

データシート：圧力容器用鋼材の特性

Data Sheets for Properties of Pressure Vessel Steel Plates and Forgings

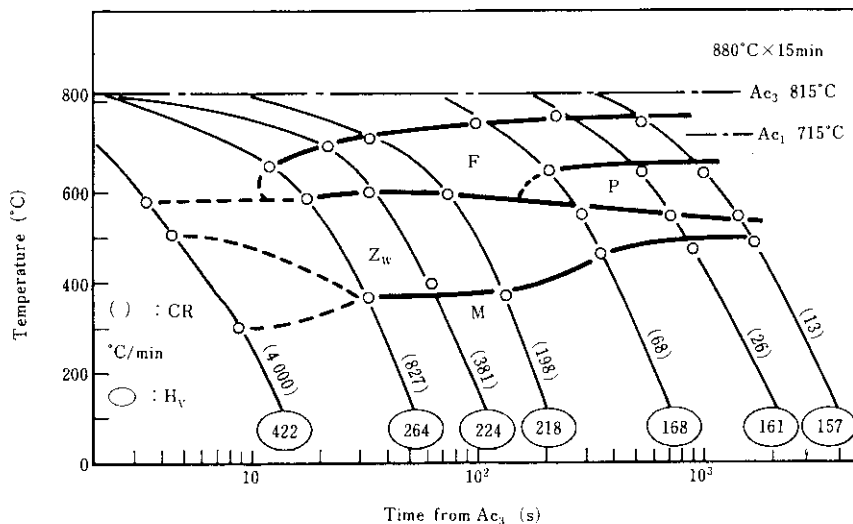
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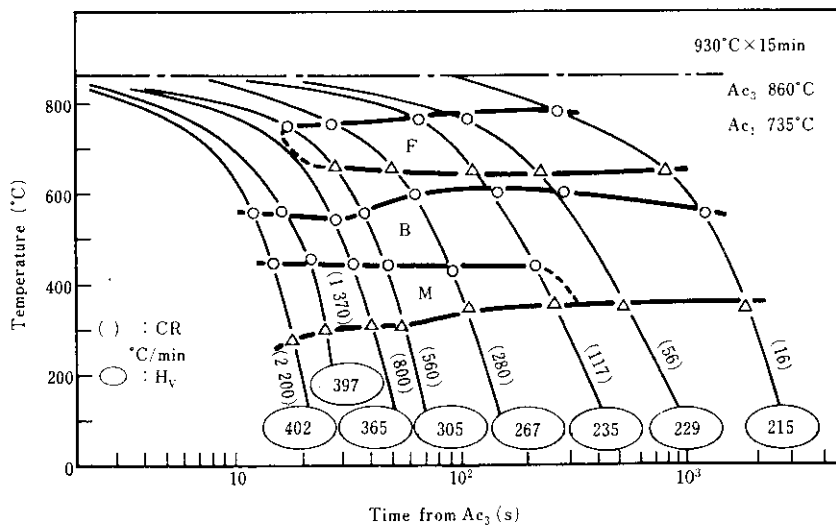
1 章 CCT線図

§1 Continuous cooling transformation diagram

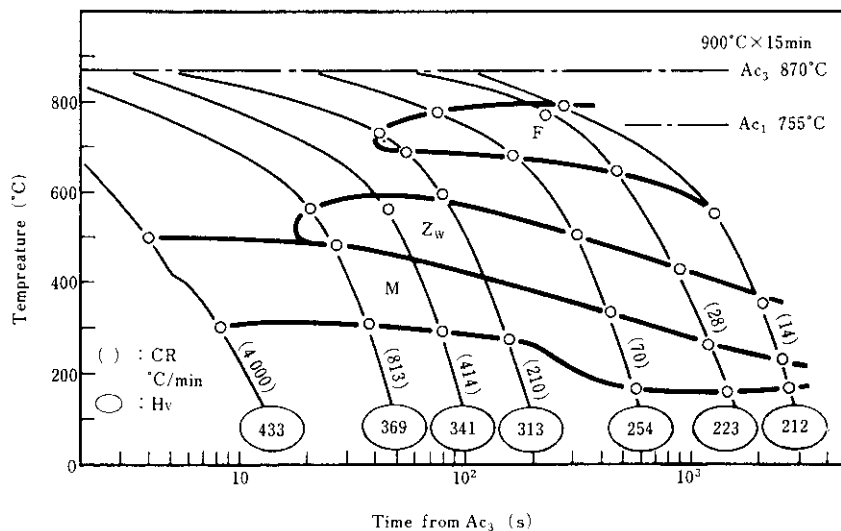
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA204 Gr.B	0.20 ~0.27	0.15 ~0.30	0.90 Max.	0.035 Max.	0.040 Max.	—	—	—	0.45 ~0.60	—
SA182 F1	0.28 Max.	0.15 ~0.35	0.60 ~0.90	0.045 Max.	0.045 Max.	—	—	—	0.44 ~0.65	—
Steel	0.25	0.25	0.63	0.012	0.005	0.02	0.02	0.05	0.48	0.011



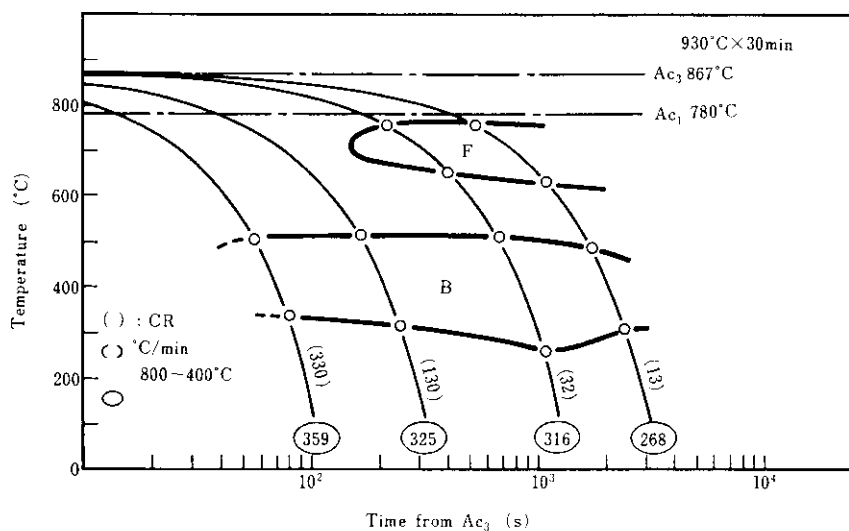
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr.12	0.17 Max.	0.15 ~0.30	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	0.80 ~1.15	0.45 ~0.60	—
SA182 F12	0.10 ~0.20	0.10 ~0.60	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	0.80 ~1.25	0.44 ~0.65	—
Steel	0.16	0.24	0.54	0.012	0.004	0.01	0.02	1.04	0.47	0.003



