Southern California Edison Company

23 PARKER STREET

IRVINE, CALIFORNIA 92718

F. R. NANDY
MANAGER OF NUCLEAR LICENSING

TELEPHONE
(714) 587-5400

June 8, 1990

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Subject: Docket No. 50-206
Drawings and ASME Code Case for the
Thermal Shield Support System Replacement
San Onofre Nuclear Generating Station
Unit 1

The enclosures to this letter provide information regarding the proposed ASME code case (89-031), and the drawings for the thermal shield support system replacement. This information was requested by the NRC in the meeting of May 7, 1990.

Enclosure 1 provides a description of fatigue characteristics for austenitic stainless steels, a brief description of the proposed ASME code case (89-031) that would increase the stress intensity range requirement of Figure I-9.2.2 (Figure V-5 of Enclosure 1) of ASME Code Section III from 27.2 ksi to 44 ksi, and the proposed code case. The proposed code case (89-031) has been approved by the ASME Code Subcommittee on Fatigue during the ASME meetings held the week of May 14, 1990. The ASME Subcommittee on Design is expected to review the code case sometime in September 1990.

Enclosure 2 provides the drawings for the thermal shield replacement support system. As discussed in the May 7, 1990 meeting, the drawings provided by this submittal, though not final, will not change significantly when final drawings are issued and can be used to complete your review.

If you have any questions or desire further information, please let me know.

Very truly yours,

Enclosure

cc: J. B. Martin, Regional Administrator, NRC Region V
C. Caldwell, NRC Senior Resident Inspector, San Onofre
Units 1, 2 and 3

A001 1/1 Prop Drawings To: Reg Files

Fatigue Characteristics

Fatigue damage is a process of crack initiation and propagation. At a given strain range the influencing factors are load sequence, material variability, environment, surface finish, size and shape, and residual stress.

The austenitic stainless steels under cyclic strain experience strain hardening above their elastic limit but also cycle harden to increase their linear elastic limit. The cyclic-hardening record, V-1, for a T304SS illustrates the cyclic and strain hardening loop under increasing strain range. The linear elastic strain on unloading after a strain reversal is called the core stress and constant after several reversals. The value for annealed austenitics is about 60 ksi. Therefore, at a stress range of 60 ksi, the material shows shakedown with an alternating stress of ± 30 ksi even though the mean stress at the start is as high as 60 ksi, V-2. Above ± 30 ksi amplitude strain ratchetting will occur.

When the loading is stress controlled, V-3, the shakedown is shown for increasing initial mean stresses. The strain range for increasing mean stress and constant temperature will shakedown to an elastic range but at a higher mean strain. A particular design will have a strain limit governed by other requirements, V-3.

Under strain control the elastic follow up will return the strain to near the original strain, thus the initial mean strain will reduce in the cyclic shakedown process. Four cases are shown in V-4 to demonstrate that the core stress is always constant but that the strain range will determine the life or number of cycles to failure. The limit case, L, shows shakedown in one cycle.

Therefore for design, V-5, the range of Pl + Pb + Q should have been selected as twice the value of curve A at 10" or 48 ksi. Above this value strain ratchetting can occur and the design allowable moves down to curve B or C. For conservatism, the core stress has been reduced to 0.9 of the double value of curve A at 10^8 cycles, 44 ksi. This is the recommended value for the criterion for the design use of the code curves (Code Case 89-031).

In calculating the usage factor, the effect of the influencing factors must be considered. The design curve has been reduced from the data curve to cover these factors. The reduction factors are different at low numbers of cycles than those for high numbers because of the dominant mechanical damage (high inelastic strains) at failures for less than 10^3 cycles.

Environment can play a dominant role for larger number of cycles. Tests in pure and BWR water (Figures 1 and 2 attached) have shown larger effects in fatigue than air in the lives from 10^3 to 10^6 cycles. Above 10^6 cycles the effect is low in tests because of the small inelastic strain range where the surface remains intact.

The code reduction factors (2 or 20 on the mean failure curve) contain an allowance for the test environment of air. Thus if any other environment is active, the reduction factor of that environment should be accounted for, but the applied factor should take into consideration the factor for air already included in the design curve. The correction should be limited in the cycle range of 10^3 to 10^6 where this factor is dominant.

