KAWASAKI STEEL TECHNICAL REPORT No. 18 May 1988

Embrittlement of Steel Plates and Forgings and Their Weldments by Neutron Irradiation*

Synopsis:

The change in mechanical properties of heavy section

Lower temperature between the values calculated by the following equations:

$$RT_{PTS} = I + M + \Delta RT_{NDT} \cdots\cdots\cdots (3a)$$

$$RT_{\quad} = I + M + 156f^{0.194} \cdots\cdots\cdots (3b)$$

ferrite[12, 13].

As mentioned above, the sensitivity of steels to neutron irradiation embrittlement strongly depends on chemical composition and metallurgical structure.

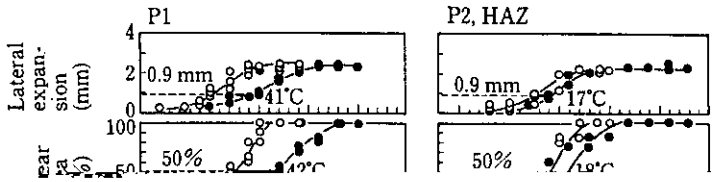
Table 2 Mechanical properties

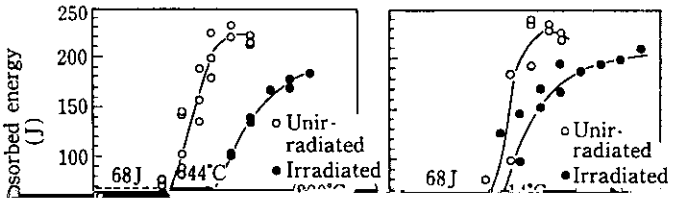
irradiation.

When fracture was elastic, fracture toughness K_Q was

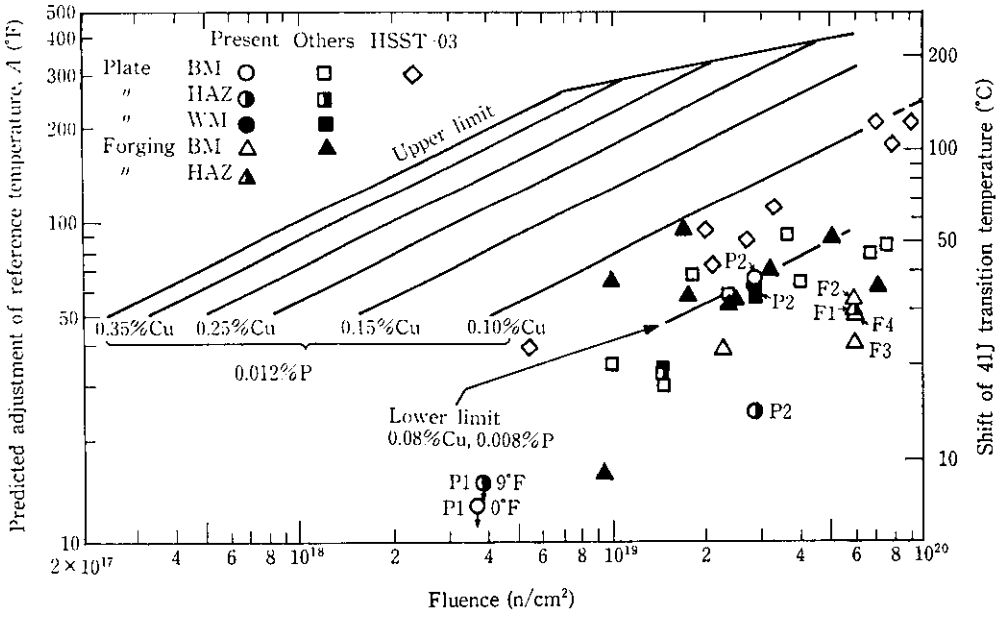
Table 5 Effect of neutron irradiation on tensile test results

Steel	Test temperature	YS (MPa)		TS (MPa)		El (%)	
		Irradiation	Difference	Irradiation	Difference	Irradiation	Diff


P1
P2, HAZ
Lateral expansion (mm)
4
2
0
0.9 mm
41°C
17°C
100
50%
50%

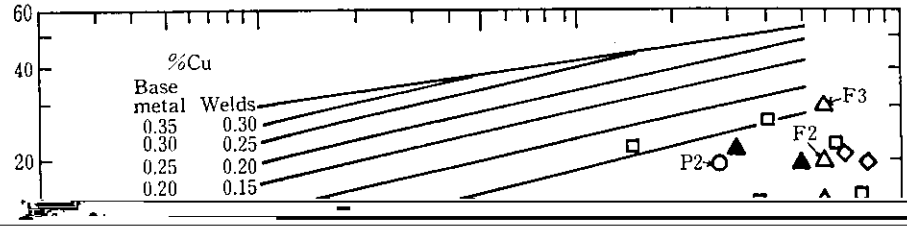

sorbed energy (J)
250
200
150
100
68 J
44°C
Unir-radiated
Irradiated
68 J
Unir-radiated
Irradiated

