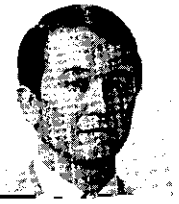
KAWASAKI STEEL TECHNICAL REPORT No. 19 November 1988

Development of High Strength C110 Grade Steel and 13% Cr Stainless Steel for OCTG in Corrosive Wells

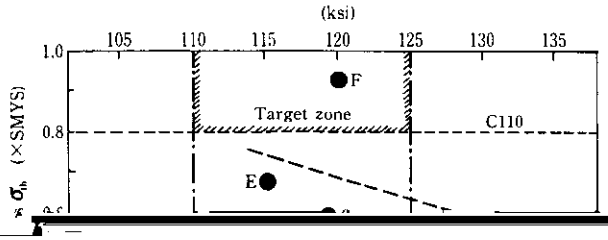


Synopsis:

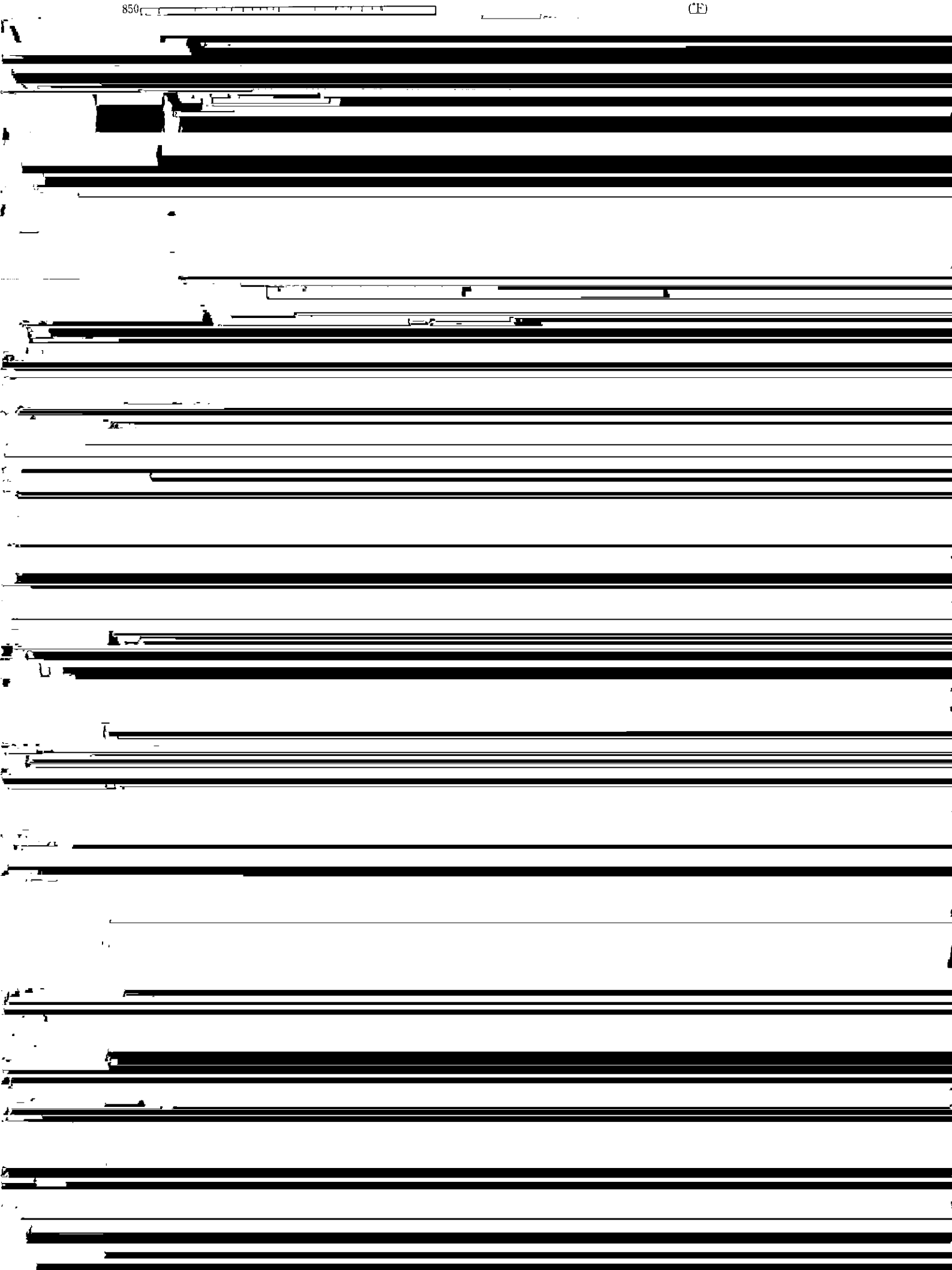
In sour oil wells, where the danger of sulfide stress cracking (SSC) exists, OCTG with YS levels of up to 95 ksi are conventionally used. To meet higher strength requirements, C110 grade OCTG was developed using a high C, low alloy steel, providing an SSC threshold stress