M. J. Manjoine

6/1/90

PROPOSED CODE CASE ON FATIGUE 89-031

Alternate limit on primary plus secondary stress intensity range permitted for austenitic stainless steel to use design fatigue Curve A in Figure I-9.2.2 Section III, Division 1.

Inquiry: When using the design fatigue curve on Figure I-9.2.2 for austenitic stainless steel is it permissible to limit the primary plus secondary stress intensity range excluding thermal bending to the elastic portion of the applicable cyclic stress-strain curve in lieu of meeting the specified value of 27.2 ksi?

Reply: It is permitted to use the minimum elastic limit of 44 ksi for austenitic stainless steel in the fatigue analysis in lieu of the specified value of 27.2 ksi to determine the acceptability of using design fatigue Curve A on Figure I-9.2.2. Keeping the primary plus secondary stress intensity range below this value of 44 ksi assures the fatigue analysis is independent of whether the applied loading is strain or load controlled.

Curve 691485-A

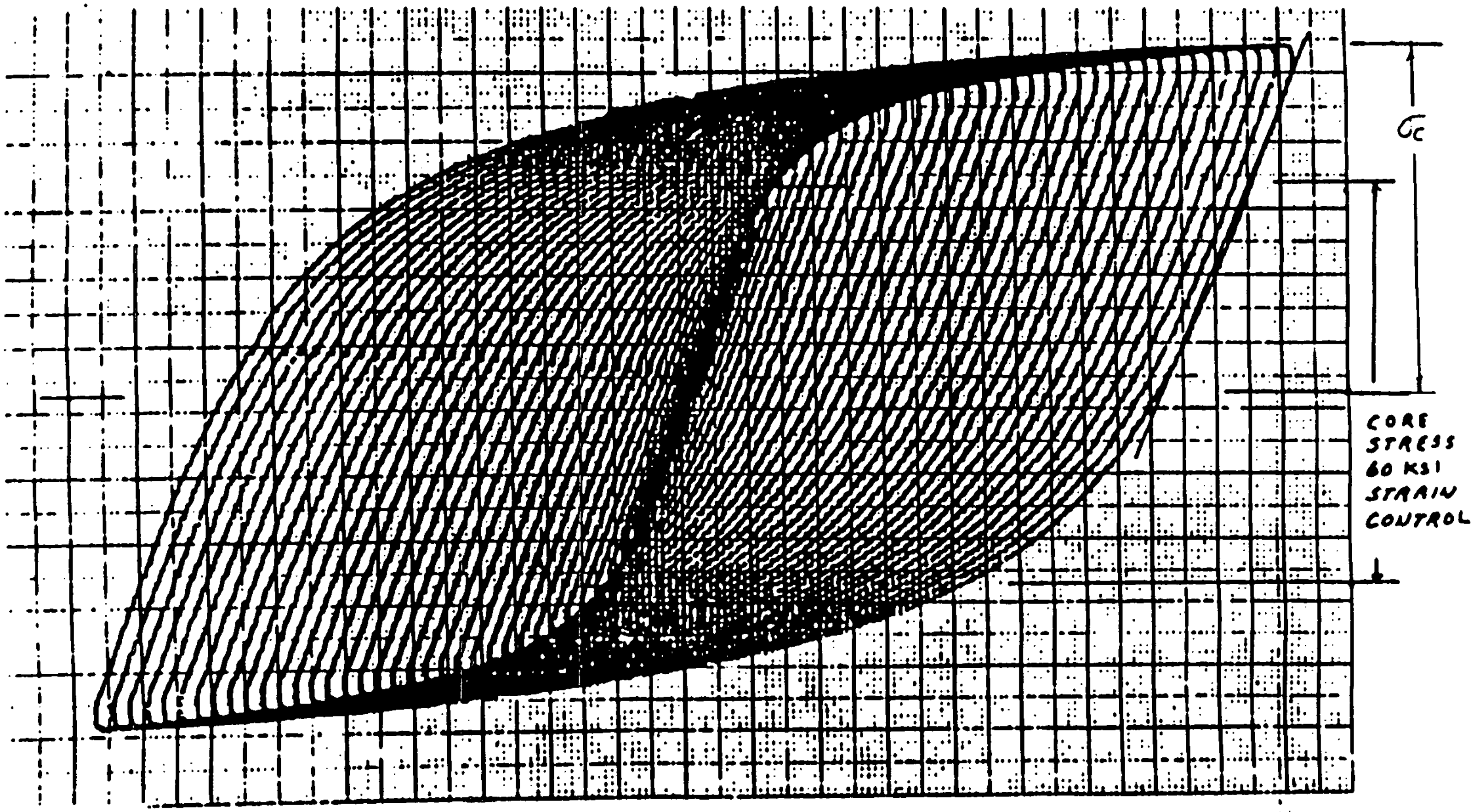


Fig. 2.3b – Cycle-hardening record, Specimen C12. Deflection from 1.00 in. (25.4 mm) clip-on extensometer. Decreasing strain   T 304SS σ_u = 86.7 KSI   RA = 79.4%

