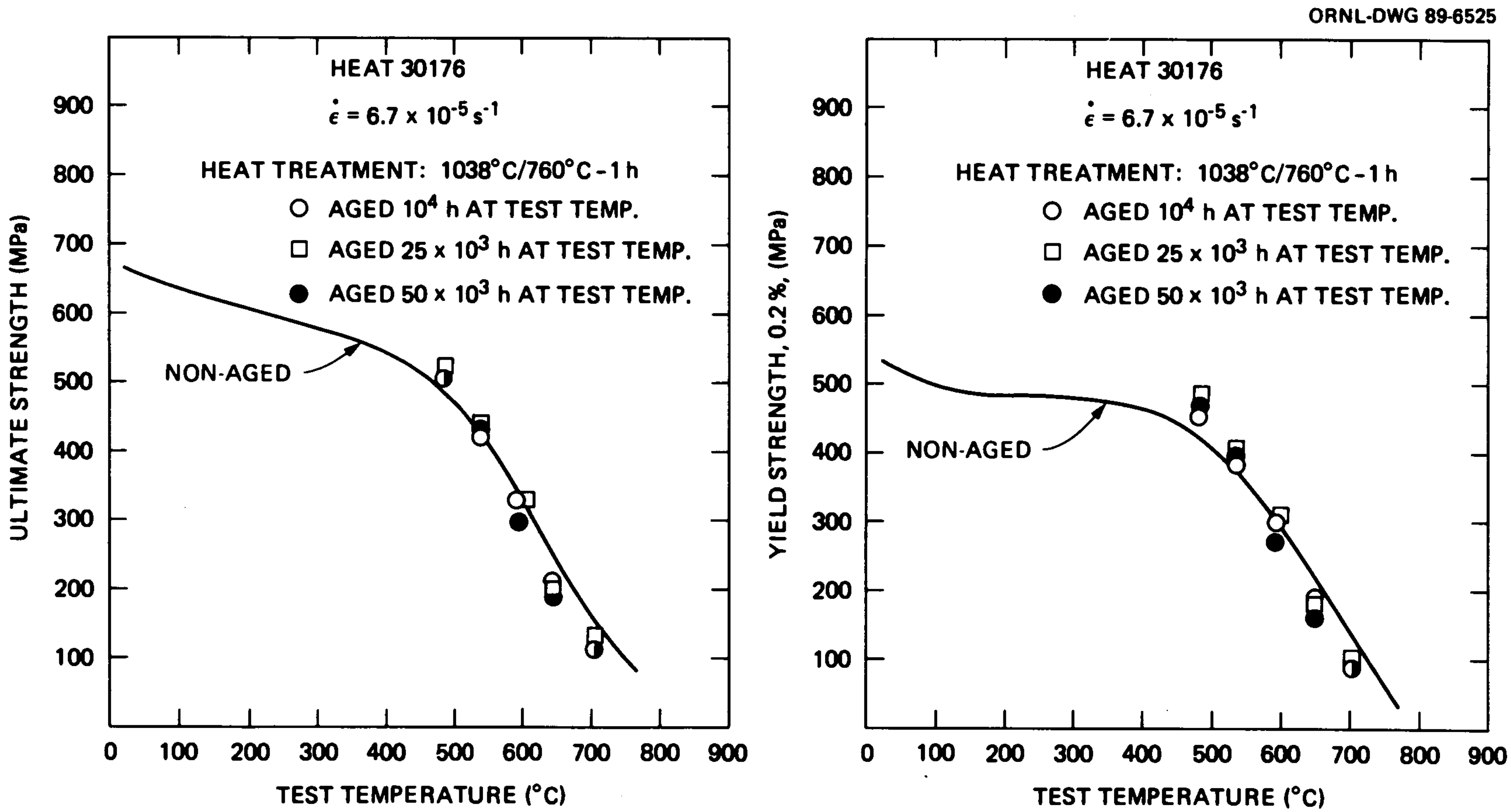


Fig. 4. Influence of aging time on the ultimate and yield strengths of heat 30176 of Modified 9Cr-1Mo steel.

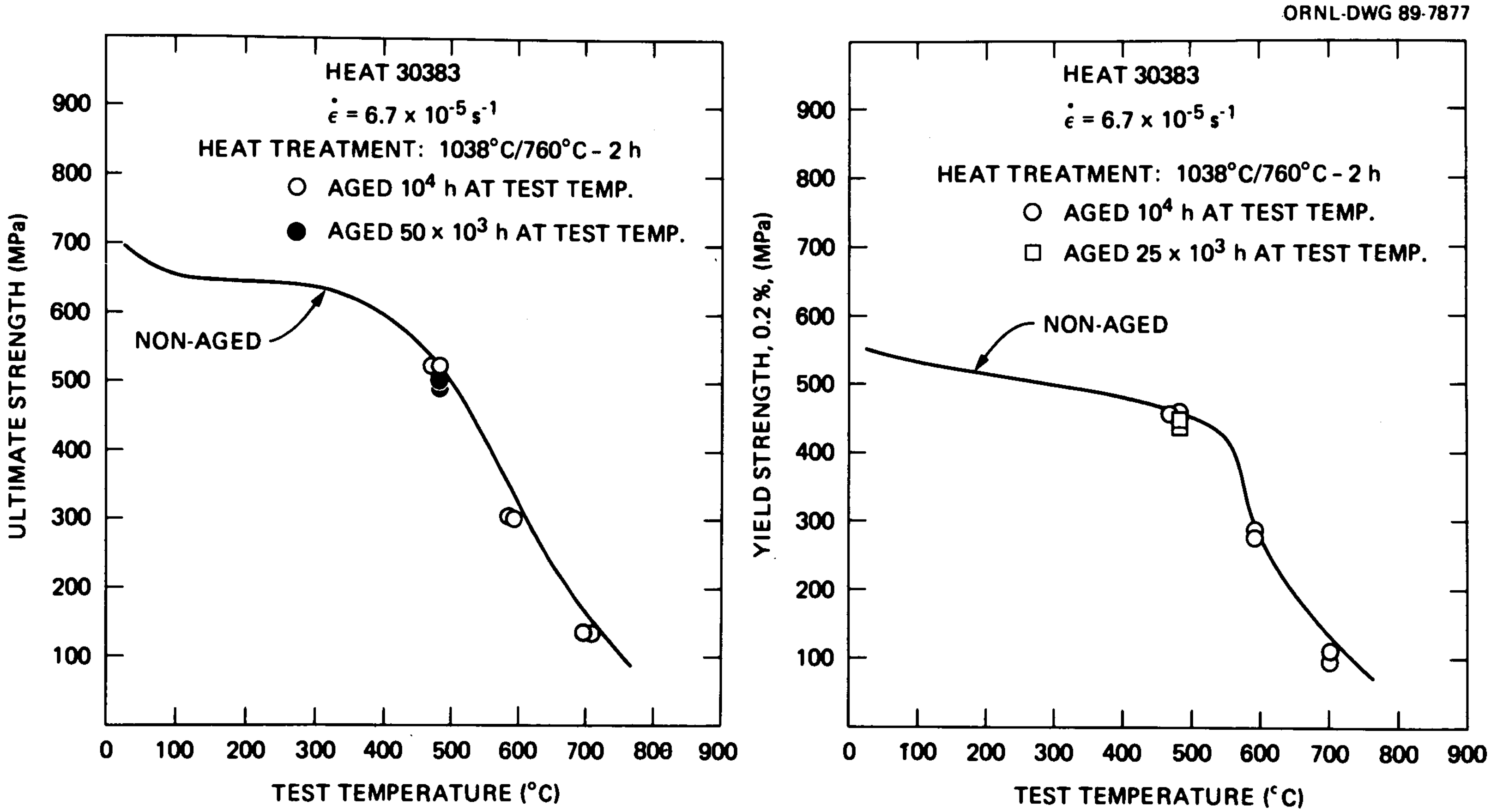


Fig. 5. Influence of aging time on the ultimate and yield strengths of heat 30383 of Modified 9Cr-1Mo steel.