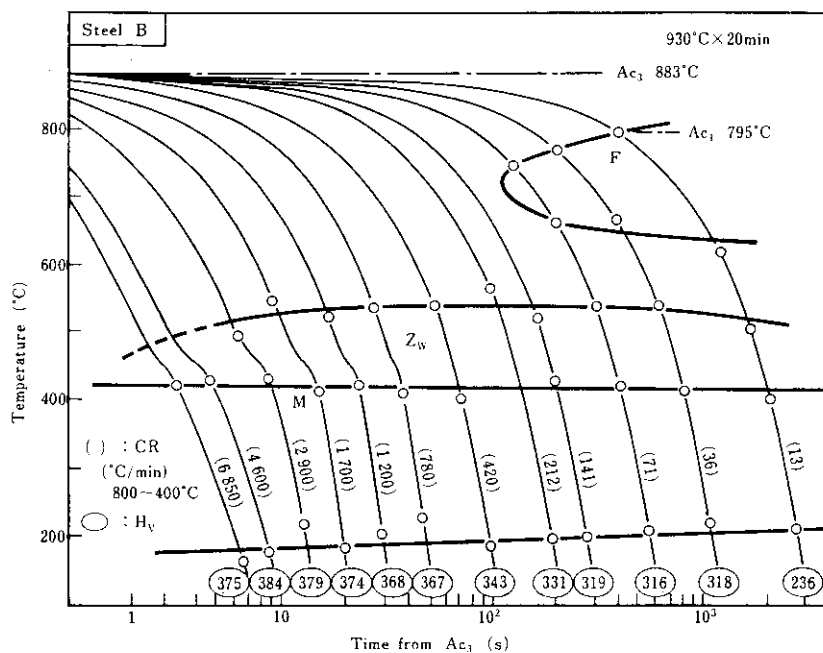
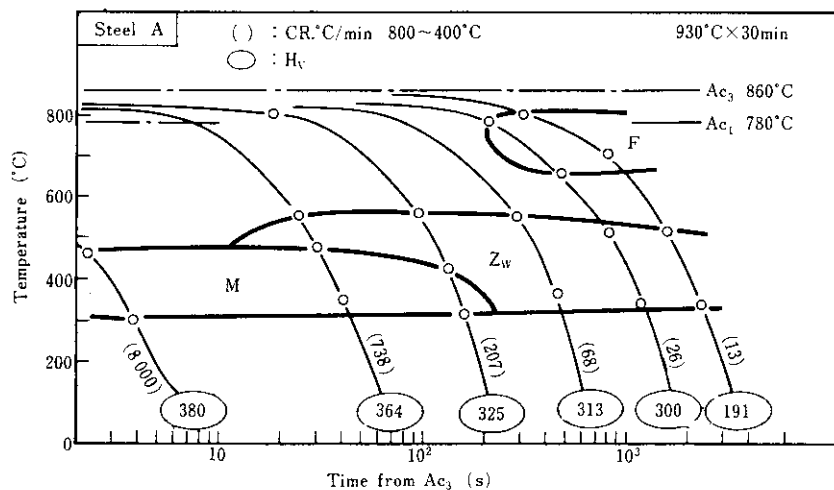
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 11	0.17 Max.	0.50 ~0.80	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	1.00 ~1.50	0.45 ~0.65	—
SA182 F11	0.10 ~0.20	0.50 ~1.00	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	1.00 ~1.50	0.44 ~0.65	—
Steel	0.15	0.64	0.64	0.012	0.004	0.03	0.02	1.41	0.59	0.016



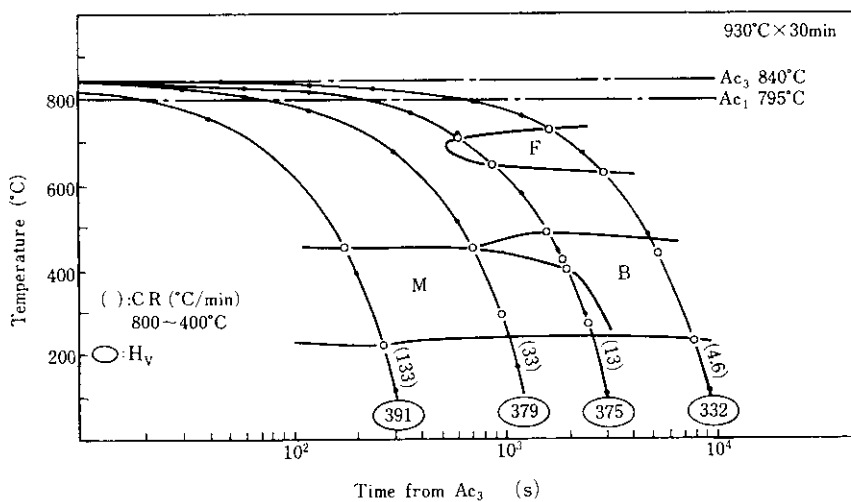
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.75 ~3.25	0.90 ~1.10	—
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.65 ~3.35	0.80 ~1.06	—
Steel	0.12	0.13	0.50	0.010	0.007	0.03	0.02	3.02	1.05	0.006



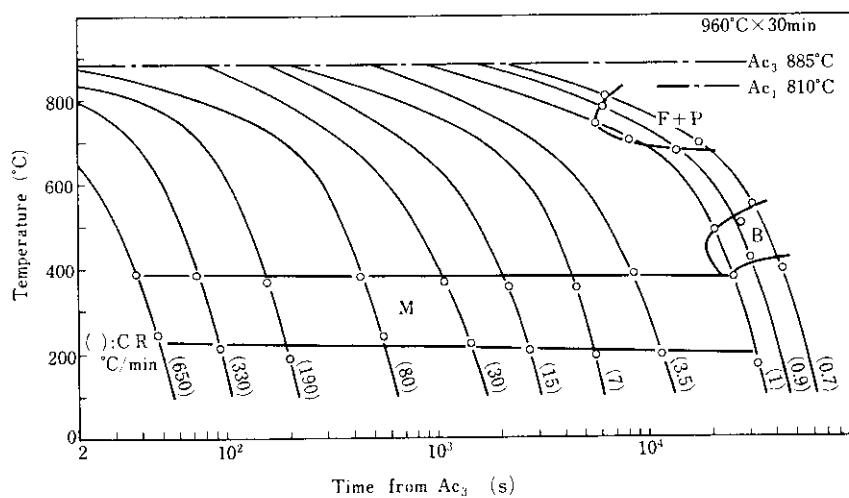
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.00 ~2.50	0.90 ~1.10	—
SA182 F22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.00 ~2.50	0.87 ~1.13	—
Steel A	0.12	0.08	0.52	0.011	0.007	0.01	0.03	2.45	0.99	0.025
Steel B	0.14	0.24	0.51	0.006	0.003	0.12	0.16	2.43	0.97	0.014



	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.030 Max.	—	—	4.00 ~6.00	0.45 ~0.65	—
SA182 F5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	—	—	4.0 ~6.0	0.44 ~0.65	..
Steel	0.13	0.13	0.50	0.010	0.008	0.11	0.11	5.08	0.54	0.008



	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 9	0.15 Max.	1.00 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	—	—	8.00 ~10.00	0.90 ~1.10	—
SA182 F9	0.15 Max.	0.50 ~1.00	0.30 ~0.60	0.030 Max.	0.030 Max.	—	—	8.0 ~10.0	0.90 ~1.10	—
Steel	0.13	0.61	0.44	0.012	0.006	0.01	0.10	8.76	0.94	



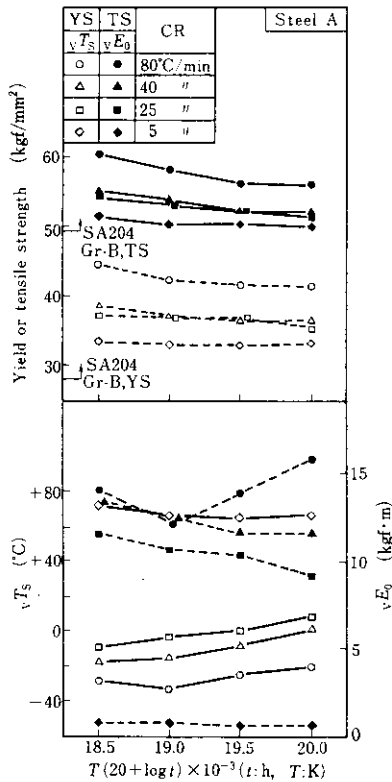
2章 強度と靱性

§ 2 Strength and toughness

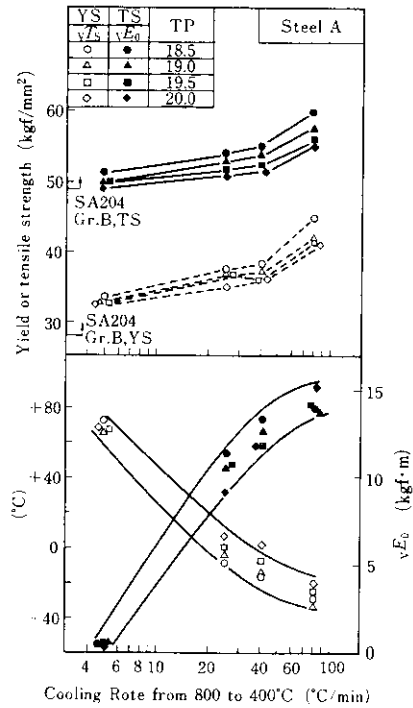
 $\frac{1}{2}$ Mo steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA204 Gr. B	0.20 ~0.27	0.15 ~0.30	0.90 Max.	0.035 Max.	0.040 Max.	—	—	—	0.45 ~0.60	—
SA182 F1	0.28 Max.	0.15 ~0.35	0.60 ~0.90	0.045 Max.	0.045 Max.	—	—	—	0.44 ~0.65	—
Steel A	0.25	0.25	0.63	0.012	0.005	0.01	0.02	0.05	0.48	0.011
Steel B	0.17	0.26	0.73	0.008	0.008	0.02	0.02	0.06	0.48	0.010