Figure V-1

MANJOINE
2-'88

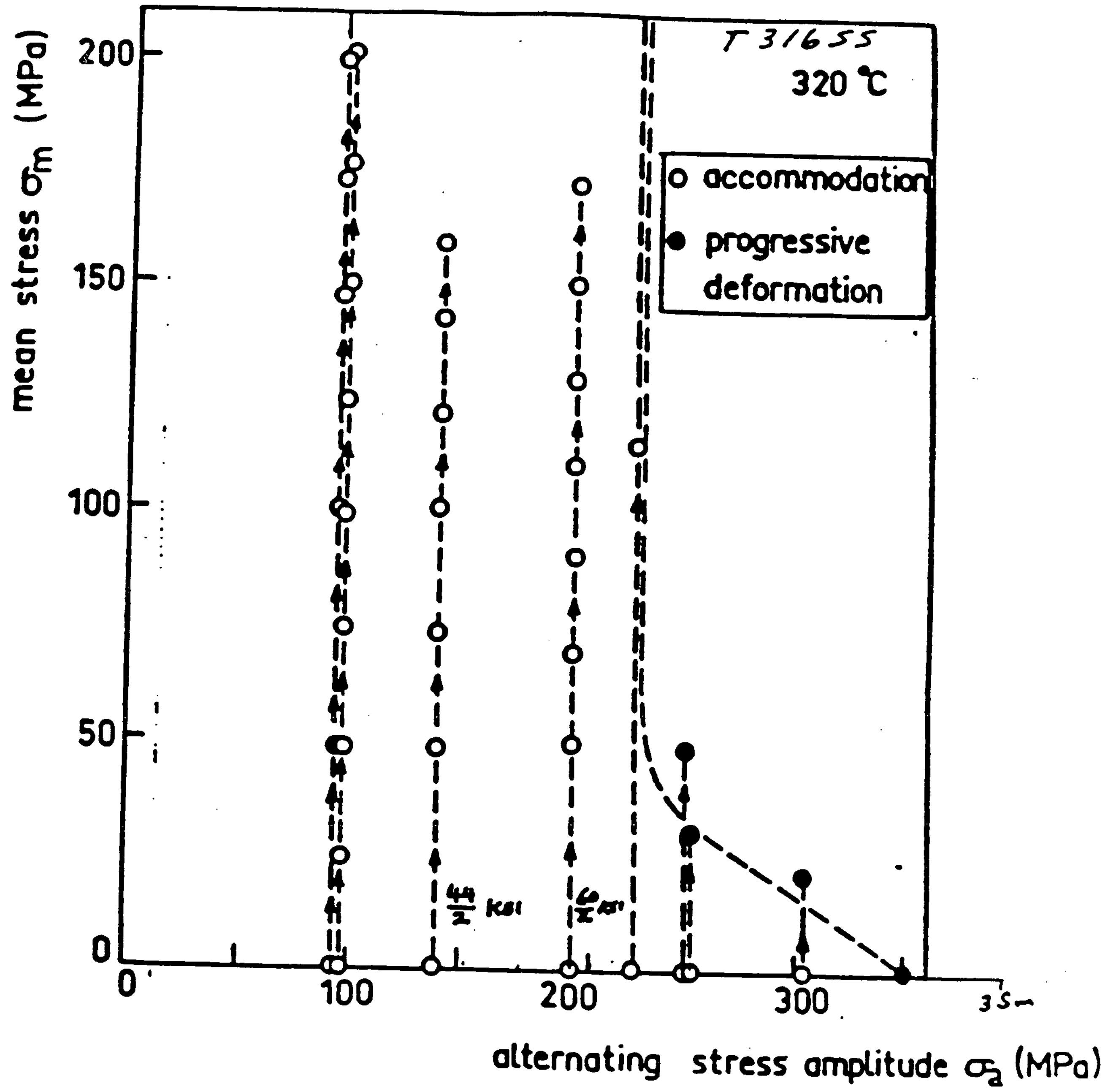