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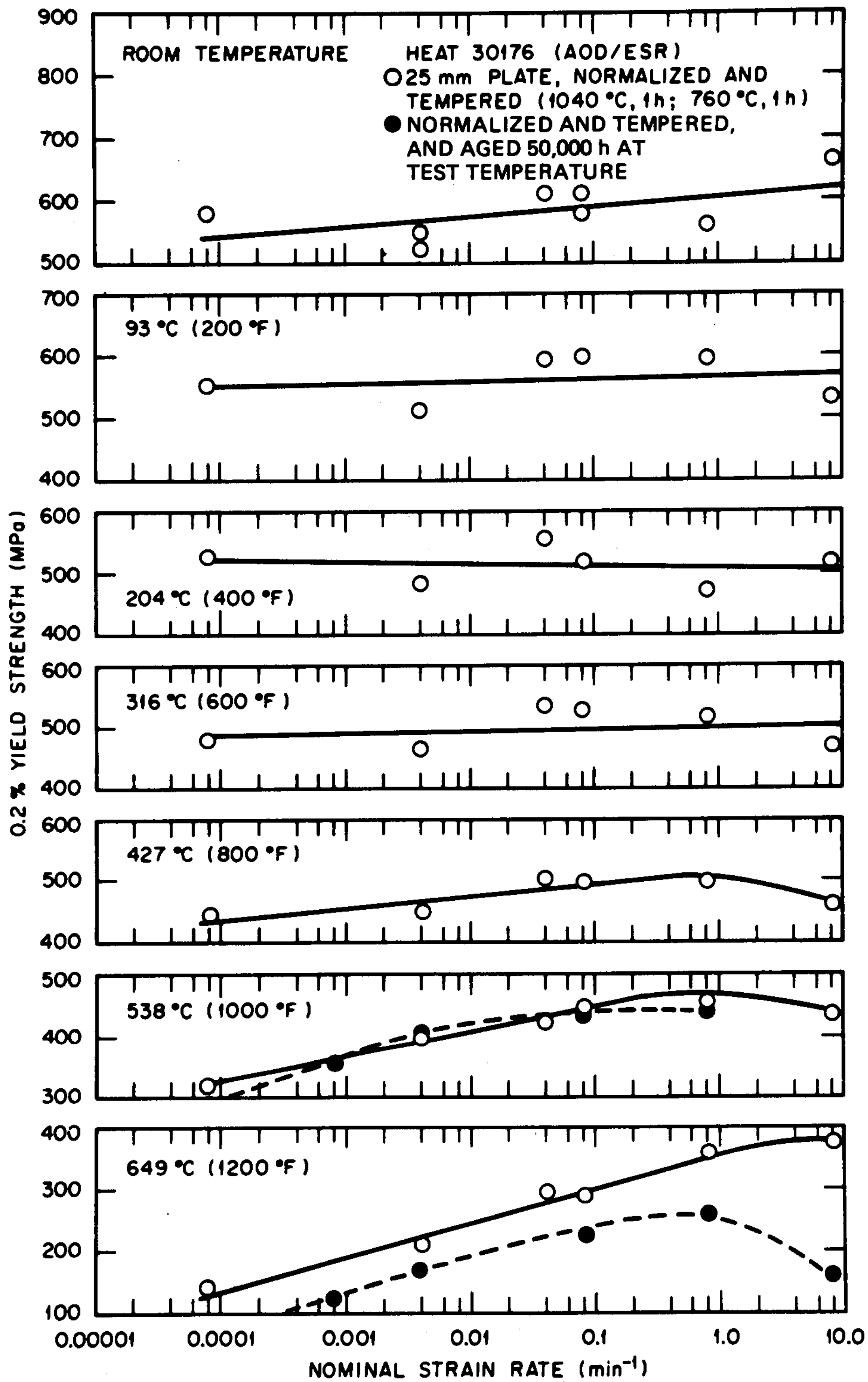
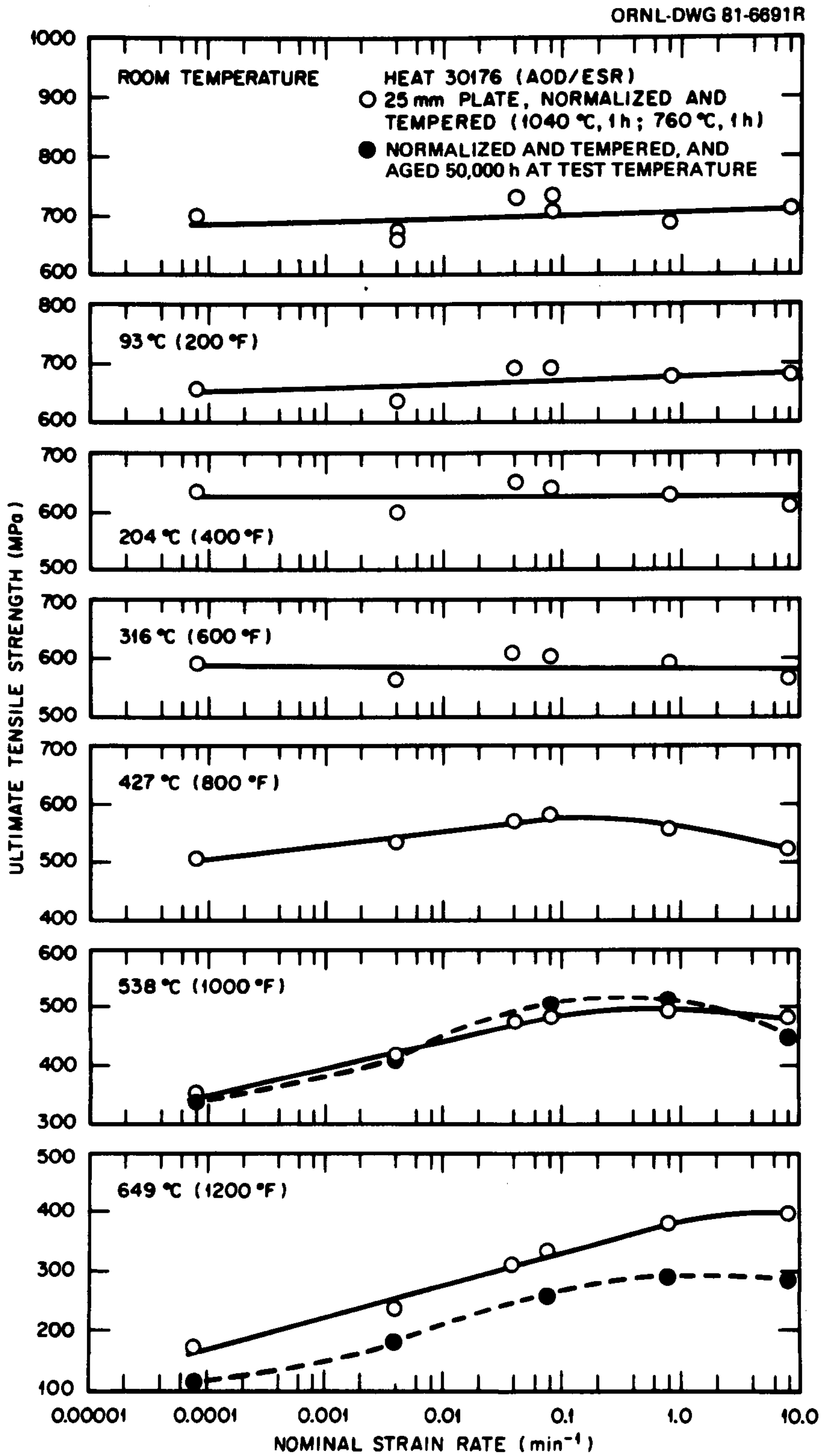


