Material: Ferritic Steel: F82H

Property: Ultimate Tensile Stress, 0.2% Offset Yield Stress, Reduction of Area, Total Elongation

Data: Experimental

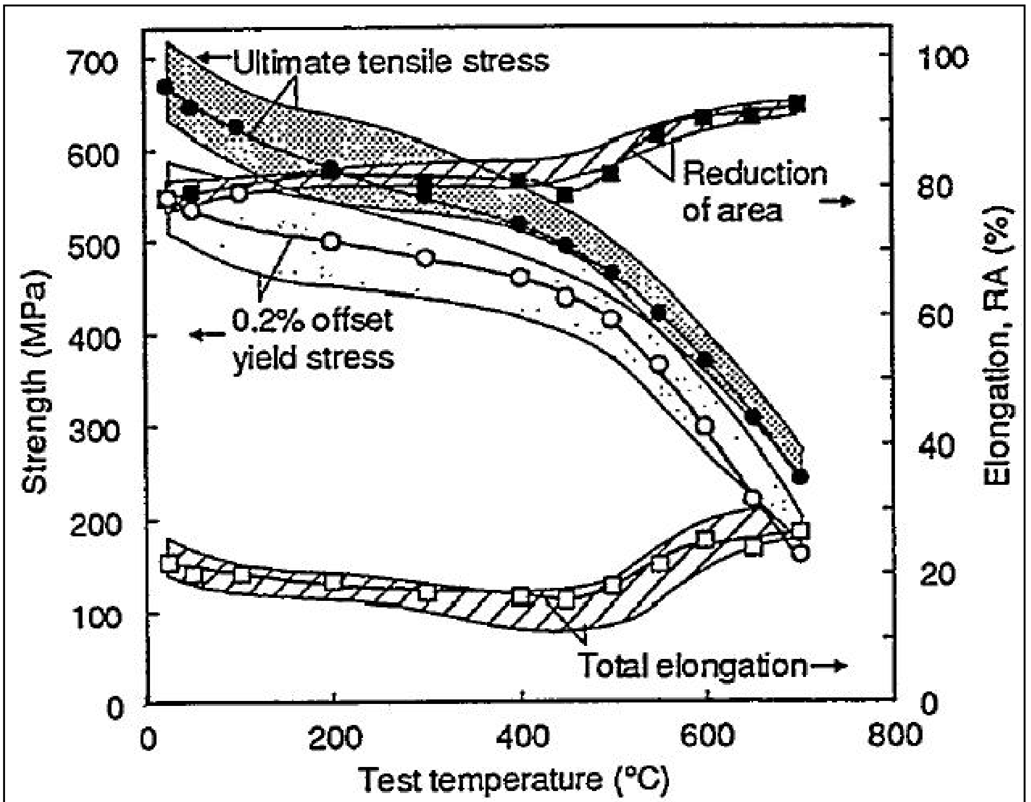
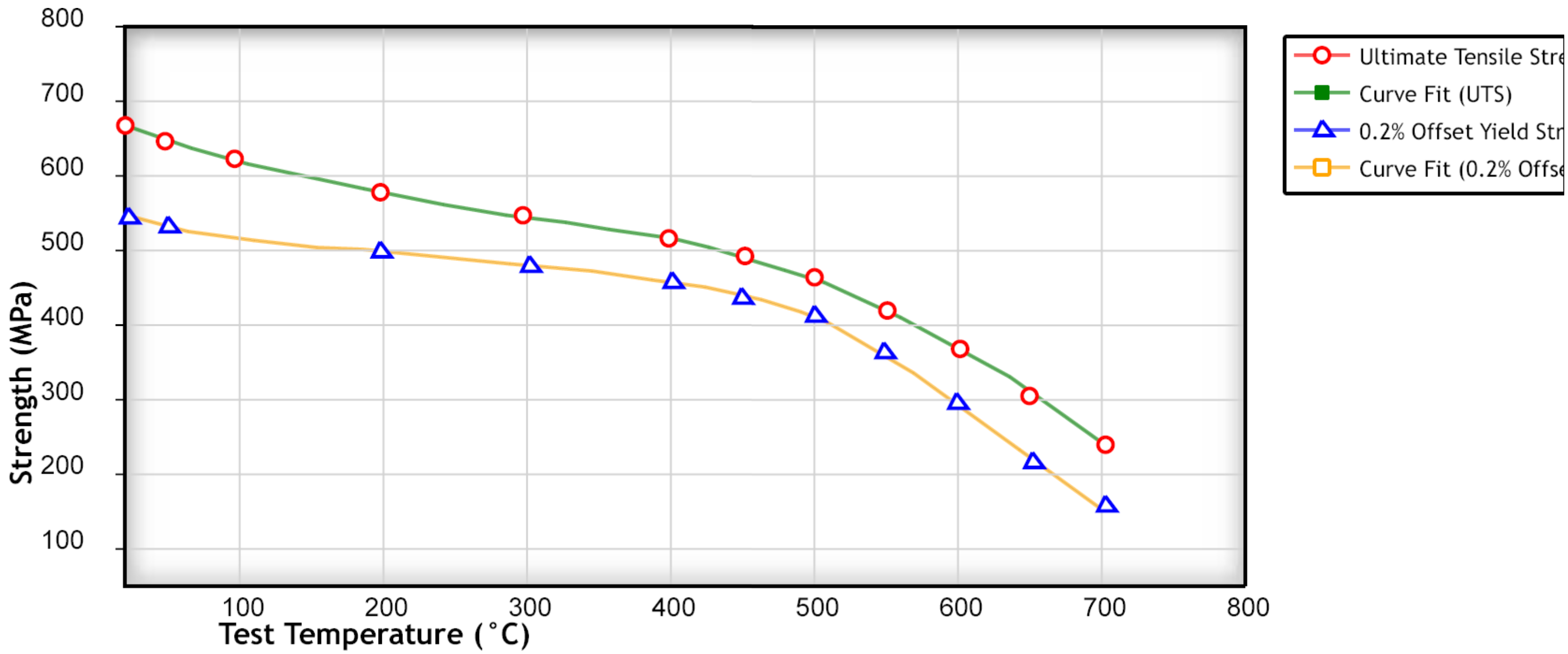