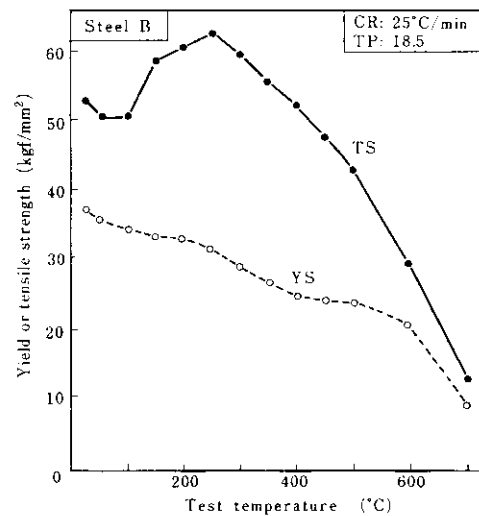
(1) Effect of tempering



(2) Effect of cooling rate



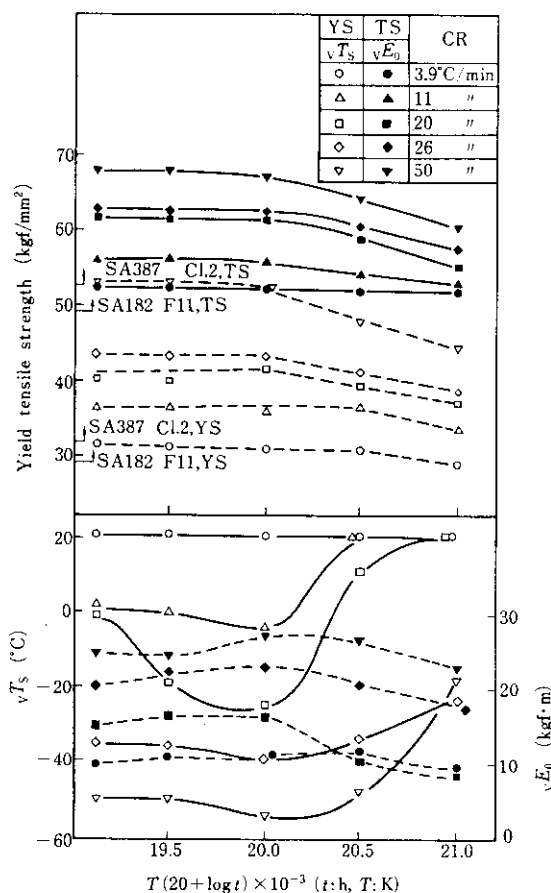
(3) Strength at elevated temperature



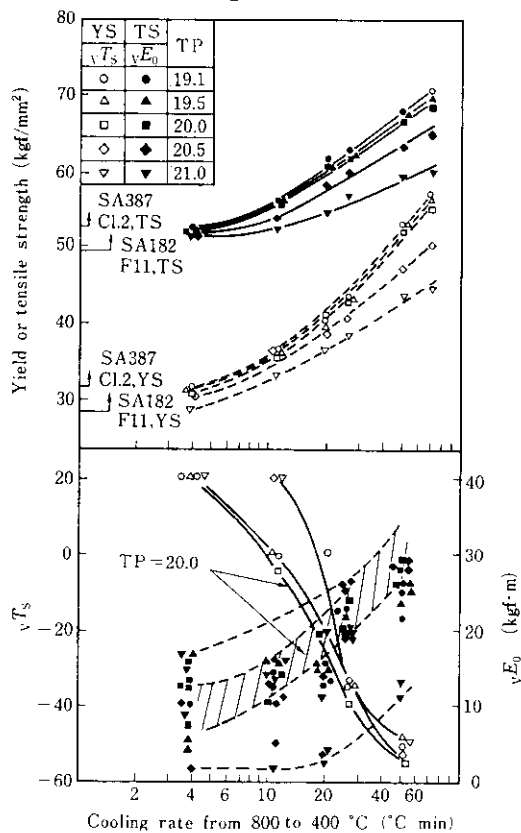
1 1/4 Cr - 1/2 Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. II	0.17 Max.	0.50 ~0.80	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	1.00 ~1.50	0.45 ~0.65	—
SA182 F11	0.10 ~0.20	0.50 ~1.00	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	1.00 ~1.50	0.44 ~0.65	—
Steel	0.14	0.63	0.64	0.015	0.008	0.01	0.02	1.41	0.59	0.025

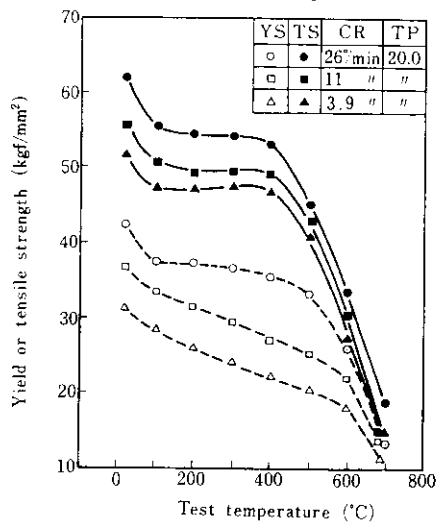
(1) Effect of tempering



(2) Effect of cooling rate



(3) Strength at elevated temperatures

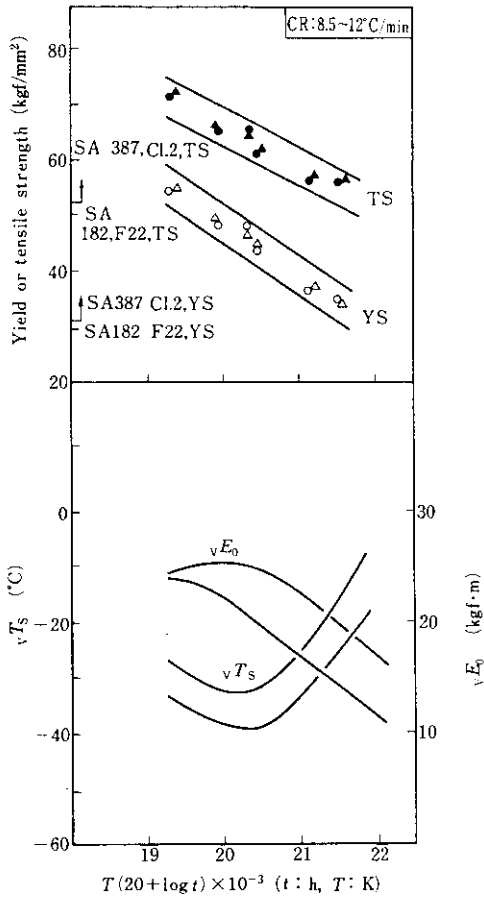


2 $\frac{1}{4}$ Cr-1Mo Steel (2)(3)