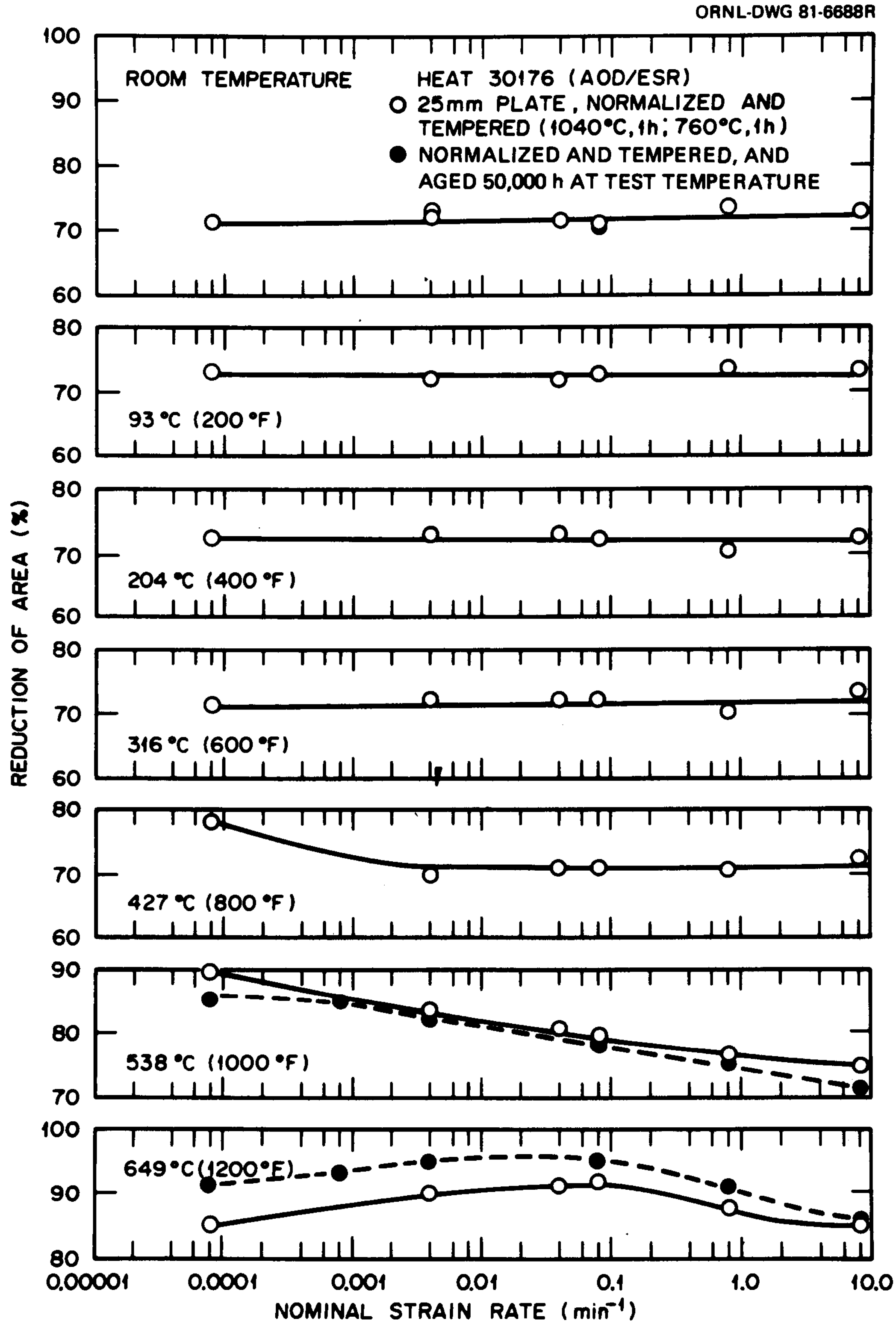
(a)

Fig. 6. Influence of strain rate and aging time on the tensile properties of heat 30176 at several temperatures. (*a*) Yield strength, (*b*) ultimate strength, and (*c*) reduction of area.



(b)

Fig. 6. (continued)



(c)

Fig. 6. (continued)

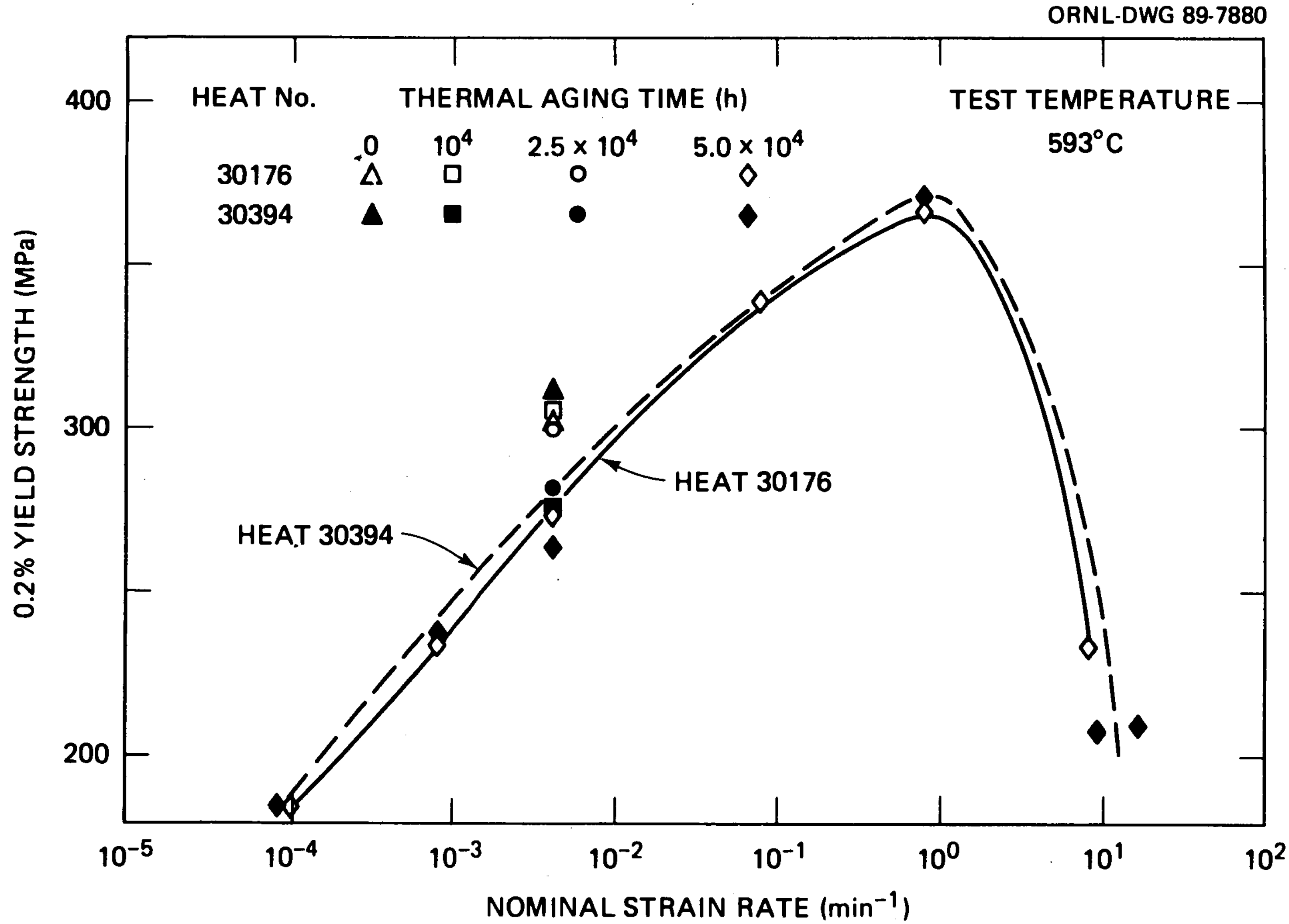


Fig. 7. Influence of strain rate on the yield strength of two heats of Modified 9Cr-1Mo steel aged up to 50,000 h at 593°C.

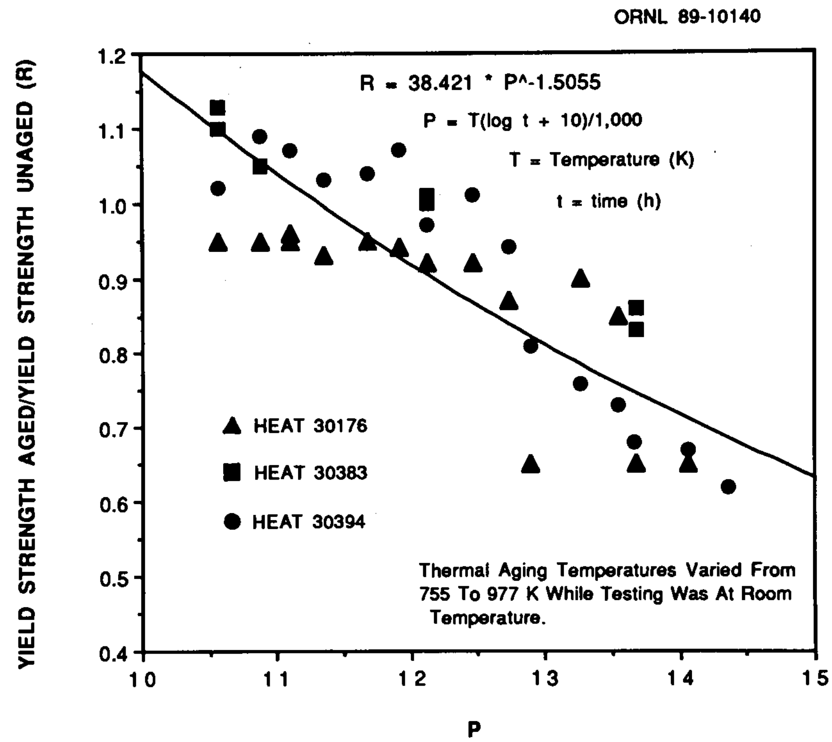


Fig. 8. Ratio (R) of yield strength of aged to yield strength of unaged material as a function of time and temperature in a parameterized (P) form for three heats of Modified 9Cr-1Mo steel. All tests were conducted at room temperature.