Fig. 5 Tensile properties of F82H IEA heat

Source:
Fusion Materials Semi-Annual Progress Reports 20 (June 30, 1996) 190-194

Title of paper (or report) this figure appeared in:
Preliminary Results of the Round-Robin Testing of F82H

Author of paper or graph:
K. Shiba, N. Yamanouchi, A. Tohyama



Tensile properties of F82H IEA heat (Figure 1 of 2).

Reference:

Author: *K. Shiba, N. Yamanouchi, A. Tohyama*
Title: *Preliminary Results of the Round-Robin Testing of F82H*
Source: *Fusion Materials Semi-Annual Progress Reports (June 30, 1996), Volume 20, Page 190-194*, [PDF]

View Data
Author Comments

Plot Format:

Y-Scale: ◉ linear ○ log ○ ln
X-Scale: ◉ linear ○ log ○ ln

Update Close Window

PRELIMINARY RESULTS OF THE ROUND-ROBIN TESTING OF F82H --- K. Shiba, N. Yamanouchi [Japan Atomic Energy Research Institute (JAERI)] and A. Tohyama [Nippon Kohkan Co. (NKK)]

OBJECTIVE

The IEA round-robin tests for the accumulation of the basic properties of the low activation ferritic steels are in progress under the international corporation. Preliminary results of a reduced activation martensitic steel F82H IEA obtained in this round-robin tests are reviewed in this report.

SUMMARY

Preliminary results of metallurgical, physical and mechanical properties of low activation ferritic steel F82H (IEA heat) were obtained in the round-robin test in Japan.

The properties of IEA heat F82H were almost the same as the original F82H.

PROGRESS AND STATUS

The basic property tests of a low activation martensitic steel F82H is in progress by IEA international corporation now. The irradiation experiment of this steel is included in the Japan/US collaborative program on the fusion reactor materials, either. Some data obtained from the Japanese round-robin test program are reported in this report.

EXPERIMENTAL PROCEDURE

The alloy investigated was a low activation martensitic steel F82H (8Cr-2WVTa) This steel was prepared for the reference material for the IEA international collaborative research on the low activation ferritic/martensitic steels, hereafter, this alloy is called as F82H IEA heat to distinguish from the original F82H. The plates used for the tests are listed in Table 1 and the chemical composition of these plates are shown in table 2. These alloys were normalized at 1040°C for 1 h, then tempered at 720°C.