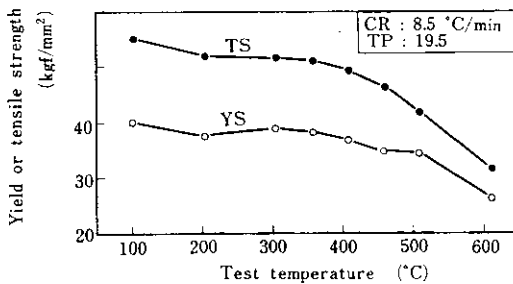
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.00 ~2.50	0.90 ~1.10	—
SA182 F22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.00 ~2.50	0.87 ~1.13	—
Steel A	0.14	0.24	0.51	0.006	0.003	0.12	0.16	2.43	0.97	0.014
Steel B	0.14	0.35	0.56	0.003	0.004	0.01	0.06	2.18	1.02	0.018

Steel A : Medium Si

(1) Effect of tempering

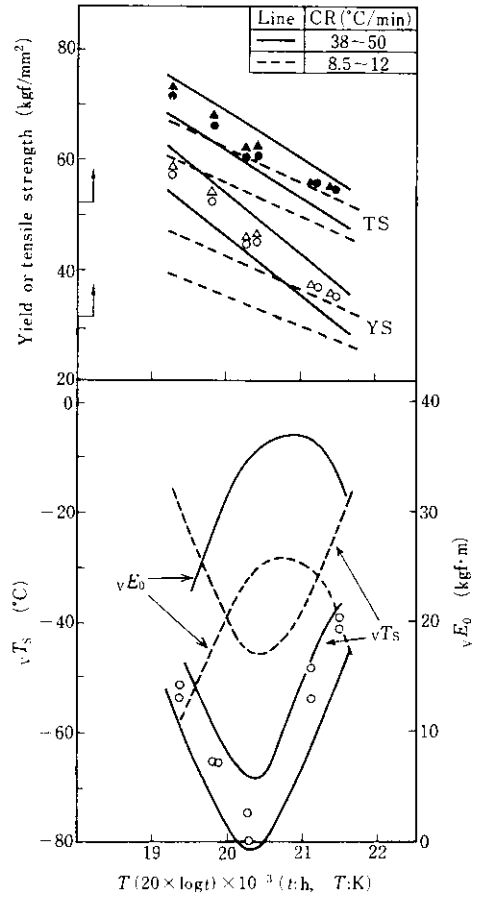


(2) Strength at elevated temperatures

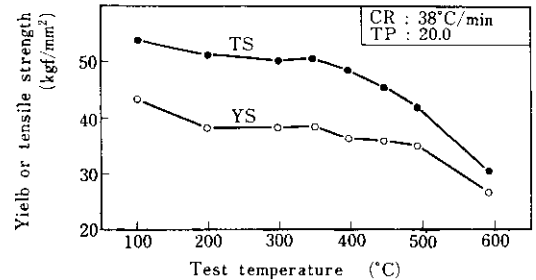


Steel B : High Si-Extra low P

(1) Effect of tempering



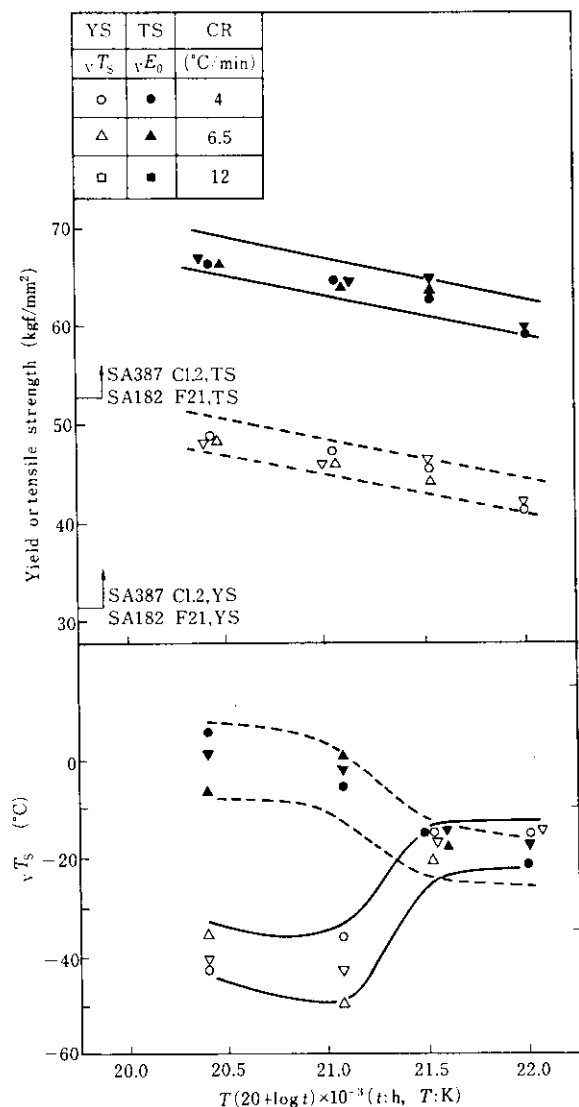
(2) Strength at elevated temperatures



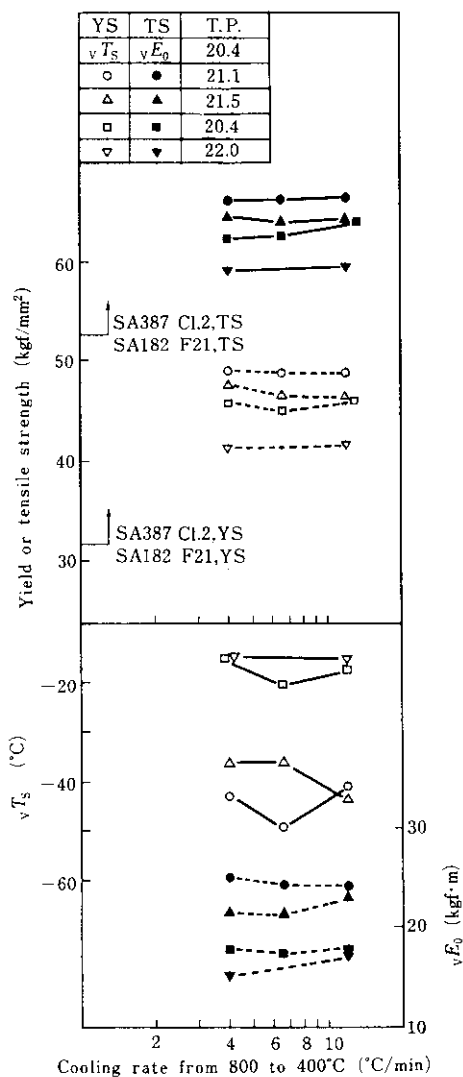
3Cr-1Mo Steel (1) High Si

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.75 ~3.25	0.90 ~1.10	—
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.65 ~3.35	0.80 ~1.06	—
Steel	0.15	0.48	0.57	0.010	0.005	0.11	0.11	3.05	1.05	0.014