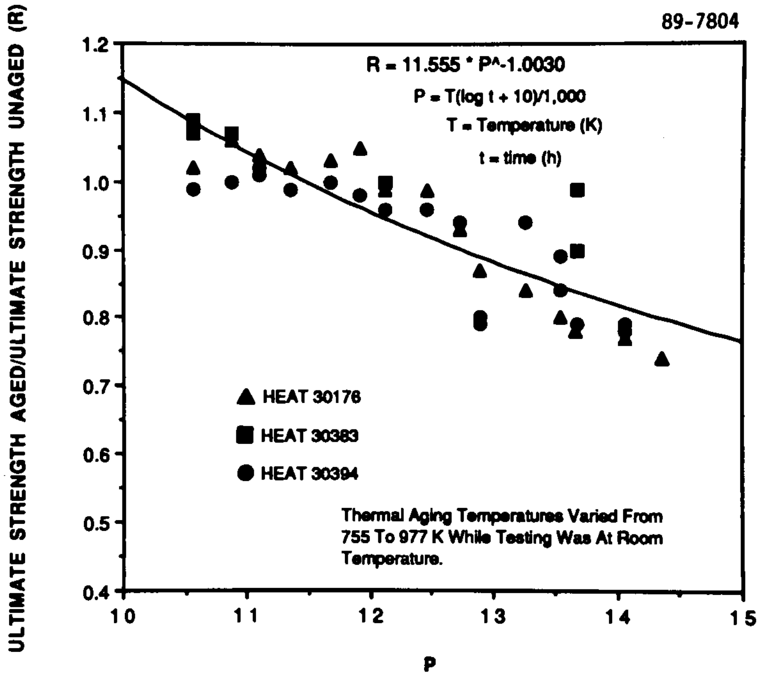


Fig. 9. Ratio (R) of ultimate strength of aged to ultimate strength of unaged material as a function of time and temperature in a parameterized (P) form for three heats of Modified 9Cr-1Mo steel. All tests were conducted at room temperature.

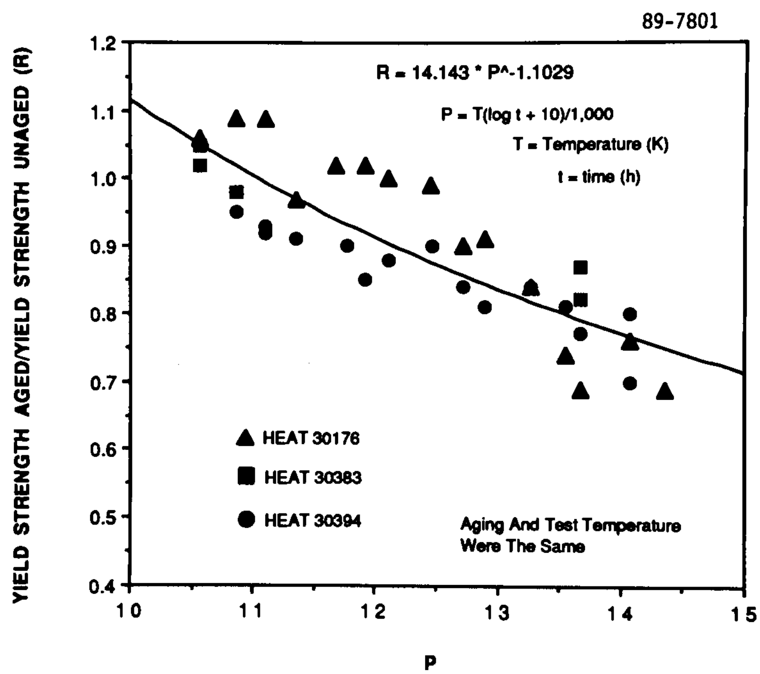
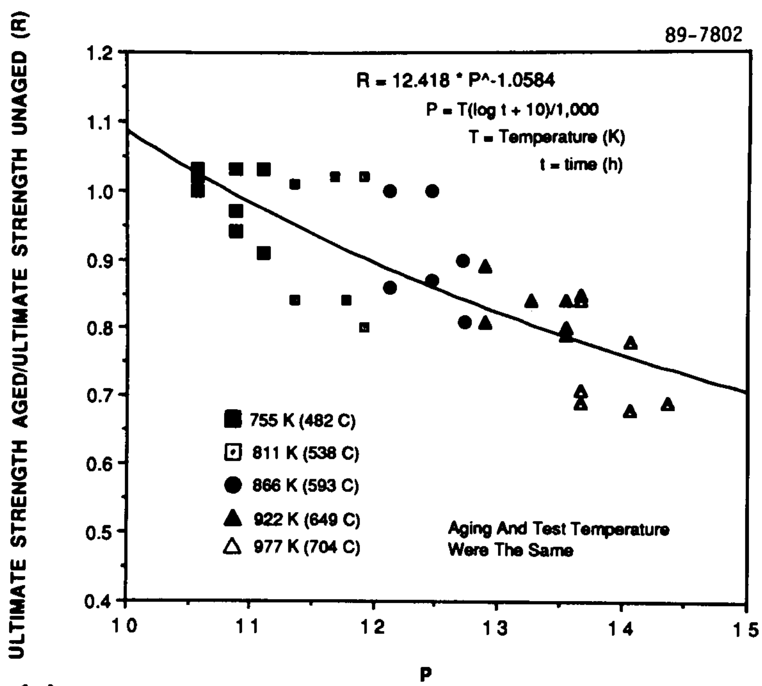
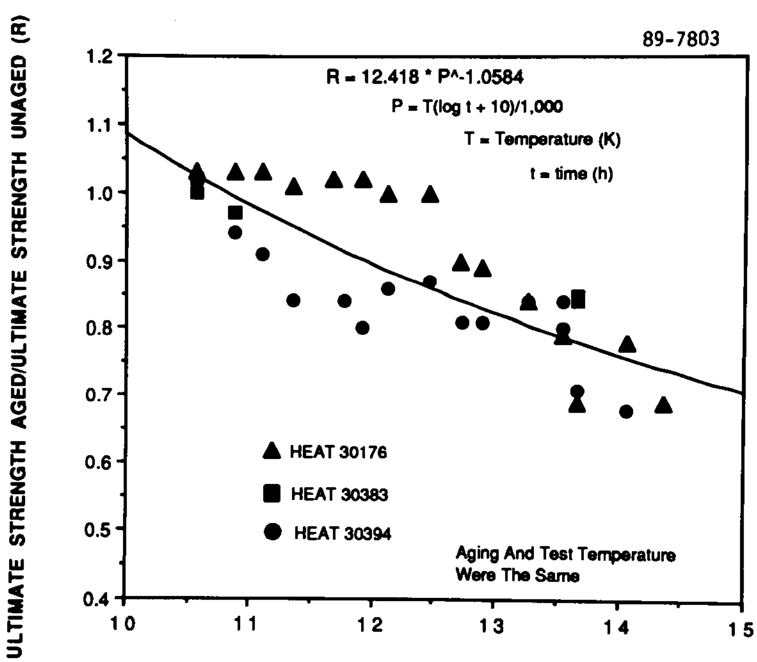


Fig. 10. Ratio (R) of yield strength of aged to yield strength of unaged material as a function of time and temperature in a parameterized (P) form for three heats of Modified 9Cr-1Mo steel. All tests were conducted at the thermal aging temperature.



(a)



(b)

Fig. 11. Ratio (R) of ultimate strength of aged to ultimate strength of unaged material as a function of time and temperature in a parameterized (P) form for three heats of Modified 9Cr-1Mo steel. All tests were conducted at the thermal aging temperature: (*a*) shows specific temperatures and (*b*) shows specific heats.

Appendix B gives the numerical values obtained using this equation. Figures 8 and 9 show the reductions in yield and the ultimate strengths, respectively, that can be expected to occur in room-temperature properties following thermal aging. One can thus make calculations giving estimates of properties following thermal aging. As an example, ASTM specification A213 (Seamless Boiler, Superheater, and Heat Exchanger Tubes)[3] specifies that the minimum room-temperature yield and tensile strengths shall be 415 and 585 MPa, respectively. The equations given in Figs. 8 and 9 allow calculations to be made about estimates of the times required for average room-temperature properties to be reduced to minimum values. These estimates of required times are given in Table 3. Note the long-term stability of room-temperature properties to temperatures of about 593°C.

Similar calculations to those given above were also made for the elevated-temperature properties (i.e., aging and test temperature being the same) using the equations given in Figs. 10 and 11. In this case, a plant life of 60 years was assumed; and the percent decrease in properties were calculated, with the results shown in Table 4. Note that for a plant operating at about 538°C for 60 years, one would estimate only a 15 to 16% decrease in elevated-temperature yield and tensile strengths.

In the development of ASME Code Case N-47, there has been concern about potential degradation of short-term tensile properties below minimum values due to prolonged exposure at elevated temperature. Such degradation would be important to define for analysis purposes for short-time loading events (e.g., earthquakes). Accordingly, Table 5 was prepared to compare estimated degradation of tensile properties of Modified 9Cr-1Mo steel with several other Code Case N-47 materials following 300,000 h (34.2 years) of exposure at the indicated temperatures.[4]

The comparison shows that the short-term tensile properties of Modified 9Cr-1Mo steel following prolonged thermal aging hold up well in comparison to other materials.