Fig. V-2- The progressive deformation threshold at 320° C

A. Pellissier-Tanon et al
1991

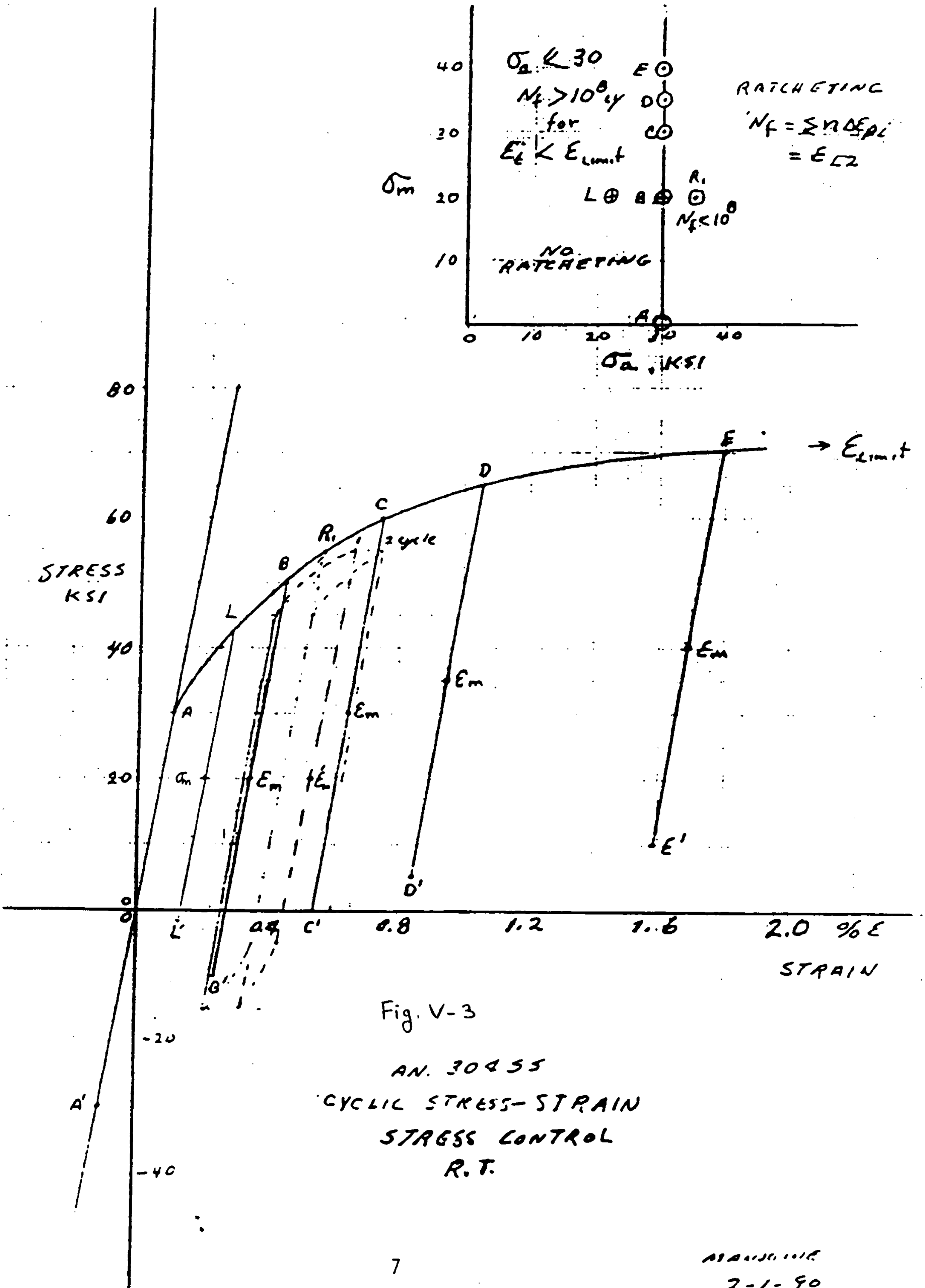
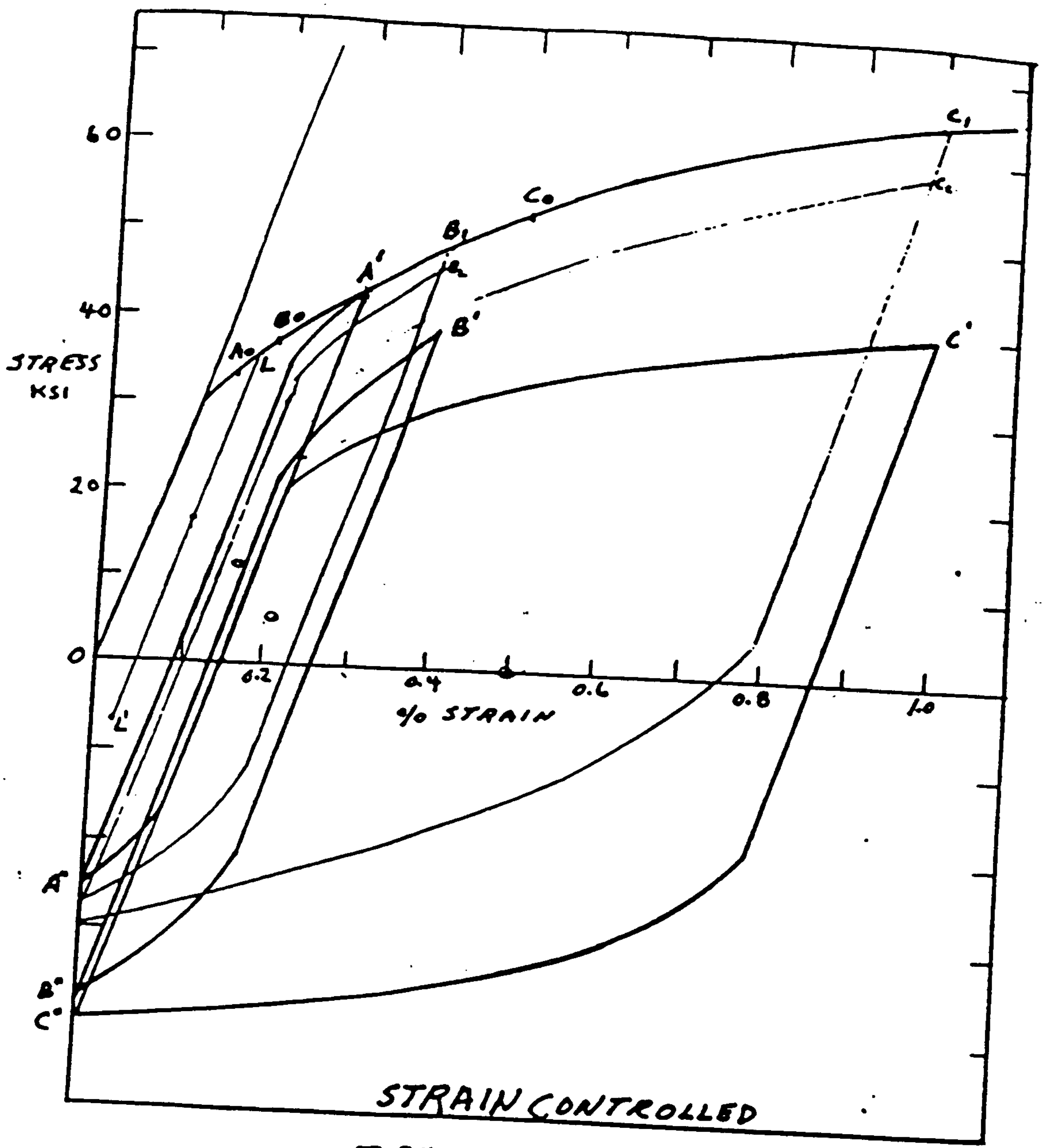


