shows some results obtained earlier in this laboratory for cadmium of commercial purity. These latter specimens were 5 mm in diameter and their resistance was measured using a Kelvin double bridge. Only one point of this data is shown on Fig. 1. Other results obtained from this experiment indicate a linear behaviour to approximately 13 per cent elongation. The point on curve *D* represents the average data of eighteen 49-cadmium specimens. The deviation from the average value noted on the plot is insignificant.

It is interesting to note that the addition of slight amounts of copper has very little influence on the ρ versus ε curves over what is observed for high-purity cadmium. Additional impurities such as magnesium, at least at a concentration of 1,000 p.p.m., shows no effect. Lead, however, does affect the slope of these curves. As the lead concentration increases, the slope decreases from that observed for high-purity cadmium and then increases toward the high-purity slope as the lead concentration approaches 1,000 p.p.m.

The effect of other impurities such as silicon, iron, silver and aluminium is not very clear. Nevertheless, the 49-cadmium contains all these elements and does have the lowest ρ versus ε slope. Whether it is primarily the lead or these other elements which is influencing this behaviour must await further investigation.

It is recognized that impurities in copper and other metals influence defect formation such as stacking faults. It can be speculated that the behaviour noted in cadmium is associated with twin formation, stacking faults, dislocation multiplication, influence of impurities on preferred orientation, etc. Obviously, a more complete investigation is necessary to elucidate this phenomenon.

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Elevated Temperature Embrittlement induced in a 20 per cent Chromium : 25 per cent Nickel : Niobium Stabilized Austenitic Steel by Irradiation with Thermal Neutrons

IT has been known for some time that neutron irradiation at ambient temperatures produces increases in the proof and ultimate tensile stresses and reductions in ductility of austenitic steels in room temperature tensile tests[1]. These changes in properties result from the interaction of dislocations with the vacant lattice sites and interstitial atoms produced by fast neutron-atom collisions and are recovered on testing at temperatures of about 500° C due to annihilation of the point defects[2].

More recently it has been established that irradiation in a nuclear reactor also reduces the ductility of austenitic steels and austenitic type alloys at test temperatures above about 600° C. This high-temperature brittleness is manifested as decreases in the elongation and reduction of area values in post-irradiation uniaxial tensile tests[3], reduced strengths and elongations in post-irradiation stress rupture tests[4] and reductions in the circumferential elongations to fracture in 'in-pile' tube bursting tests[5].

The mechanism responsible for this type of embrittlement is being investigated in a double-vacuum-melted 20 per cent chromium : 25 per cent nickel : niobium stabilized steel, the analysis of which is given in Table 1.

Tensile specimens with a parallel gauge-length of 0·835 in. were die-stamped from a strip 1 in. wide and 0·0215 in. thick and heat-treated for 0·5 h at 1,050° C in pure argon followed by rapid cooling. The specimens were electropolished and individual batches were irradiated as follows: (1) at 40° C in the core of the *Herald* light-water moderated and cooled reactor; (2) at 135° in the 4VGR hole; (3) at 50° C in the 2V hole in the *Dido* heavy-water moderated and cooled reactor. Cobalt and nickel monitors were included with each batch of specimens to measure the thermal and fission neutron doses respectively. The specimens were afterwards tested at room temperature, 750° or 850° C at a strain rate of 2 × 10^{-4} sec^{-1} in a hard beam autographically recording dynamometer tensile machine operated remotely within a 4-ft. thick concrete cell; the elevated temperature tests were made in purified argon and the temperatures were stabilized for 0·5 h before commencing the tests. At least two specimens were tested in each condition and the mean results of the 750° and 850° C tests are given in Table 2.

Table 1. ANALYSIS OF STEEL

Element	C	Cr	Ni	Mo	Nb	Ti	Cu
Wt. %	0·025	20·7	24·85	0·013	0·7	0·008	0·003
Element	Sn	Mn	As	P	S	B	Pb
Wt. %	0·0025	0·67	0·001	0·003	0·01	0·0005	0·0015
Element	Ta	N					
Wt. %	0·03	0·008					

Table 2. ELEVATED TEMPERATURE TENSILE TEST RESULTS ON UNIRRADIATED AND IRRADIATED 20 PER CENT CHROMIUM : 25 PER CENT NICKEL: NIOBIUM STABILIZED AUSTENITIC STEEL

Irradiation facility	Neutron dose (n cm^{-2}) Thermal	Fission	Test temperature (° C)	0·2% Proof stress (lb./in.²)	Ultimate tensile stress (lb./in.²)	% Elongation
—	—	—	750	18,200	27,600	55·5
Herald	$7{\cdot}6 \times 10^{18}$	$3{\cdot}8 \times 10^{18}$	750	18,500	26,400	48·3
Dido 4VGR	$2{\cdot}2 \times 10^{19}$	$1{\cdot}9 \times 10^{16}$	750	16,400	27,200	29·1
Dido 2V	$1{\cdot}5 \times 10^{20}$	$7{\cdot}4 \times 10^{17}$	750	14,600	27,800	17·9
—	—	—	850	13,200	14,200	56·4
Herald	$7{\cdot}6 \times 10^{18}$	$3{\cdot}8 \times 10^{18}$	850	13,100	14,400	41·1
Dido 4VGR	$2{\cdot}2 \times 10^{19}$	$1{\cdot}9 \times 10^{16}$	850	14,600	15,800	38·6
Dido 2V	$1{\cdot}5 \times 10^{20}$	$7{\cdot}4 \times 10^{17}$	850	13,100	15,300	20·8

With the possible exception of the 0·2 per cent proof stresses of the samples tested at 750° C, the stress values are not significantly affected by the irradiation; however, the elongations to fracture are markedly reduced at both test temperatures. This elevated temperature embrittlement is a function of the thermal neutron dose and cannot be correlated with the fission (or fast) neutron dose. This is in contrast to the room temperature point defect hardening and embrittlement which is dependent on the fast neutron dose as shown in Table 3.

Table 3. ROOM TEMPERATURE TENSILE TEST RESULTS ON UNIRRADIATED AND IRRADIATED 20 PER CENT CHROMIUM : 25 PER CENT NICKEL : NIOBIUM STABILIZED AUSTENITIC STEEL

Irradiation facility	Irradiation dose (n cm^{-2}) Thermal	Fission	0·2% Proof stress (lb./in.²)	Ultimate tensile stress (lb./in.²)	% Elongation
—	—	—	30,700	76,800	48·2
Dido 4VGR	$2{\cdot}2 \times 10^{19}$	$1{\cdot}9 \times 10^{16}$	37,500	84,600	42·2
Dido 2V	$1{\cdot}9 \times 10^{20}$	$1{\cdot}7 \times 10^{18}$	48,100	84,700	30·2
Herald	$7{\cdot}6 \times 10^{18}$	$3{\cdot}8 \times 10^{18}$	54,500	89,000	31·6

Additional experiments are in progress to confirm these observations and to investigate the mechanism whereby the thermal neutrons are effective in causing the elevated temperature embrittlement of austenitic steels.

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