Table 3. Estimated times for yield and ultimate strengths to drop below minimum room-temperature values following thermal aging at the indicated temperatures

(Average initial values of 537 and 675 MPa were assumed for the yield and ultimate tensile strengths, respectively)

Temperature (°C)	Time, h (years)	
	Yield strength	Ultimate strength
482	5.4×10^7 (6164)	2.9×10^7 (3262)
538	3.2×10^6 (365)	1.8×10^6 (203)
593	2.9×10^5 (33)	1.7×10^5 (18.9)
649	3.3×10^4 (3.4)	2.0×10^4 (2.2)

Table 4. Estimated decreases in yield and ultimate strengths following 60-year exposure at the indicated temperatures

(Note that aging and test temperature were the same)

Temperature (°C)	Yield strength (MPa)			Ultimate tensile strength (MPa)		
	Before exposure	After exposure	Decrease (%)	Before exposure	After exposure	Decrease (%)
482	410	378	8	475	432	9
538	345	293	15	410	344	16
593	275	217	21	320	251	22

Table 5. Comparison of estimated percent reduction in tensile properties of several materials following 300,000 h (34.2 years) at several temperatures[a]

Material	Temperature (°C)	Percent reduction	
		Yield strength	Ultimate tensile strength
2.25Cr-1Mo (annealed)	482	30	32
2.25Cr-1Mo (annealed)	538	40	40
Modified 9Cr-1Mo (normalized and tempered)	482	6	8
Modified 9Cr-1Mo (normalized and tempered)	538	13	15
304 or 316 stainless	482		Unknown
304 or 316 stainless	538		20[b]

[a]Aging temperatures (without stress) were the same as test temperatures.

[b]Reduction estimated to be maximum amount due to effects of prior creep deformation on subsequent tensile properties at the indicated temperature.

CONCLUSIONS

Results of room- and elevated-temperature tensile tests were reported from tests conducted on three heats of Modified 9Cr-1Mo steel thermally aged at various temperatures from 482 to 704°C and at aging times to 50,000 h. The following are specific conclusions.

1. Variations in yield and tensile strengths due to changes in the microstructure[2] were clearly apparent after thermal aging to 50,000 h. The change that occurred (i.e., slight increase or decrease) was dependent on the thermal aging temperature with the higher aging temperatures producing reduction in properties.

2. Varying the strain rate over the range of 8×10^{-5} min^{-1} (0.27/s) demonstrated a similar strain-rate sensitivity for aged and unaged material for the heats characterized. The yield and ultimate strengths increased with increasing strain rate, showing a strain aging peak at temperatures of approximately 538 to 593°C.

3. The yield and tensile strengths were analyzed in terms of a time-temperature parameter in order to make estimates of both the room- and elevated-temperature changes following prolonged periods of thermal exposure in service. As an example, it was estimated that an exposure time of 60 years would produce only a 15 to 16% decrease in the elevated-temperature yield and tensile strengths at 538°C.

4. Comparisons were made on the estimated amount of degradation, due to thermal aging, in tensile and yield strengths in Modified 9Cr-1Mo steel and several other steels including annealed 2.25Cr-1Mo and the austenitic stainless steels. This comparison indicated that these properties held up very well (i.e., the expected degradation in Modified 9Cr-1Mo steel was generally less, in comparison to the other materials following 300,000 h aging in the range of 482 to 538°C).

ACKNOWLEDGMENTS

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APPENDIX A

TENSILE DATA ON THREE HEATS OF MODIFIED 9Cr-1Mo STEEL

Page Title:	Heat number and strain rate $(\text{min})^{-1}$, note that minute equals 60 s
Specimen No.:	Specimen number
Heat Treatment:	Material was normalized and tempered (NT) and then tested in the NT or in NT plus thermal aged condition. Thermal aging occurred for 10K (10,000 h), 25K (25,000 h), or 50K (50,000 h) at the indicated temperature (e.g., AGE/50K/649 indicates an aging treatment of 50,000 h at 649°C).
Test Temp:	Test temperature (°C)
Modulus:	Apparent Young's modulus
PL:	Proportional unit
0.02% YS:	0.02% yield strength
UTS:	Ultimate tensile strength
UE:	Uniform elongation
TE:	Total elongation measured over 25.4-cm specimen from gage markings
RA:	Reduction of area

HEAT 30176, 0.00008/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.20% YS MPa	UTS MPa	UE %	TE %	RA %
22369	92T	1038/760/1h	25	199	410	495	577	696	5.32	22.45	71.20
22370	93T	1038/760/1h	93	189	372	453	552	656	5.16	23.84	73.25
22371	94T	1038/760/1h	204	195	376	449	528	631	4.25	21.55	72.34
22372	95T	1038/760/1h	316	184	283	377	481	590	5.24	22.05	71.51
22373	96T	1038/760/1h	427	158	271	283	444	508	3.53	30.92	78.36
	480T	AGE/50K/482	482	128	246		401	433	1.21	35.17	84.91
22374	97T	1038/760/1h	538	121	135	221	320	350	1.14	30.25	89.54
	491T	AGE/50K/538	538	133	154	196	296	334	1.53	29.50	85.02
	503T	AGE/50K/593	593	75	119	143	184	212	1.98	36.90	85.94
22375	98T	1038/760/1h	649	76	46	86	140	171	2.52	32.35	84.91
	515T	AGE/50K/649	649	38	36	52	83	105	2.23	49.02	91.75
	527T	AGE/50K/704	704		31	38	51	58		75.92	94.03

ALL TEMPERATURES IN °C

HEAT 30176, O.0008/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	483T	AGE/50K/482	482					473	1.13	28.60	82.96
	492T	AGE/50K/538	538	185	161	217	357	391	0.41	31.02	85.38
	504T	AGE/50K/593	593	95	132	170	233	258	1.07	39.60	88.93
	516T	AGE/50K/649	649	73	61	84	126	155	2.63	55.00	93.42
	528T	AGE/50K/704	704	45	31	45	69	81	1.67	58.40	96.00

ALL TEMPERATURES IN °C

HEAT 30176, 0.004/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.20% YS MPa	UTS MPa	UE %	TE %	RA %
23800	198T	AGE/10K/482	25	215	414	499	584	717	6.05	26.69	69.00
23801	214T	AGE/10K/538	25	227	359	479	592	720	5.25	19.34	65.79
23802	230T	AGE/10K/593	25	228	375	481	555	697	4.99	20.58	68.86
23803	246T	AGE/10K/649	25	219	327	391	463	612	7.70	27.92	73.57
23804	262T	AGE/10K/704	25	189	256	330	392	551	10.83	33.21	73.24
24047	328T	AGE/25K/482	25	203	378	531	625	745	5.00	22.48	66.46
24049	344T	AGE/25K/538	25	256	348	489	596	725	4.80	21.88	65.21
24051	362T	AGE/25K/593	25	211	320	491	580	696	2.78	20.69	66.67
24053	378T	AGE/25K/649	25	278	190	349	436	592	7.96	27.39	73.12
24055	394T	AGE/25K/704	25	210	270	334	382	543	11.30	31.98	74.07
	478T	AGE/50K/482	25	213	408	513	610	735	5.55	23.39	64.87
	490T	AGE/50K/538	25	205	339	497	612	737	4.93	23.23	64.69
	502T	AGE/50K/593	25	244	342	453	540	657	5.50	24.51	69.09
	514T	AGE/50K/649	25	233	303	362	415	567	10.19	31.22	74.92
	526T	AGE/50K/704	25	210	280	322	353	520	13.39	36.32	75.34
23805	199T	AGE/10K/482	482	182	288	351	455	504	2.52	25.08	78.26
24048	329T	AGE/25K/482	482	156	275	376	482	521	1.08	24.52	78.31
	477T	AGE/50K/482	482	165	310	378	464	505	1.91	25.77	80.56
23806	215T	AGE/10K/538	538	198	157	249	382	419	1.08	34.08	84.85
24050	345T	AGE/25K/538	538	187	148	267	400	433	0.88	28.55	82.52
	489T	AGE/50K/538	538	158	168	243	399	427	0.76	25.81	82.73
23807	231T	AGE/10K/593	593	116	134	209	306	327	1.14	34.62	87.53
24052	363T	AGE/25K/593	593	129	147	206	301	327	0.82	42.69	87.01
	501T	AGE/50K/593	593	126	154	193	273	291	0.90	39.61	89.82
23808	247T	AGE/10K/649	649	104	96	124	189	208	1.26	44.19	99.67
24054	379T	AGE/25K/649	649	105	59	106	173	196	1.18	49.61	93.83
	513T	AGE/50K/649	649	98	65	93	154	185	0.54	49.99	94.42
23809	263T	AGE/10K/704	704	75	31	51	90	109	1.87	57.25	95.28
24056	395T	AGE/25K/704	704	70	38	63	102	121	1.31	54.97	95.32
	525T	AGE/50k/704	704	215	28	43	90	110	1.25	63.90	96.00