Fig. V-3

AN. 304SS
CYCLIC STRESS-STRAIN
STRESS CONTROL
R.T.

2-1-90



T 3XX STAINLESS STEELS

SHAKE DOWN

ITEM	% ε_m	% ε_a	$\Delta\varepsilon_t$	$+\sigma$	$-\sigma$ (KSI)	$\Delta\sigma$	CORE σ	N_f
A	0.15	0.15	0.30	43	25	68	60	$>10^8$
B	0.2	0.2	0.40	38	38	76	60	10^6
C	0.5	0.5	1.0	40	40	80	60	10^4
L	0.078	0.078	.156	34	10	44	60	$>10^8$

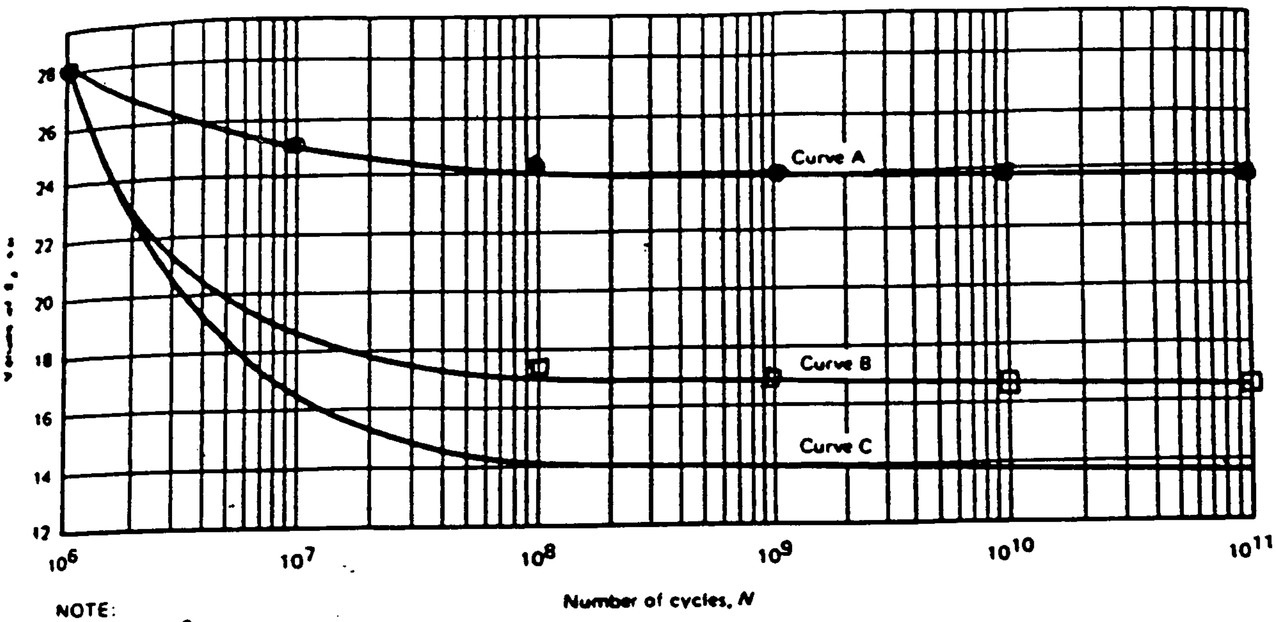
(RT to 800F) (E≈28.3E6, R.T. to 24.1)

Fig. V-4

An: T 3XX SS f. TEMPERATURES

● MJM 1990 EQNS. STRAIN CONTROL

□ " " " LOAD CONTROL



NOTE:
$E = 28.3 \times 10^6$ psi

Criteria for the Use of the Curves in This Figure[1,2,3,4]

Curve	Elastic Analysis of Material Other Than Welds and Heat Affected Zones	Elastic Analysis of Welds and Heat Affected Zones
A	$(P_L + P_b + Q)_{Range}$ < 44 ksi	...
B	...	$(P_L + P_b + Q)_{Range}$ < 44 ksi
C	$(P_L + P_b + Q)_{Range}$ > 44 ksi	$(P_L + P_b + Q)_{Range}$ > 44 ksi

NOTES:

(1) Range applies to the individual quantities P_L, P_b, and Q, and applies to the set of cycles under consideration.

(2) Thermal bending stresses resulting from axial and radial gradients are excluded from Q.

(3) Curve A is also to be used with inelastic analysis with $S_a = \frac{1}{2} \Delta \epsilon_t E$, where $\Delta \epsilon_t$ is the total effective strain range.

(4) The maximum effect of retained mean stress is included in curve C.

Fig. V-5

FIG. I-9.2.2 DESIGN FATIGUE CURVE FOR AUSTENITIC STEELS, NICKEL—CHROMIUM—IRON ALLOY, NICKEL—IRON—CHROMIUM ALLOY, AND NICKEL—COPPER ALLOY FOR $S_a \leq 28.2$ ksi, FOR TEMPERATURES NOT EXCEEDING 800°F

(For $S_a > 28.2$ ksi, use Fig. I-9.2.1.)