Table 1 Specifications of Kawasaki Steel's special OCTG for sour or sweet services

	Grade	Chemical analysis (wt%)											YS (ksi)	TS (ksi)	HRC	σ_{th} (ksi)
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	Nb	V	B				
Sour service	KO-80S	0.16-0.35	≦0.35	≦1.35	≦0.030	≦0.015	≦0.30	≦0.10	≦1.60	0.05-1.10	≦0.050	—	≦0.0040	80-95	≧95	≦22	
	90S	0.16-0.35	≦0.35	≦1.35	≦0.030	≦0.015	≦0.30	≦0.10	≦1.60	0.05-1.10	≦0.050	—	≦0.0040	90-105	≧100	≦24	
	95S	0.16-0.35	≦0.35	≦1.35	≦0.030	≦0.015	≦0.30	≦0.10	≦1.60	0.05-1.10	≦0.050	—	≦0.0040	95-110	≧105	≦25	
	KO-85SS	0.16-0.35	≦0.35	≦1.00	≦0.030	≦0.015	≦0.30	≦0.10	0.80-1.60	0.15-1.10	≦0.050	—	≦0.0040	85-100	≧95	≦23	≧70


(ksi)
105
110
115
120
125
130
135
1.0
0.8
F
E
Target zone
C110
(×SMYS)

Sample No.	Size (OD×WT)	Quenching method	Tempering condition	YS (ksi)	TS (ksi)	El (%)	σ_{th} *1 (ksi)	S_c *2 (10ksi)	K_{ISCC} *3 (ksi $\sqrt{in}$)
1	7″×0.507″	WQ	710°C×40min	129	140	24.5	88.0 (0.800×SMYS)	7.2	22.4
2	7″×0.507″	WQ	710°C×55min	125	135	24.7	99.0 (0.900×SMYS)	9.9	23.7
3	7″×0.507″	WQ	715°C×45min	120	130	28.2	110.0 (1.000×SMYS)	10.1	32.4
4	7″×0.507″	WQ	715°C×55min	112	121	27.7	104.5 (0.950×SMYS)	12.0	32.3
5	7″×0.788″	WQ	710°C×40min	125	135	28.9	107.3 (0.975×SMYS)	8.4	24.5
6	7″×0.788″	WQ	710°C×55min	120	130	30.3	110.0 (1.000×SMYS)	11.1	25.6
7	7″×0.788″	WQ	715°C×45min	119	128	32.5	110.0 (1.000×SMYS)	11.2	31.2
8	7″×0.788″	WQ	715°C×65min	113	123	32.2	104.5 (0.950×SMYS)	12.4	29.5



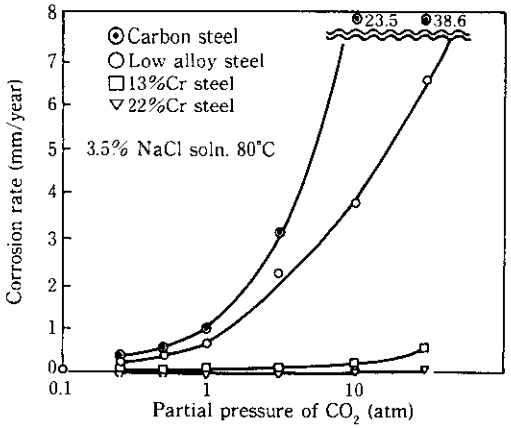
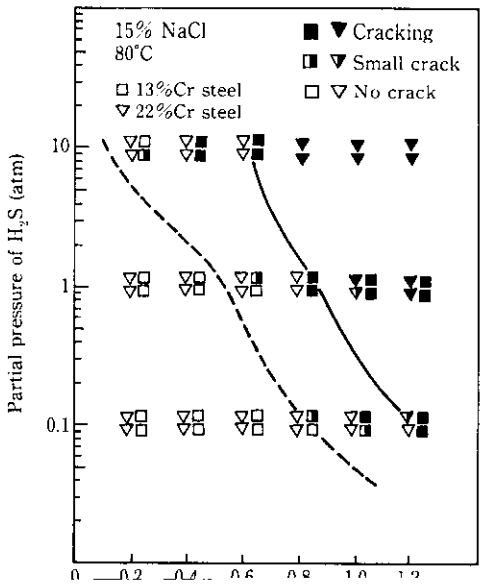


Fig. 10 Effect of CO_2 partial pressure on corrosion rates at 80°C



times greater than that of the 13% Cr steel. The maximum service temperature of the 13% Cr steel is thus limited to 150°C.

Applied stress (σ/σ_y)

Fig. 11 Effect of applied stress and H_2S partial pressure on the SSC susceptibility of 13% Cr