ALL TEMPERATURES IN °C

HEAT 30176, 0.04/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22362	85T	1038/760\1h	25	230	379	508	609	729	6.70	24.13	71.32
22363	86T	1038/760\1h	93	209	418	516	592	690	5.11	20.60	71.52
22364	87T	1038/760\1h	204	224	307	461	558	649	3.78	21.15	73.01
22365	88T	1038/760\1h	316	199	334	446	534	610	2.86	19.40	72.09
22366	89T	1038/760\1h	427	214	230	369	501	572	3.08	19.58	71.01
22367	90T	1038/760\1h	538	191	115	223	425	477	1.67	27.50	80.81
22368	91T	1038/760\1h	649	108	143	210	294	310	0.76	38.50	90.99

ALL TEMPERATURES IN °C

HEAT 30176, 0.08/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22355	78T	1038/760/1h	25	227	374	518	609	730	6.41	19.90	70.83
22348	71T	1038/760/1h	25	223	372	494	578	705	6.47	20.65	70.19
22356	79T	1038/760/1h	93	229	387	517	597	691	5.56	21.75	72.15
22357	80T	1038/760/1h	204	198	333	433	518	641	4.44	18.95	71.59
22358	81T	1038/760/1h	316	231	304	436	529	604	3.02	18.85	72.12
22359	82T	1038/760/1h	427	165	298	395	496	581	3.01	17.82	71.00
	484T	AGE/50K/482	482	211	247	339	473	527	2.11	26.62	76.40
22360	83T	1038/760/1h	538	129	238	341	448	486	1.79	24.19	79.31
	494T	AGE/50K/538	538	168	238	327	439	470	1.18	24.72	79.14
	506T	AGE/50K/593	593	152	175	245	339	361		33.51	87.88
22361	84T	1038/760/1h	649	85	153	215	289	332	0.86	49.10	91.72
	518T	AGE/50K/649	649	146	101	151	219	241	0.93	73.58	95.35
	530T	AGE/50K/704	704	106	49	87	147	157	0.77	66.70	94.49

ALL TEMPERATURES IN °C

HEAT 30176, 0.8/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% Ys MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22465	10T	1038/760/1h	25	234	302	473	554	683	6.84	25.76	73.62
22349	72T	1038/760/1h	93	219	497	550	594	676	5.98	26.70	73.05
22350	73T	1038/760/1h	204	183	341	417	471	628	4.63	23.15	73.49
22351	74T	1038/760/1h	316	368	343	476	518	592	3.42	20.60	70.07
22352	75T	1038/760/1h	427	179	342	419	796	558	3.00	18.33	70.46
	481T	AGE/50K/482	482	198	225	341	457	510	2.30	19.52	74.66
22353	76T	1038/760/1h	538	192	194	338	457	498	2.71	22.02	76.45
	495T	AGE/50K/538	538	198	231	328	447	485	1.56	24.12	75.69
	507T	AGE/50K/593	593	171	171	264	367	389	1.46	23.51	81.56
	519T	AGE/50K/649	649	130	133	185	253	267	1.37	28.48	90.55
22354	77T	1038/760/1h	649	145	182	265	359	377	1.11	30.24	87.27
	531T	AGE/50K/704	704	123	64	106	164	183	1.30	48.75	94.62

ALL TEMPERATURES IN °C

HEAT 30176, 8.0/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22341	64T	1038/760/1h	25	255	519	603	659	711	9.66	21.62	72.59
22342	65T	1038/760/1h	93		352	417	530	667	7.13	24.28	72.95
22343	66T	1038/760/1h	204				518	609	5.82	23.68	72.39
22344	67T	1038/760/1h	316	386	257	361	469	566	4.86	21.90	73.49
22345	68T	1038/760/1h	427	413	218	341	460	525	3.19	18.60	72.54
	479T	AGE/50K/482	482				353	459	3.91	18.48	70.76
22346	69T	1038/760/1h	538	409	188	314	439	485	2.48	19.94	74.48
	496T	AGE/50K/538	538					444	3.76	21.42	71.34
	508T	AGE/50K/593	593	158	112	152	233	353	3.51	21.00	75.20
22347	70T	1038/760/1h	649	293	167	259	376	394	1.37	26.45	84.88
	520T	AGE/50K/649	649	148	67	84	151	278	6.49	35.50	86.62
	532T	AGE/50K/704	704	104	28	53	104	205	6.88	44.95	89.58

ALL TEMPERATURES IN °C

HEAT 30176,16.0/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	485T	AGE/50K/482	25							23.62	65.29
	497T	AGE/50K/538	25	205	147	194	390	663	4.28	22.35	65.08
	509T	AGE/50K/593	25	181	127	166	353	619	6.45	26.82	68.42
	521T	AGE/50K/649	25	185	104	136	272	576	6.71	29.49	72.67
	533T	AGE/50K/704	25	196	84	111	231	535	9.64	33.68	68.77
	486T	AGE/50K/482	482					390	3.94	13.82	71.93
	493T	AGE/50K/538	538					358	3.70	20.31	72.33
	505T	AGE/50K/593	593					307	3.29	22.78	77.13
	517T	AGE/50K/649	649	169	49	71	150	259	7.35	32.75	81.74
	529T	AGE/50K/704	704	119	31	46	96	193	9.34	45.50	90.15

ALL TEMPERATURES IN °C

HEAT 30383, 0.00008/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	381T	AGE/25K/482	25	209	430	476	577	726	6.17	24.38	59.23
	171T	AGE/10K/593	25	226	359	467	553	684	6.24	20.91	78.67
	150T	AGE/10K/704	25	224	343	399	448	604	9.91	27.60	67.80
	214T	AGE/10K/482	482	133	162	220	318	351	1.64	35.42	85.65
	382T	AGE/25K/482	482	172	197	267	395	432	2.04	31.90	82.68
	172T	AGE/10K/593	593	111	71	117	188	225	1.85	33.62	83.31
	152T	AGE/10K/704	704	35	21	34	57	73	2.85	52.42	89.28

ALL TEMPERATURES IN °C

HEAT 30383, 0.004/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22150	1T	1038/760/2H	25	218	384	482	547	695	8.73	24.3	64.22
25392	373T	AGE/25K/482	25	227	414	494	576	744	6.26	24.51	57.59
25393	374T	AGE/25K/482	25	223	364	493	576	741	6.73	25.42	59.91
25386	205T	AGE/10K/482	25	225	450	527	619	756	5.61	21.95	60.38
25387	206T	AGE/10K/482	25	247	419	510	599	747	6.58	23.07	62.21
25380	163T	AGE/10K/593	25	239	346	463	553	698	6.56	21.51	57.8
25381	164T	AGE/10K/593	25	242	338	451	547	694	6.77	26.31	58.6
25374	142T	AGE/10K/704	25	249	320	418	468	624	9.56	26.88	67.25
25375	143T	AGE/10K/704	25	263	265	395	459	689	8.49	28.28	67.34
22151	2T	1038/760/2H	38	225	384	489	552	705	7.65	24.72	67.92
22152	3T	1038/760/2H	93	218	356	455	532	639	7.59	23.28	68.39
22153	4T	1038/760/2H	149	225	307	450	523	649	6.97	23.32	67.13
22154	5T	1038/760/2H	204	219	336	434	511	640	5.9	17.8	68.68
22155	6T	1038/760/2H	260	206	364	427	501	646	5.88	21.49	62.52
22156	7T	1038/760/2H	316	168	342	412	488	611	6.09	19.7	65.32
22157	8T	1038/760/2H	371	185	343	413	485	630	5	19.15	58.54
22158	9T	1038/760/2H	427	163	259	357	457	562	5.43	23.82	66.36
22159	10T	1038/760/2H	482	152	308	364	448	511	3.48	27.55	74.9
25388	207T	AGE/10K/482	482	176	260	348	469	523	2.61	25.51	75.46
25389	208T	AGE/10K/482	482	251	211	323	457	513	2.53	28.79	72.54
25394	375T	AGE/25K/482	482	174	321	349	441	498	2.93	31.22	74.56
25395	376T	AGE/25K/482	482	227	133	259	438	495	3.45	26.78	74.96
22160	11T	1038/760/2H	538	129	202	296	394	440	1.42	34.2	83.65
25382	165T	AGE/10K/593	593	125	124	188	278	304	1.11	43.25	85.04
25383	166T	AGE/10K/593	593	109	179	203	275	299	1.23	40.82	87.63
22446	32T	1038/760/2H	593	141	84	168	296	329	1.03	42.85	90.2
22162	13T	1038/760/2H	649	108	73	129	205	233	2.03	51.65	94.43
22163	14T	1038/760/2H	704	74	42	76	120	152	2.93	47.1	94.11
25377	145T	AGE/10K/704	704	68	42	64	104	129	2.64	73.22	94.48
25376	144T	AGE/10K/704	704	83	34	57	98	128	2.24	51	94.55
22164	15T	1038/760/2H	760	39	32	47	70	91	3.53	63.15	95.52