(1) Effect of tempering



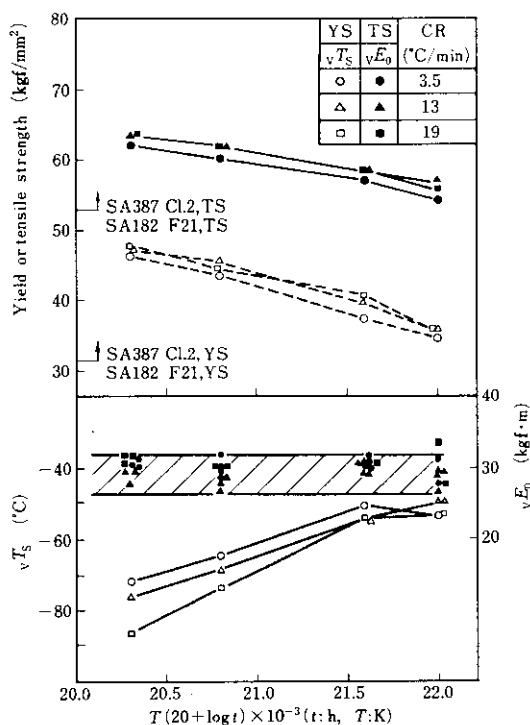
(2) Effect of cooling rate



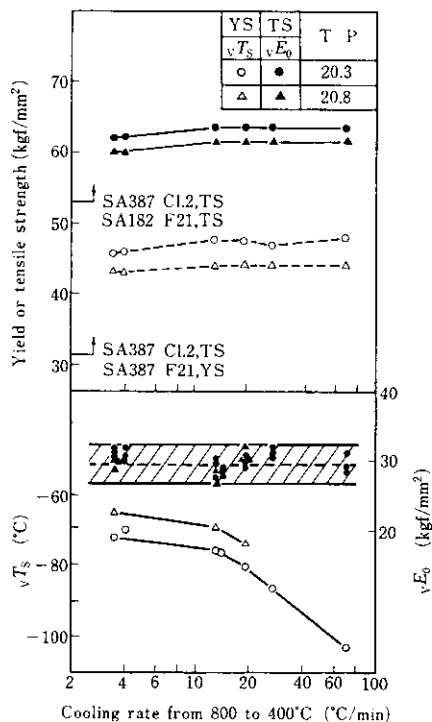
3Cr-1Mo Steel (2) Low Si

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.75 ~3.25	0.90 ~1.10	—
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.65 ~3.35	0.80 ~1.06	—
Steel	0.13	0.08	0.50	0.010	0.007	0.01	0.03	3.22	0.96	0.014

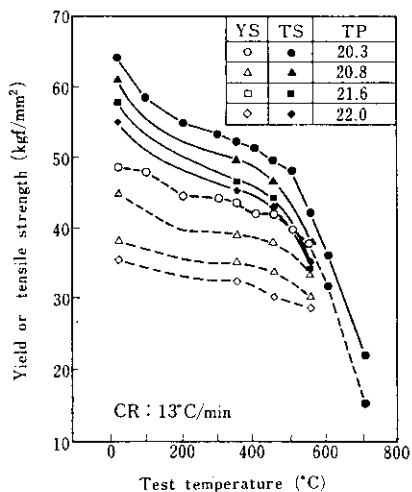
(1) Effect of tempering



(2) Effect of cooling rate



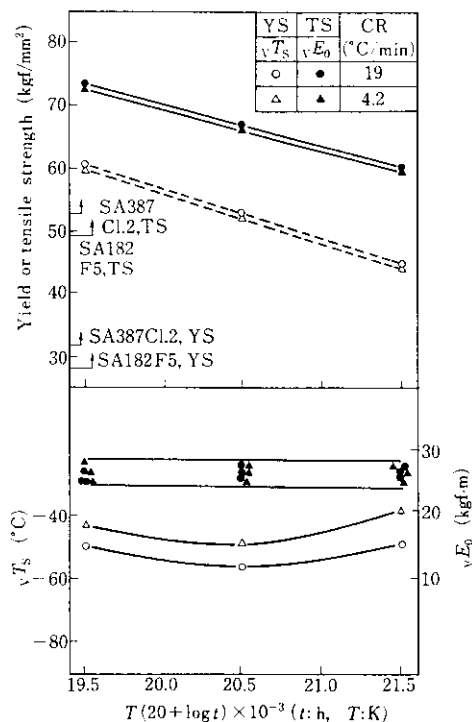
(3) Strength at elevated temperatures



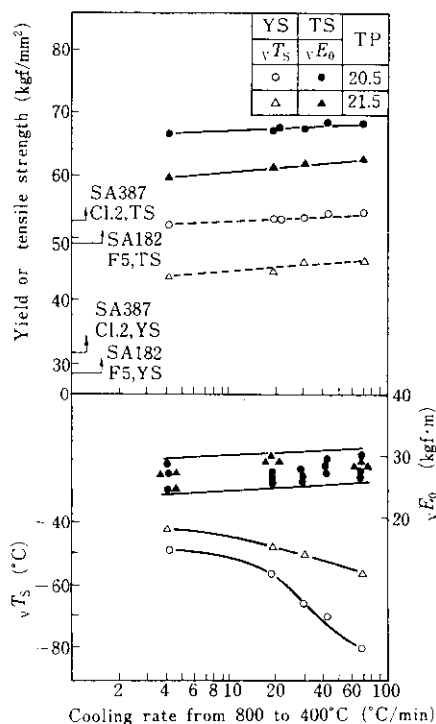
5Cr- $\frac{1}{2}$ Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.030 Max.	—	—	4.00 ~6.00	0.45 ~0.65	—
SA182 F 5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	—	0.50 Max.	4.0 ~6.0	0.44 ~0.65	—
Steel	0.14	0.13	0.50	0.004	0.006	0.01	0.06	4.96	0.60	0.002

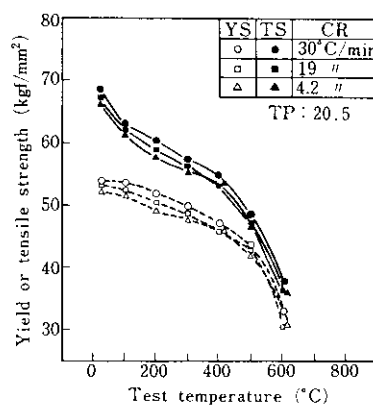
(1) Effect of tempering



(2) Effect of cooling rate



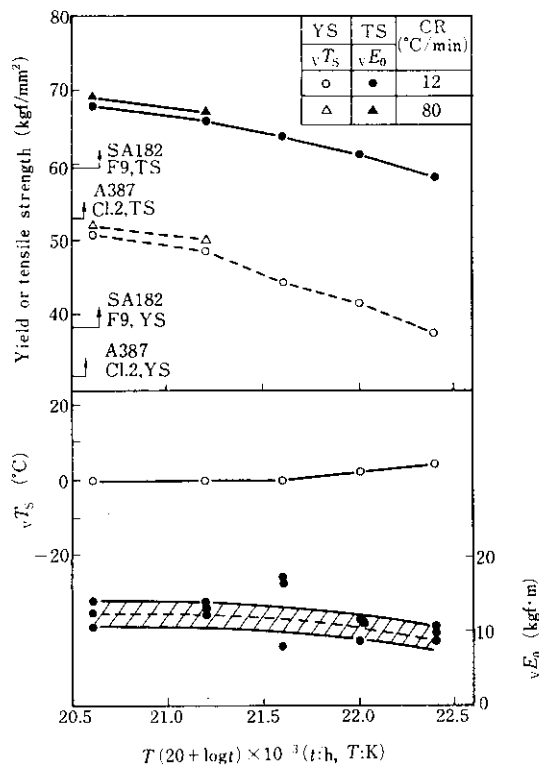
(3) Strength at elevated temperature



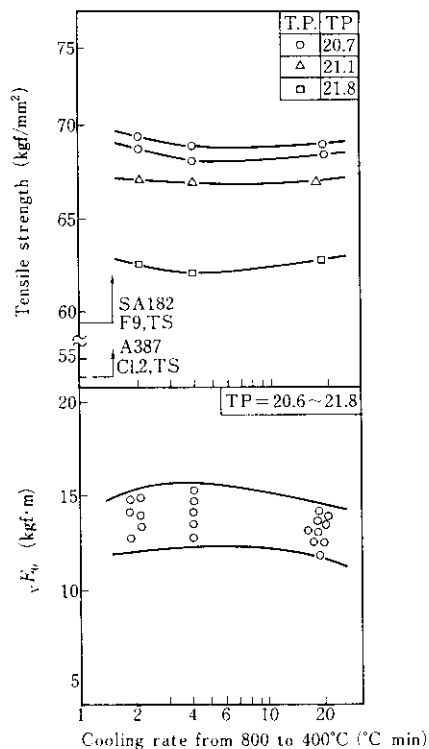
9Cr-1Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
A387 Gr. 9	0.15 Max.	1.00 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	---	---	8.00 ~10.00	0.90 ~1.10	---
SA182 F9	0.15 Max.	0.50 ~1.00	0.30 ~0.60	0.030 Max.	0.030 Max.	---	---	8.0 ~10.0	0.90 ~1.10	---
Steel	0.13	0.61	0.44	0.012	0.006	0.01	0.01	8.76	0.94	0.009