Table 1 The plate IDs

Alloy ID	Plate IDs	Thickness (mm)
RB801-5	5-3, 5-14, 5-16	7.5
KG819-2	2w-10, 2w-23	15
KG820-2	42w-18	25

Table 2 Chemical composition of F82H materials (IEA heat)

Alloy ID	Elements (mass%)[1]								
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo
RB801-1	0.09	0.11	0.16	0.002	0.002	0.01	0.02	7.70	0.003
KG819-2	0.09	0.07	0.1	0.003	0.001	0.01	0.02	7.87	0.003
KG820-2	0.09	0.07	0.1	0.003	0.001	0.01	0.02	7.84	0.003

Alloy ID	Elements (mass%)[1]								
	V	Nb	B	T.N	Sol. Al	Co	Ti	Ta	W
RB801-1	0.16	0.0001	0.0002	0.006	0.003	0.005	0.01	0.02	1.94
KG819-2	0.19	0.0002	0.0002	0.006	0.001	0.003	0.004	0.04	1.98
KG820-2	0.19	0.0002	0.0002	0.007	0.001	0.003	0.004	0.04	1.98

1) Ladle analysis results

Metallurgical Tests

The specimens (50 x 30 x t mm) were fabricated from the 7.5, 15, 25 mm plates (5-14, 2w-23, 42w-18) were polished and etched (Ethanol 100 : Hydrochloric acid 5 : Picric acid 1). Non-metallic inclusions were tested according to the ASTM E45-87 "Standard Practice for Determining the Inclusion contest of Steel". The hardness of the micro structure specimens were also tested with Vickers' hardness test machine. The test load was 10 kgf (98 N).

Physical properties Measurements

Specific heat

Specific heat of the specimen (ϕ14 x 30L mm) fabricated from a 15 mm plate (2w-10) were measured in the temperatures between room temperature and 800°C by the isothermal continuous measurement. The time (Δt) for the temperature increment ($\Delta\theta$) was measured in the isothermal condition.

Thermal expansion

Rod specimen (4 x 4 x 12 mm) machined from the 15 mm plate (2w-10) were used for the thermal expansion measurement in the temperatures between room temperature and 1000°C. The expansion of specimen was measured by the contacting rod. The expansion during the heating and cooling pass was obtained. The rates for heating and cooling were both 0.4°C/min.

Thermal conductivity

Disk specimens (ϕ10 x 2 mm) fabricated from the 15 mm plate (2w-10) were used for the thermal conductivity measurement in the temperatures between room temperature and 800°C by the laser flash method. The temperature of a specimen surface rises by the uniform heating of the another side. Thermal diffusion coefficient (α) is calculated with the following equation by the measured half-time (t) for the temperature saturation and the thermal conductivity is the product of α, specific heat (measured in this paper) and density (7.89 g/cm^2);

$$\alpha = 1.37\frac{L^2}{\pi^2 t} \qquad (1)$$

, where L is the specimen thickness

Young's modulus, modulus of rigidity and Poisson ratio

Young's modulus and modulus of rigidity were measured in the temperature ranging room temperature to 800°C using density measurement specimens (2w-10; ϕ16 x 10L mm) by ultrasonic method. The sound speed in the specimen was calculated from the interval of the multiple reflected echo of the signal emitted by the oscillator contacted to a specimen surface (parallel with the another surface) and specimen thickness. Young's modulus (E), modulus of rigidity (G) and Poisson ratio (ν) were calculated by the following equations;

$$E = \rho\frac{V_S{}^2(3V_C{}^2 - 4V_S{}^2)}{V_C{}^2 - V_S{}^2}, \quad G = \rho V_S{}^2, \quad \nu = (\frac{E}{2G}) - 1 \qquad (2)$$

, where

ρ: Density (7.89 g/cm^2)

Vc: Velocity of longitudinal wave (m/s)

Vs: Velocity of transverse wave (m/s)

Magnetic property

Disk Specimens (ϕ7 x 0.5t mm) were fabricated from 7.5 mm plate (5-3). Magnetic property measurements were carried out at temperatures of room temperature, 200, 300 and 400°C in air. Magnetic moment was measured by AC voltage produced by the cyclic movement of magnetized specimen in the secondary coil.