HEAT 30383, 0.08/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.20% YS MPa	UTS MPa	UE %	TE %	RA %
25422	209T	AGE/10K/482	482	216	266	360	477	548	2.95	20.49	67.21
25423	377T	AGE/25K/482	482	181	261	348	449	527	3.6	24.71	69.79
25420	167T	AGE/10K/593	593	151	137	244	341	364	1.15	36.41	74.42
25418	146T	AGE/10K/704	704	138	45	79	147	177	1.29	55.21	95.51

ALL TEMPERATURES IN °C

HEAT 30383, 0.8/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL GPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
25431	210T	AGE/10K/482	482	152	330	404	487	552	3.05	19.11	66.57
25432	378T	AGE/25K/482	482	224	175	336	451	529	3.68	20.19	68.47
25430	168T	AGE/10K/593	593	301	173	270	364	391	1.66	33.79	80.39
25429	147T	AGE/10K/704	704	123	97	155	219	229	1.03	60.82	93.73

ALL TEMPERATURES IN °C

HEAT 30383, 8.0/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
25453	212T	AGE/10K/482	25		182	438	657	785	7.24	28.82	62.39
25455	380T	AGE/25K/482	25		391	502	625	810	6.86	19.72	55.71
25451	170T	AGE/10K/593	25		276	483	603	734	7.52	24.3	60.76
25449	149T	AGE/10K/704	25		268	423	509	659	11.12	28.22	54.09
	153T	AGE/10K/704	25				379	610	8.04	27.55	66.69
25452	211T	AGE/10K/482	482		266	376	488	542	3.02	18.25	66.21
25454	379T	AGE/25K/482	482		120	329	464	535	3.98	19.38	67.14
25450	169T	AGE/10K/593	593		173	288	391	409	2.49	25	74.9
25448	148T	AGE/10K/704	704		70	120	221	264	0.95	52.62	93.05

ALL TEMPERATURES IN °C

HEAT 30394, 0.00008/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	639T	AGE/50K/482	25	230	393	457	537	709	7.26	24.50	62.28
	608T	AGE/25K/704	25	210	284	320	355	540	16.64	34.15	71.74
	638T	AGE/50K/482	482	137	238	288	373	417	1.69	30.75	81.54
	646T	AGE/50K/538	538	87	178	209	271	300	0.93	36.25	86.89
	658T	AGE/50K/593	593	80	98	122	185	213	1.00	34.50	85.31
	623T	AGE/50K/649	649	67	42	56	97	128	2.83	44.78	84.50

ALL TEMPERATURES IN °C

HEAT 30394, 0.0008/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02 % YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	608T	AGE/25K/704	25	210	284	320	355	540	16.64	34.15	71.74
	639T	AGE/50K/482	25	230	393	457	537	709	7.26	24.50	62.28
	638T	AGE/50K/482	482	137	238	288	373	417	1.69	30.75	81.54
	647T	AGE/50K/593	538	168	161	225	310	334	1.05	36.72	86.86
	659T	AGE/50K/538	593	125	87	136	218	245	1.32	39.58	88.65
	623T	AGE/50K/649	649	67	42	56	97	128	2.83	44.78	84.50
	609T	AGE/25K/704	704	58	22	32	50	66	1.37	45.65	90.10

ALL TEMPERATURES IN °C

HEAT 30394, 0.004/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
22118	19T	1038/760/1H	25	226	393	494	578	715	7.66	26	69.05
22989	299T	AGE/10K/593	25	204	379	451	534	685	6.69	26.4	65.21
23984	568T	AGE/25K/482	25	213	372	457	549	716	6.27	24.39	64.24
22987	267T	AGE/10K/482	25	213	384	473	547	709	7.92	27.15	70.75
22992	313T	AGE/10K/649	25	215	227	312	375	573	13.57	34.16	73.41
22988	283T	AGE/10K/538	25	213	337	431	536	710	6.94	23.98	62.75
22991	328T	AGE/10K/704	25	221	276	333	376	566	12.13	33.35	71.13
23990	616T	AGE/25K/538	25	248	325	440	551	712	5.29	20.72	60.91
23986	584T	AGE/25K/649	25	233	299	320	518	672	7.21	24.58	64.26
22990	312T	AGE/10K/649	25	199	301	315	377	566	14.69	24.42	73.13
25367		AGE/25K/704	25	232	242	313	374	564	14.2	36.32	71.7
25368		AGE/25K/704	25	206	312	348	376	559	15.86	37.28	71.27
	645T	AGE/50K/538	25	245	387	464	543	702	6.96	24.58	63.99
23988	600T	AGE/25K/593	25	232	337	435	531	684	6.58	24.42	62.98
25361	616T	AGE/50K/649	25	248	344	420	491	638	9.14	31.22	65.14
25397	630T	AGE/50K/482	25	227	388	463	554	731	7.82	24.22	60.35
25398	631T	AGE/50K/482	25	203	421	477	547	726	6.53	21.78	59.92
	657T	AGE/50K/593	25	204	342	426	505	673	6.52	28.88	64.32
25362	617T	AGE/50K/649	25	278	304	407	493	602	9.56	30.31	65.38
22119	20T	1038/760/1H	38	214	430	507	575	711	7.81	27.52	67.63
22120	21T	1038/760/1H	93	202	381	470	551	682	6.09	23.15	70.33
22121	22T	1038/760/1H	149	213	393	467	538	664	6.1	23.23	70.75
22122	23T	1038/760/1H	204	207	344	449	527	666	5.38	21.63	71.44
22123	24T	1038/760/1H	260	207	352	426	518	641	4.96	19.11	69.1
22124	25T	1038/760/1H	316	235	268	373	504	627	4.86	21.02	69.19
22125	26T	1038/760/1H	371	191	305	387	496	617	4.81	20.6	67.56
22126	27T	1038/760/1H	427	171	295	386	484	610	5.2	24.27	73.06
23712	482	AGE/10K/482	482	142	193	305	363	476	3.08	28.81	80.61
22127	28T	1038/760/1H	482	162	260	357	457	526	3.07	29.25	78.1
23985	569T	AGE/25K/482	482	164	249	334	435	497	3.24	27.3	78.27
25399	632T	AGE/50K/482	482	141	342	364	425	478	3.01	31.02	78.92
25400	633T	AGE/50K/482	482	199	245	322	420	483	2.86	31.88	79.99
22128	29T	1038/760/1H	538	125	231	315	403	467	1.36	34.75	85.29
23991	617T	AGE/25K/538	538	175	215	281	361	393	1.81	34.88	86.05
23713	284T	AGE/10K/538	538	143	194	307	365	394	1.54	33.95	85.07
	644T	AGE/50K/538	538	144	161	239	341	374	1.28	38.83	88.17
23989	601T	AGE/25K/593	593	121	149	209	282	300	0.82	30.12	86.45
23714	300T	AGE/10K/593	593	128	141	196	275	297	1.05	31.9	89.34
	656T	AGE/50K/593	593	129	115	178	263	281	0.8	36.48	90.99

HEAT 30394, 0.004/min.