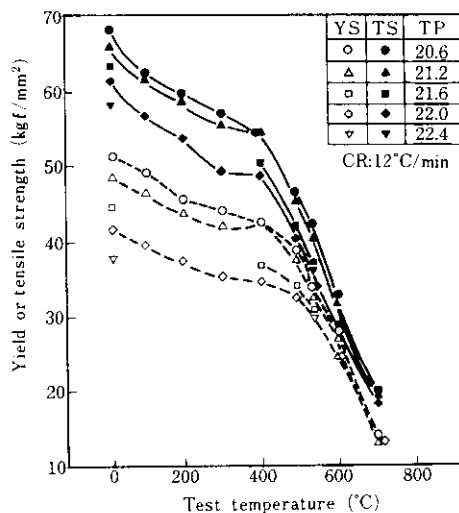
(1) Effect of tempering



(2) Effect of cooling rate



(3) Strength at elevated temperatures



3章 焼もどし脆化特性

§3 Susceptibility to temper embrittlement

(1) Base metal

Material	Cooling rate (°C/min)	Structure	Before temper embrittlement				After temper embrittlement			
			Y S	T S	$\sqrt{T_S}$	$\sqrt{T_{40}}$	$\sqrt{T_S}$	$\sqrt{T_{40}}$	$\Delta\sqrt{T_S}$	$\Delta\sqrt{T_{40}}$
			kgf/mm ²	kgf/mm ²	°C	°C	°C	°C	°C	°C
Carbon steel	33~100	F + P	28~30	49~51	-43~-33	-65~-55	-32~-25	-65~-51	5~13	0~8
$\frac{1}{2}$ Mo steel	$\frac{1}{2}$ Mo	F + P	33~34	50~51	0	-23~-20	5	-13~-4	5	10~16
	Mn- $\frac{1}{2}$ Mo	F + P + B	42~50	54~64	12~32	-21~-20	-9~-35	-28~-5	-17~-23	-23~-9
1Cr- $\frac{1}{2}$ Mo steel	Fine grain	F + P	28	46~47	-40~-24	-72~-55	-24~-11	-61~-36	0~16	-2~21
	"	F + B	37~45	53~60	-47~-14	-57~-35	-31~4	-49~-27	3~24	8
	Coarse grain	F + P	30~31	46~49	34	12~27	38~45	36~41	4~11	5~10
$\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo steel	11~18	F + P	35	52~56	-33~-5	-61~-37	-34~10	-59~-25	-1~15	2~12
	20~50	F + B	41~52	61~67	-55~-27	-80~-55	-5~5	-40~-30	32~50	25~40
2 $\frac{1}{4}$ Cr-1 Mo steel	Low Si	F + P + B	21~43	44~57	-66~3	-76~-2	-50~3	-65~-4	-2~24	-6~14
		B	33~55	49~63	-80~-59	-88~-70	-77~-55	-85~-59	-2~5	-6~12
	High Si () : Extra-low P	F + B	30~36 (27~41)	52~54 (51~63)	-41 (-38~-4)	-45 (-75~-30)	-30 (-36~12)	-58 (-71~-11)	11 (-23~15)	-13 (-4~13)
		"	"	"	"	"	"	"	"	"
		B	45~55 (33~57)	61~69 (52~71)	-44~-3 (-75~-30)	-76~-41 (-117~-56)	36~77 (-56~-24)	-65~-15 (-99~-60)	46~77 (3~18)	42~62 (-1~25)
3Cr-1Mo steel	Low Si	B	42~54	59~68	-100~-47	-117~-66	-75~-22	-97~-66	20~25	0~21
	High Si	B	29~38	55~56	-5~0	-45~-17	-12~26	-25~-7	10~31	0~38
5Cr- $\frac{1}{2}$ Mo steel	4.2~23	B	42~53	56~68	-79~-56	-100~-69	-83~-32	-96~-62	-4~26	-13~24
9Cr-1Mo steel	12	B	41~50	61~68	0~5	-42~-35	-5~5	-49~-35	-5~5	-7~2

(2) Welding zone

(°C)

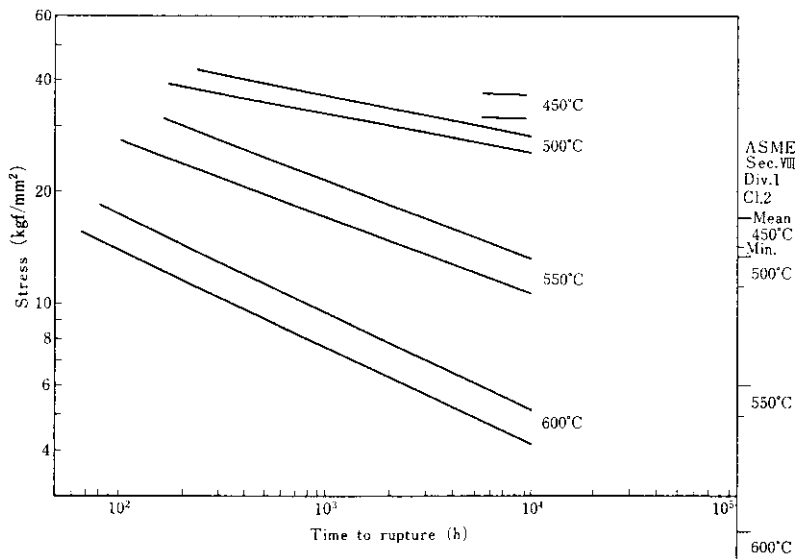
Material	Welding method	Welding zone	Before t. e.		After temper embrittlement			
			$\sqrt{T_S}$	$\sqrt{T_{40}}$	$\sqrt{T_S}$	$\sqrt{T_{40}}$	$\Delta\sqrt{T_S}$	$\Delta\sqrt{T_{40}}$
$\frac{1}{2}$ Mo steel	MAW	WM	-3	-9	-2	-11	1	2
		HAZ	-54	-96	-45	-99	9	-23
	SAW	WM	-44	-50	-31	-42	13	8
		HAZ	-34	-69	-30	53	4	16
	Mn- $\frac{1}{2}$ Mo	MAW	-4~2	-10~-2	4~10	-7~6	2~14	-5~4
			-53	-81	-47	-76	6	5
		SAW	-36~-31	-41~-39	-40~-39	50~43	-8~4	9~4
			-19	51	-16	32	3	19
1Cr- $\frac{1}{2}$ Mo steel	MAW	WM	-2~8	-8~2	9~32	6~28	1~34	4~36
		Bond	-51~-12	-58~-15	-47~3	57~-2	27~15	39~23
	SAW	WM	-8	-16	-8	-21	0	5
$\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo steel	MAW	WM	-17	-29	-3	-13	14	16
		Bond	-33	-66	-8	-20	25	46
2 $\frac{1}{4}$ Cr-1 Mo steel	MAW	WM	-12~-4	-17~-13	-3~15	-14~7	9~19	3~20
		Bond	-43~-38	-56~-55	-29	-52~-35	11~14	3~21
	SAW	WM	-21	-31	-6	5	27	26
5Cr- $\frac{1}{2}$ Mo steel	SAW	WM	-25	-35	-18	-23	7	12