Mechanical Property Tests

The specimens machined from the 15 mm plate (2w-10) in parallel with the rolling direction were used for the high temperature tensile tests at temperatures ranging between room temperature and 700°C. Round bar tensile specimen (φ6 x 30 mm in gauge section) were tested with the strain rate of 1×10^{-4} s^{-1}.

The specimens fabricated from the 15 mm plate (2w-10) were used for the Charpy impact tests. Full size V-notched Charpy specimens (10 x 10 x 55 mm, V-notch: 45° x 2 (depth) x 0.25 (root radius) mm) were machined in parallel (L) and perpendicular (T) with the plate rolling direction. The specimens were tested at temperatures ranging between -100 and -20°C to obtain the ductile-brittle transition behavior.

RESULTS

Metallurgical Tests

The inclusion test results of each plates by ASTM method are listed in Table 3. The amount of the non-metallic inclusions are small and this steel can be said clean. The hardness of each plate were almost the same each other (Table 3) and the average hardness was about HV218. This value of the hardness is in the range of the same heat material measured by the several institutes in EU homogeneity test.

Physical properties

The specific heat, thermal expansion and thermal conductivity are shown in Figs. 1 and 2 as a function of test temperature with the data of the original F82H [1]. The immersion density measured at 20°C (7.87 g/cm^3) was used to calculate the thermal conductivity. These properties of the IEA heat material are almost the same as those of the original F82H previously measured. These properties changed discontinuously above 800°C. These phenomenon were due to the re-austenization (A_{C1}). Ehrlich, et.al. estimated A_{C1b} and A_{C1e} of F82H IEA heat were about 820°C and 910°C, respectively [2].

Young's modulus, modulus of rigidity and Poisson ratio are shown in Fig. 3. Both Young's modulus and modulus of rigidity decreased linearly with the test temperature from room temperature to 450°C, then decreased linearly with steeper slope at higher temperatures. Poisson ratio was constant to 500°C, then increased with temperature over the temperature corresponding the change in Young's modulus and modulus of rigidity. This temperature dependence was caused by the annealing of the martensite structure. The same temperature dependence was obtained by the hardness measurement at high temperature.

Table 3 Non-metallic inclusions in F82H IEA heat

Alloy ID	Plate ID	Thickness (mm)	Inclusion Types (ASTM)							
			A type		B type		C type		D type	
			T	H	T	H	T	H	T	H
RB801-5	5-14	7.5	1.0	0	1.5	0.5	0	0	1.0	0.5
KG819-2	2w-23	15	0	0	1.0	1.0	0	0	1.5	0.5
KG820-2	42w-18	25	0	0	1.5	0	0	0	1.0	0.5

Table 4 Vickers' hardness of F82H IEA heat

Alloy ID	Plate ID	Thickness (mm)	HV10			
			1	2	3	Average
RB801-5	5-14	7.5	216	222	220	219
KG819-2	2w-23	15	219	215	219	218
KG820-2	42w-18	25	213	218	214	215