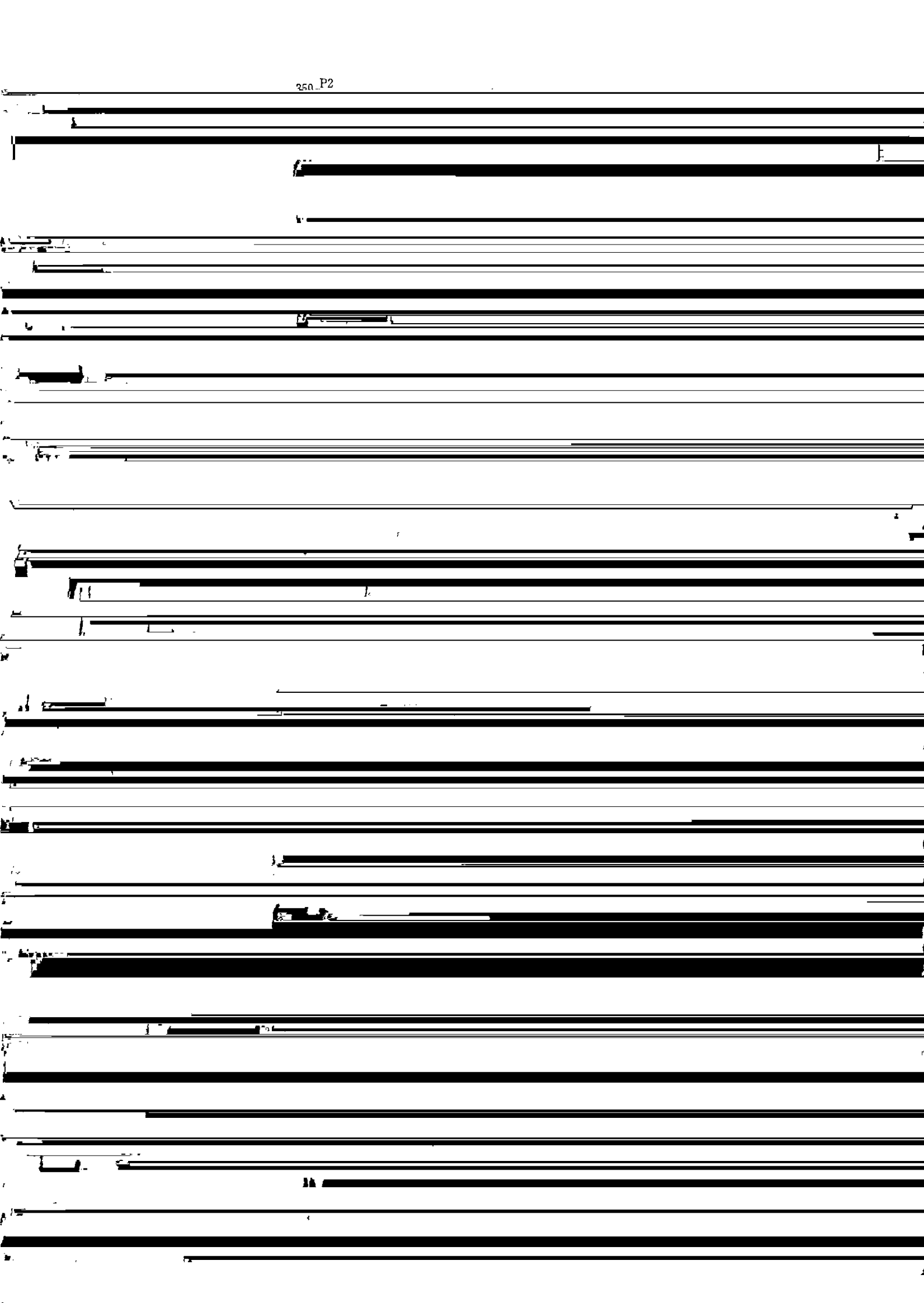
$$A = [40 + 1\,000\,(\%Cu - 0.08) + 5\,000\,(\%P - 0.008)]\,(f/10^{19})$$



shows not only the data of the steels tested in the present research, but also the data of the steels produced

Table 7 Experimental and estimated shifts of $_{v}T_{r41}$ induced by neutron irradiation


60
40
20
%Cu
Base metal
Welds
0.35
0.30
0.25
0.20
0.30
0.25
0.20
0.15
F3
F2
P2



temperature after neutron irradiation. According to JEAC4206[17] which specifies the method of verification tests of the fracture toughness for nuclear power plant components, the transition temperature after neutron irradiation must not exceed 93°C and the upper shelf energy must not be less than 68 J. In this study the plates, forgings and their welded joints gave the 41-J transition temperature below −10°C and the 100-MPa$\sqrt{m}$ transition temperature below −30°C after neutron irradiation whose fluence was either 3×10^{19}

lowest estimation given by NRC Regulatory Guide 1.99.

(8) The relation of ${}_vE = 67 \times \mathrm{LE} \pm 20$ stood between absorbed energy ${}_vE$(J) and lateral expansion LE(mm) not more than 1.5 mm.

(9) The shift of transition temperature for static fracture toughness $K(J_{IC}) = 100$ MPa$\sqrt{m}$ induced by neutron irradiation was as large as that of 41-J transition temperature.

(10) All of the plates, forgings and their welded joints