4章 クリープ

§4 Creep

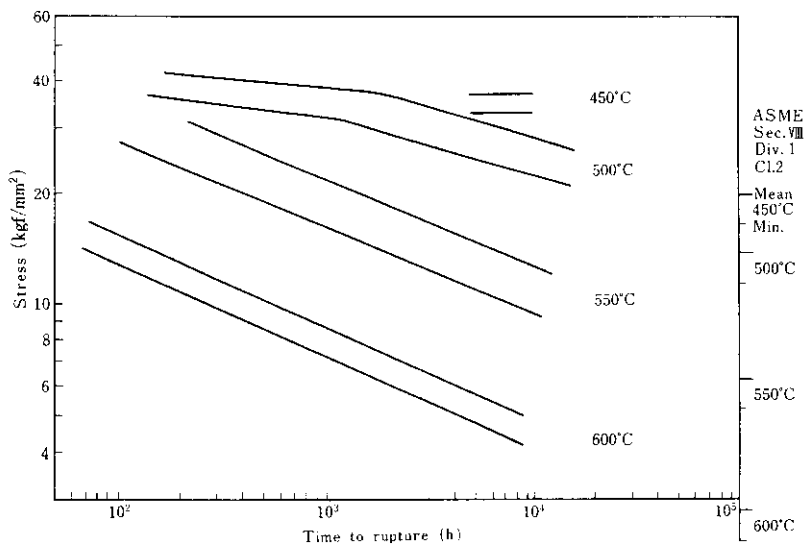
1Cr- $\frac{1}{2}$ Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 12	0.17 Max.	0.15 ~0.30	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	0.80 ~1.15	0.45 ~0.60	—
SA182 F12	0.10 ~0.20	0.10 ~0.60	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	0.80 ~1.25	0.44 ~0.65	—
Norma. -Temper.	0.13 ~0.17	0.19 ~0.26	0.52 ~0.58	0.005 ~0.013	0.002 ~0.005	0.01 ~0.04	0.02 ~0.21	1.03 ~1.11	0.49 ~0.56	0.002 ~0.014



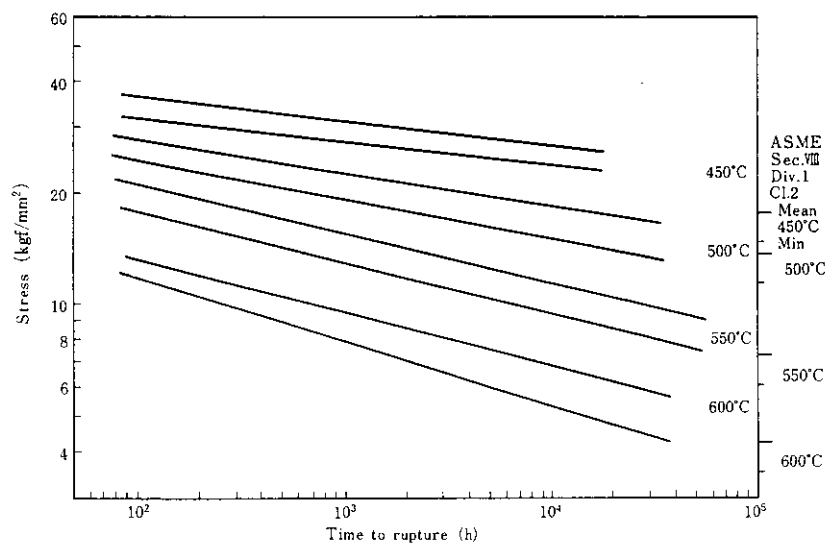
1 $\frac{1}{4}$ Cr- $\frac{1}{2}$ Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 11	0.17 Max.	0.50 ~0.80	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	1.00 ~1.50	0.45 ~0.65	—
SA182 F11	0.10 ~0.20	0.50 ~1.00	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	1.00 ~1.50	0.44 ~0.65	—
Norma. -Temper.	0.12 ~0.16	0.57 ~0.64	0.53 ~0.61	0.003 ~0.012	0.006 ~0.009	0.01 ~0.10	0.02 ~0.03	1.21 ~1.38	0.47 ~0.54	0.005 ~0.014



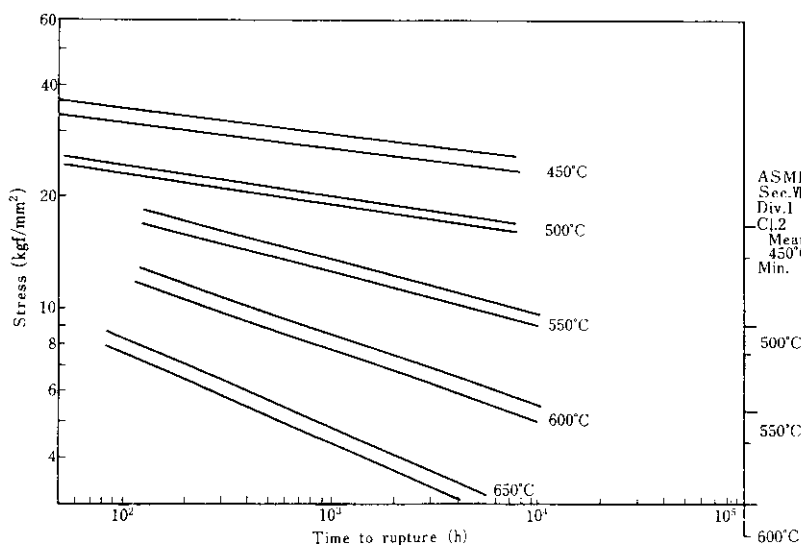
2¼Cr-1Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	---	---	2.00 ~2.50	0.90 ~1.10	---
SA182 F22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	---	---	2.00 ~2.50	0.87 ~1.13	---
Norma.-Temper. & Quench.-Temper.	0.08 ~0.15	0.06 ~0.45	0.38 ~0.60	0.006 ~0.013	0.003 ~0.010	0.01 ~0.20	0.02 ~0.20	2.05 ~2.48	0.96 ~1.05	0.001 ~0.016



5Cr-½Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.030 Max.	---	---	4.00 ~6.00	0.45 ~0.65	---
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	---	---	4.0 ~6.0	0.44 ~0.65	---
Norma.-Temper.	0.06 ~0.09	0.24 ~0.26	0.40 ~0.44	0.007 ~0.009	0.006 ~0.007	0.02	0.06 ~0.11	4.12 ~4.65	0.47 ~0.49	0.002 ~0.005