22129	31T	1038/760/1H	593	135	121	201	312	346	1.16	37.75	88.44
25364	619T	AGE/50K/649	649	68	122	137	175	196	1.79	54.42	92.13
22130	32T	1038/760/1H	649	94	76	137	209	243	1.89	38.45	88.71
25363	618T	AGE/50K/649	649	96	66	104	168	197	1.7	42.68	90.82
23987	585T	AGE/25K/649	649	93	74	120	175	205	2.27	37.39	89.27
23715	314T	AGE/10K/649	649	86	74	111	170	198	2.24	41.15	86.64
22131	33T	1038/760/1H	704	76	45	87	137	170	2.44	33.8	89.69
23716	329T	AGE/10K/704	704	87	39	61	106	121	1.49	40.32	91.16
25366		AGE/25K/704	704	79	35	58	96	115	1.7	60.8	91.25
25365		AGE/25K/704	704	43	70	86	109	116	1.08	80.28	94.21
22132	34T	1038/760/1H	760	44	25	46	73	97	3.28	40	92.85

ALL TEMPERATURES IN °C

HEAT 30394, 0.8/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
25428	482T	AGE/50K/482	482	184	287	350	438	514	3.45	20.51	72.33
	650T	AGE/50K/538	538	160	210	279	381	442	2.61	25.5	75.49
	662T	AGE/50K/593	593	163	168	238	332	377	3.04	29.99	82.8
25426	621T	AGE/50K/649	649	164	111	181	280	295	1.24	39.65	87.89
25427	605T	AGE/25K/704	704	127	96	138	177	184	1.76	77.11	92.69

ALL TEMPERATURES IN °C

HEAT 30394, 0.08/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02 % YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
25415	634T	AGE/50K/482	482	214	255	318	424	508	4.06	26.13	76.13
	648T	AGE/50K/538	538	186	247	306	381	414	2.01	30.52	81.95
25413	620T	AGE/50K/649	649	119	104	153	239	258	0.88	51.13	92.2
25414	604T	AGE/25K/704	704	83	93	120	148	161	0.92	62.19	93.73

ALL TEMPERATURES IN °C

HEAT 30394, 8.0/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
25447	637T	AGE/50K/482	25		265	467	601	768	7.94	24.78	62.36
25445	607T	AGE/25K/704	25		242	353	425	597	14.10	36.05	71.51
25446	636T	AGE/50K/482	482		141	309	450	520	4.18	20.65	71.70
	651T	AGE/50K/538	538	199	105	154	248	430	4.62	23.00	72.21
	663T	AGE/50K/593	593	108	77	105	203	362	4.87	25.60	77.36
	660T	AGE/50K/593	593	109	70	101	207	367	3.95	27.03	77.87
25443	622T	AGE/50K/649	649		139	222	304	318	1.80	22.60	82.97
25444	606T	AGE/25K/704	704				206	215	3.30	47.25	90.84

ALL TEMPERATURES IN °C

HEAT 30394, 16.0/min.

TEST NO	SPEC NO	HEAT TREATMENT	TEST TEMP	MODULUS GPa	PL MPa	0.02% YS MPa	0.2% YS MPa	UTS MPa	UE %	TE %	RA %
	652T	AGE/50K/538	25	203	140	185	365	659	4.63	25.10	63.12
	667T	AGE/50K/593	25	239	126	165	329	629	4.12	26.28	64.00
	649T	AGE/50K/538	538	150	70	105	220	438	2.68	22.70	72.24
	661T	AGE/50K/593	593	97	49	77	209	312	4.29	22.05	76.16

ALL TEMPERATURES IN °C

APPENDIX B

DATA FOR DEVELOPMENT OF THERMAL AGING FACTORS

Page title:	Elevated temperature (ET) aging with all testing performed at aging temperature, or elevated temperature aging with all testing performed at room temperature (RT).
Temp K:	Aging temperature in Kelvin
UTS Factor:	Ratio of aged to unaged ultimate tensile strength
YS Factor:	Ratio of aged to unaged yield strength (0.2% offset)
P:	Parameter or $T(\log t + 10)/1000$, where T is temperature (K) and t is time (h)
Note:	All tests were performed at a strain rate of 0.004/min

THERMAL AGING FACTORS (RT) Mon, Mar 13, 1989 15:24

	Heat No.	Temp. K	UTS Factor	YS Factor	Time (h)	P
1	30394.000	866.000	0.960	0.920	10000.000	12.120
2	30394.000	755.000	1.000	0.950	25000.000	10.870
3	30394.000	755.000	0.990	0.950	10000.000	10.570
4	30394.000	922.000	0.800	0.650	10000.000	12.900
5	30394.000	811.000	0.990	0.930	10000.000	11.350
6	30394.000	977.000	0.790	0.650	10000.000	13.680
7	30394.000	811.000	1.000	0.950	25000.000	11.680
8	30394.000	922.000	0.940	0.900	25000.000	13.270
9	30394.000	922.000	0.790	0.650	10000.000	12.900
10	30394.000	977.000	0.790	0.650	25000.000	14.070
11	30394.000	977.000	0.780	0.650	25000.000	14.070
12	30394.000	811.000	0.980	0.940	50000.000	11.920
13	30394.000	866.000	0.960	0.920	25000.000	12.470
14	30394.000	922.000	0.890	0.850	50000.000	13.550
15	30394.000	755.000	1.020	0.960	50000.000	11.100
16	30394.000	755.000	1.010	0.950	50000.000	11.100
17	30394.000	866.000	0.940	0.870	50000.000	12.730
18	30394.000	922.000	0.840	0.850	50000.000	13.550
19	30176.000	755.000	1.020	1.020	10000.000	10.570
20	30176.000	811.000	1.020	1.030	10000.000	11.350
21	30176.000	866.000	0.990	0.970	10000.000	12.120
22	30176.000	922.000	0.870	0.810	10000.000	12.900
23	30176.000	977.000	0.780	0.680	10000.000	13.670
24	30176.000	755.000	1.060	1.090	25000.000	10.870
25	30176.000	811.000	1.030	1.040	25000.000	11.680
26	30176.000	866.000	0.990	1.010	25000.000	12.470
27	30176.000	922.000	0.840	0.760	25000.000	13.270
28	30176.000	977.000	0.770	0.670	25000.000	14.070
29	30176.000	755.000	1.040	1.070	50000.000	11.098
30	30176.000	811.000	1.050	1.070	50000.000	11.920
31	30176.000	866.000	0.930	0.940	50000.000	12.730
32	30176.000	922.000	0.800	0.730	50000.000	13.550
33	30176.000	977.000	0.740	0.620	50000.000	14.360
34	30383.000	755.000	1.070	1.050	25000.000	10.870
35	30383.000	755.000	1.070	1.050	25000.000	10.870
36	30383.000	755.000	1.090	1.130	10000.000	10.570
37	30383.000	755.000	1.070	1.100	10000.000	10.570
38	30383.000	866.000	1.000	1.010	10000.000	12.120
39	30383.000	866.000	1.000	1.000	10000.000	12.120
40	30383.000	977.000	0.900	0.860	10000.000	13.680
41	30383.000	977.000	0.990	0.830	10000.000	13.680

THERMAL AGING FACTORS (ET)   Mon, Mar 13, 1989 15:22

	Heat No.	Temp. K	UTS Factor	YS Factor	Time (h)	P
1	30176.000	755.000	1.030	1.060	10000.000	10.570
2	30176.000	755.000	1.030	1.090	25000.000	10.870
3	30176.000	755.000	1.030	1.090	50000.000	11.100
4	30176.000	811.000	1.010	0.970	10000.000	11.350
5	30176.000	811.000	1.020	1.020	25000.000	11.680
6	30176.000	811.000	1.020	1.020	50000.000	11.920
7	30176.000	866.000	1.000	1.000	10000.000	12.120
8	30176.000	866.000	1.000	0.990	25000.000	12.460
9	30176.000	866.000	0.900	0.900	50000.000	12.720
10	30176.000	922.000	0.890	0.910	10000.000	12.900
11	30176.000	922.000	0.840	0.840	25000.000	13.270
12	30176.000	922.000	0.790	0.740	50000.000	13.550
13	30176.000	977.000	0.690	0.690	10000.000	13.670
14	30176.000	977.000	0.780	0.760	25000.000	14.070
15	30176.000	977.000	0.690	0.690	50000.000	14.360
16	30383.000	755.000	1.020	1.050	10000.000	10.570
17	30383.000	755.000	1.000	1.020	10000.000	10.570
18	30383.000	755.000	0.970	0.980	25000.000	10.870
19	30383.000	755.000	0.970	0.980	25000.000	10.870
20	30383.000	977.000	0.850	0.870	10000.000	13.670
21	30383.000	977.000	0.840	0.820	10000.000	13.670
22						
23	30394.000	755.000	0.940	0.950	25000.000	10.870
24	30394.000	755.000	0.910	0.930	50000.000	11.100
25	30394.000	755.000	0.910	0.920	50000.000	11.100
26	30394.000	811.000	0.840	0.900	25000.000	11.770
27	30394.000	811.000	0.840	0.910	10000.000	11.350
28	30394.000	811.000	0.800	0.850	50000.000	11.920
29	30394.000	866.000	0.870	0.900	25000.000	12.470
30	30394.000	866.000	0.860	0.880	10000.000	12.120
31	30394.000	866.000	0.810	0.840	50000.000	12.730
32	30394.000	922.000	0.840	0.810	50000.000	13.550
33	30394.000	922.000	0.800	0.810	50000.000	13.550
34	30394.000	922.000	0.840	0.840	25000.000	13.270
35	30394.000	922.000	0.810	0.810	10000.000	12.900
36	30394.000	977.000	0.710	0.770	10000.000	13.670
37	30394.000	977.000	0.680	0.700	25000.000	14.070
38	30394.000	977.000	0.680	0.800	25000.000	14.070

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