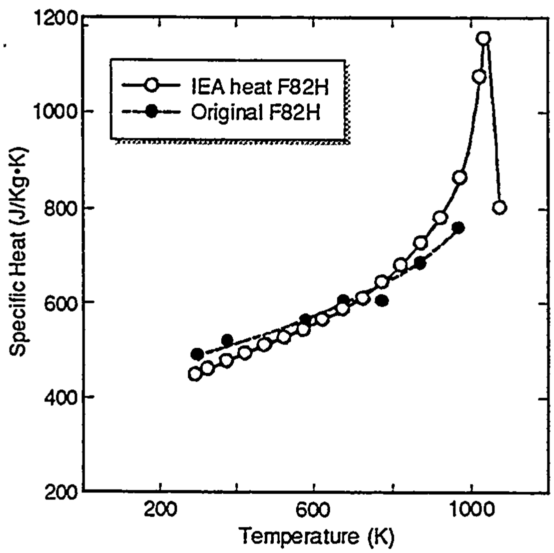


Fig. 1 Specific heat of F82H

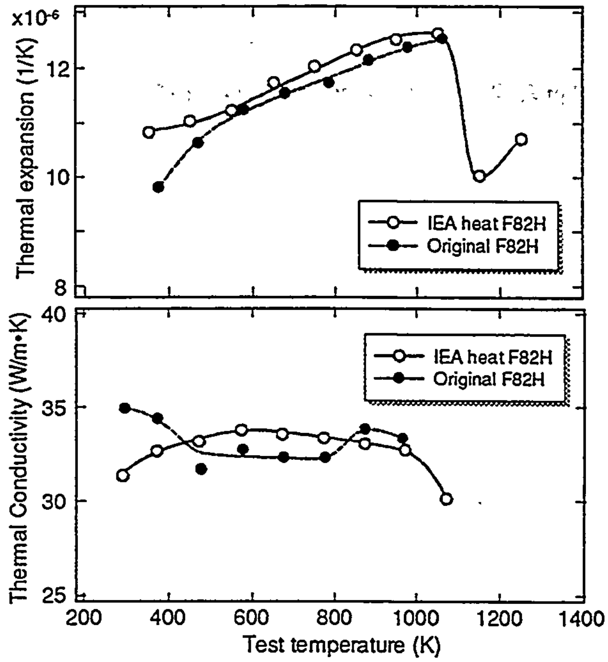


Fig. 2 Thermal expansion and Thermal conductivity of F82H

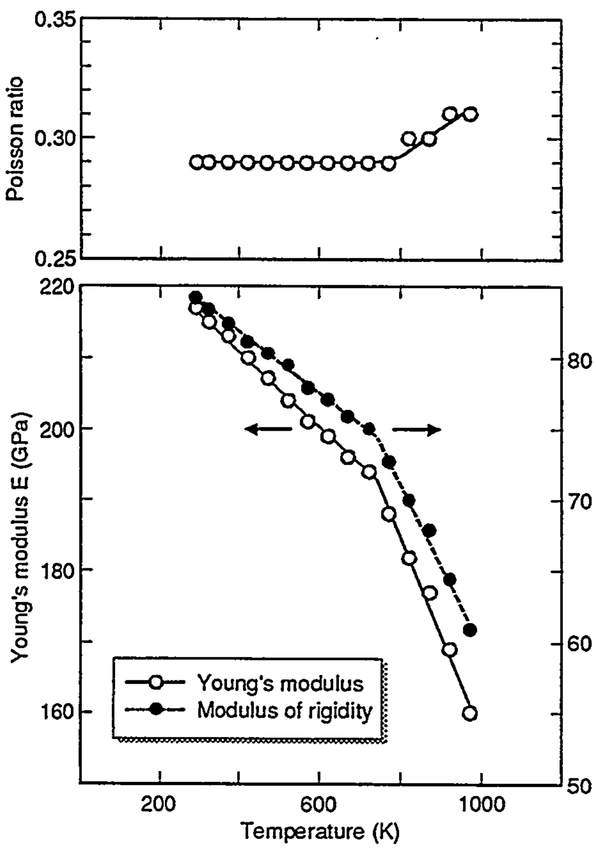


Fig. 3 Young's modulus, modulus of rigidity and Poisson ratio of F82H

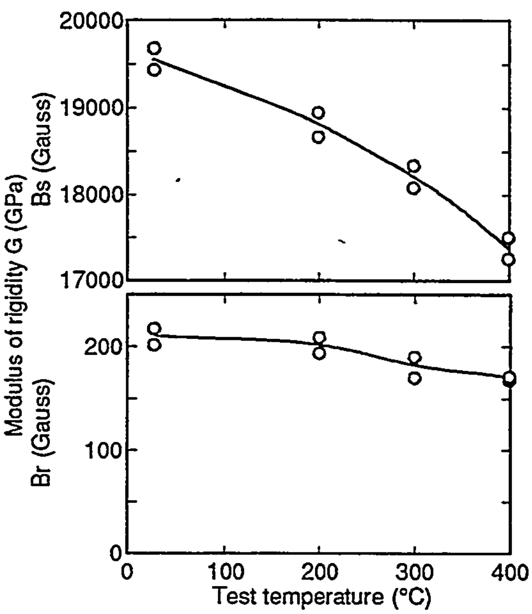


Fig. 4 Saturation and residual magnetization of F82H

Magnetic hysteresis loops were measured in the temperature ranging between room temperature and 400°C. The temperature dependence of the saturation and residual magnetization were plotted in Fig. 4. Saturation and residual magnetization were about 19500 and 200 Gauss at room temperature and both of them decreased with temperature increase.