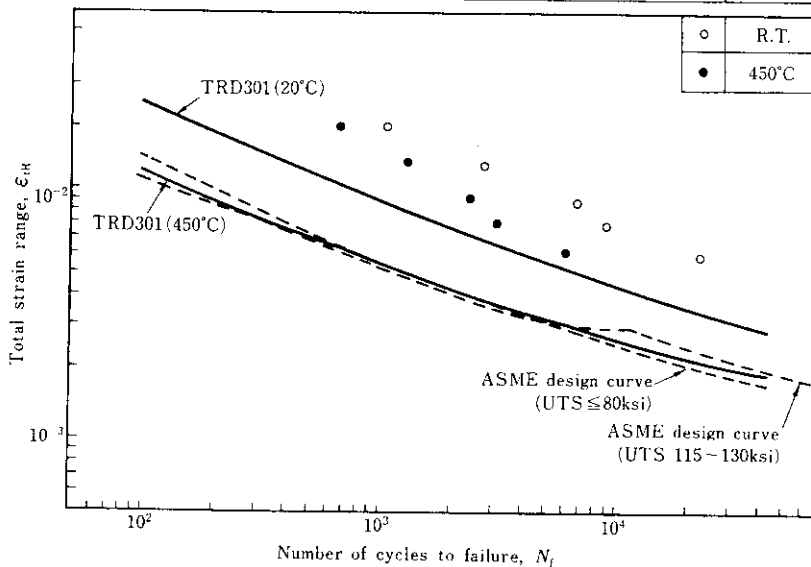


5章 疲労特性

§5 Fatigue

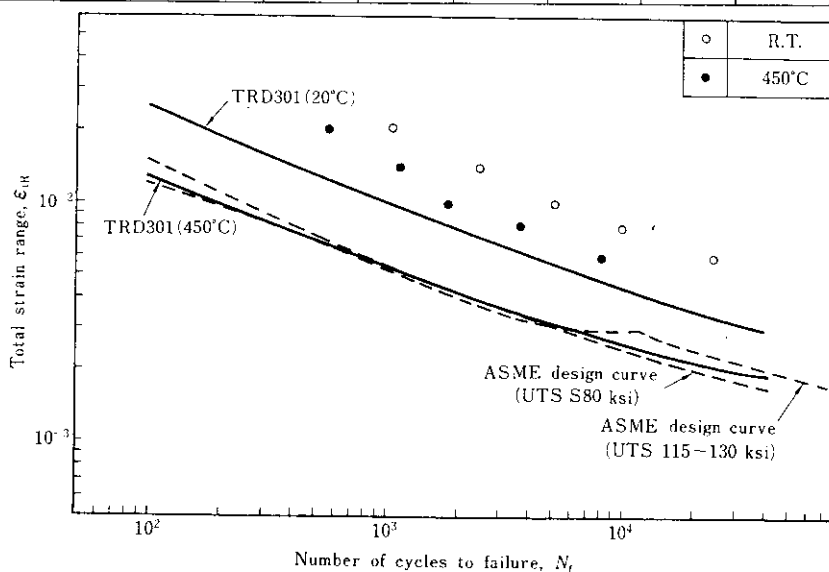
$\frac{1}{2}$ Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA204 Gr. B	0.20 ~0.27	0.15 ~0.30	0.90 Max.	0.035 Max.	0.040 Max.	—	—	—	0.45 ~0.60	—
SA182 F1	0.28 Max.	0.15 ~0.35	0.60 ~0.90	0.045 Max.	0.045 Max.	—	—	—	0.44 ~0.65	—
Norma.	0.25	0.24	0.73	0.010	0.008	0.01	0.03	0.04	0.49	0.017



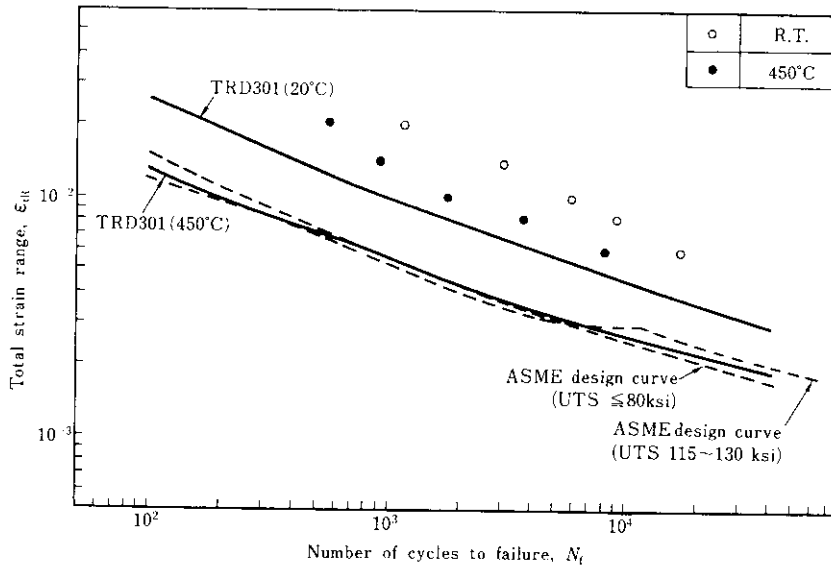
1Cr- $\frac{1}{2}$ Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 12	0.17 Max.	0.15 ~0.30	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	0.80 ~1.15	0.45 ~0.60	—
SA182 F12	0.10 ~0.20	0.10 ~0.60	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	0.80 ~1.25	0.44 ~0.65	—
Norma. -Temper.	0.16	0.26	0.58	0.010	0.003	0.01	0.20	1.03	0.54	0.014



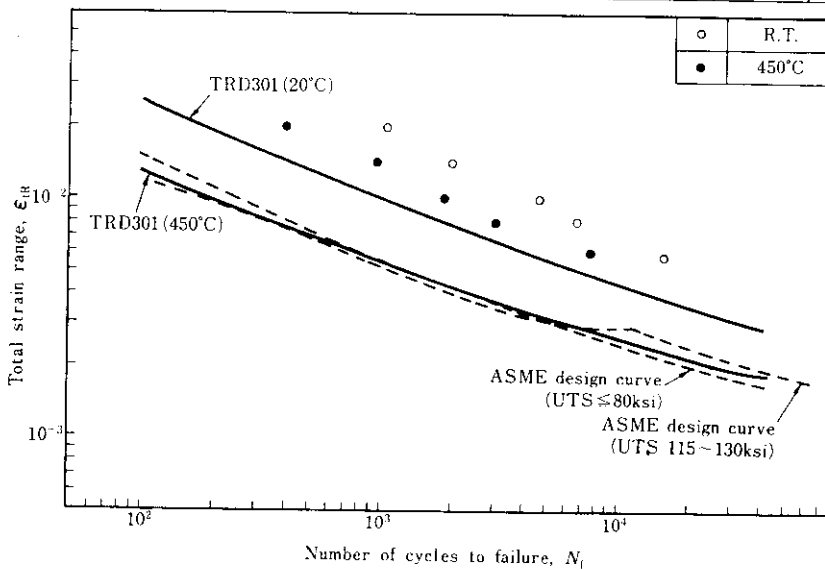
1¼Cr - ½Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 11	0.17 Max.	0.50 ~0.80	0.40 ~0.65	0.035 Max.	0.040 Max.	—	—	1.00 ~1.50	0.45 ~0.65	—
SA182 F11	0.10 ~0.20	0.50 ~1.00	0.30 ~0.80	0.040 Max.	0.040 Max.	—	—	1.00 ~1.50	0.44 ~0.65	—
Norma. -Temper.	0.12	0.59	0.54	0.011	0.009	0.01	0.03	1.38	0.47	0.009



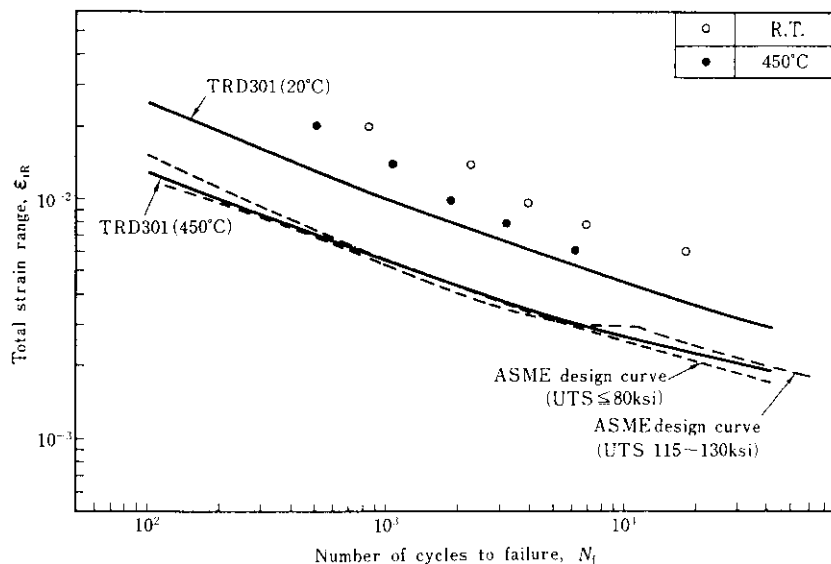
2¼Cr - 1Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.00 ~2.50	0.90 ~1.10	—
SA182 F22	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.00 ~2.50	0.87 ~1.13	—
Quench.-Temper.	0.13	0.08	0.51	0.009	0.008	0.12	0.12	2.41	1.04	0.011



3Cr-1Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.035 Max.	0.035 Max.	—	—	2.75 ~3.25	0.90 ~1.10	—
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.040 Max.	—	—	2.65 ~3.35	0.80 ~1.06	—
Norma.-Temper.	0.15	0.48	0.57	0.010	0.005	0.11	0.11	3.05	1.05	0.014



5Cr-1/2Mo Steel

	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Al
SA387 Gr. 5	0.15 Max.	0.50 Max.	0.30 ~0.60	0.040 Max.	0.030 Max.	—	—	4.00 ~6.00	0.45 ~0.65	—
SA182 F21	0.15 Max.	0.50 Max.	0.30 ~0.60	0.030 Max.	0.030 Max.	—	—	4.0 ~6.0	0.44 ~0.65	—
Norma.-Temper.	0.09	0.24	0.44	0.007	0.007	0.03	0.07	4.65	0.47	0.002