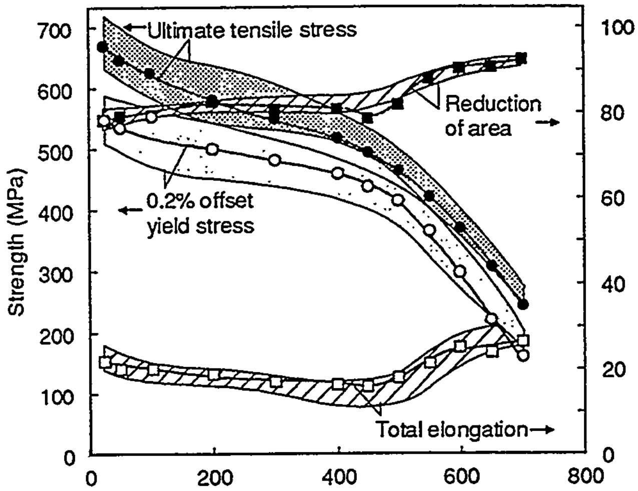


Fig. 5 Tensile properties of F82H IEA heat

Mechanical properties

The results of round bar tensile test are shown in Fig. 5. The hatched regions indicate the data band of the original F82H in this figure. The strength decreased with temperature increase and the ductility increased above 550°C.

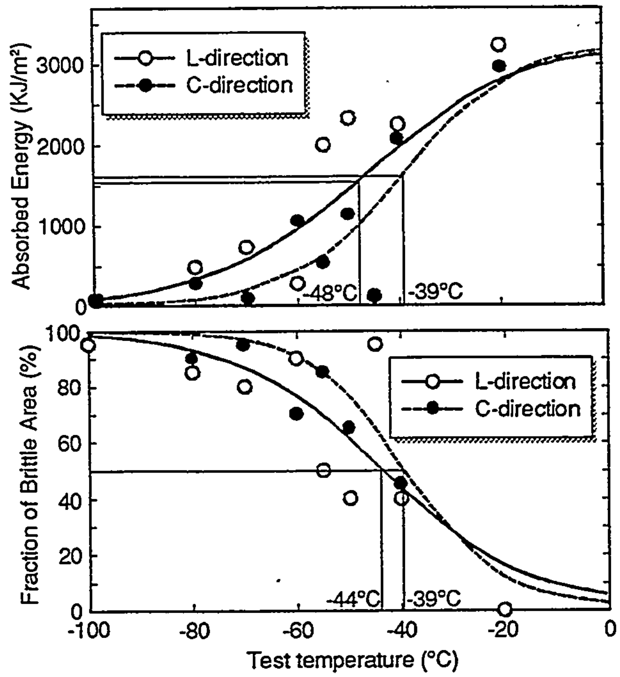


Fig. 6 Charpy impact test results of F82H IEA heat

The results of Charpy impact test are plotted in Fig. 6. The specimens were machined along the rolling direction (L-direction) and perpendicular with the rolling direction (C-direction). The curves in the figure were fit by hyperbolic arc tangent and the ductile-brittle transition temperatures (DBTT) were obtained from this fitting curve. The DBTT in the absorbed energy and the fracture surface area were -48°C and -44°C in L-direction, respectively. C-direction exhibited slightly higher DBTT than L-direction, but the difference in both direction was small (5 - 10°C).

FUTURE WORK

The testing of some other properties, such as fatigue and creep properties are in progress. The aging of base metal to 3000 and 5000 h in the temperature ranging 450 to 650°C have been completed and the testing are going on. The fabrication of the welded joints (TIG and EB welding) have been completed. The properties of welded joints will be available soon.

REFERENCE

[1] N. Yamanouchi, M. Tamura, H. Hayakawa, A. Hishinuma and T. Kondo, J. Nucl. Mater. 191-194 (1992) 822.

[2] R.L. Klueh, "Proceedings of the IEA Working Group Meeting on Ferritic/Martensitic Steels", ORNL/M-4939 (1995).