Table I-9.2.2 Contains Tabulated Values for Accurate Interpolation of This Curve

EFFECTS OF BWR WATER ENVIRONMENT ON FATIGUE STRENGTH OF AUSTENITIC STAINLESS STEELS AND NICKEL BASE ALLOYS

M. Higuchi *1

K. Iida *2

*1 Research Institute,
Ishikawajima-Harima Heavy Industries Co., Ltd.,
Isogo-ku, Yokohama City, Japan

*2 Professor Emeritus, University of Tokyo
Dept. of Mechanical Engineering,
Shibaura Institute of Technology,
Minato-ku, Tokyo, Japan

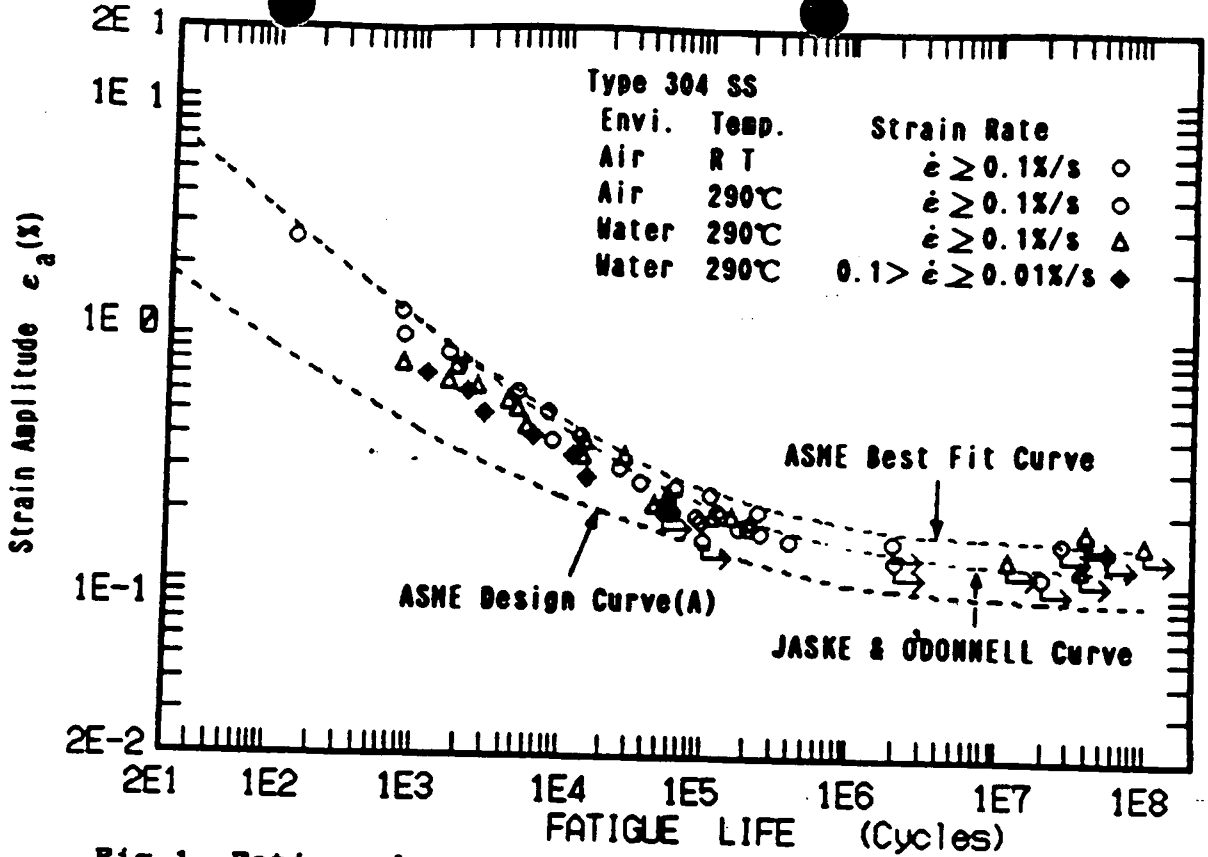


Fig.1 Fatigue data of type 304 stainless steel in air and simulated BWR water environment

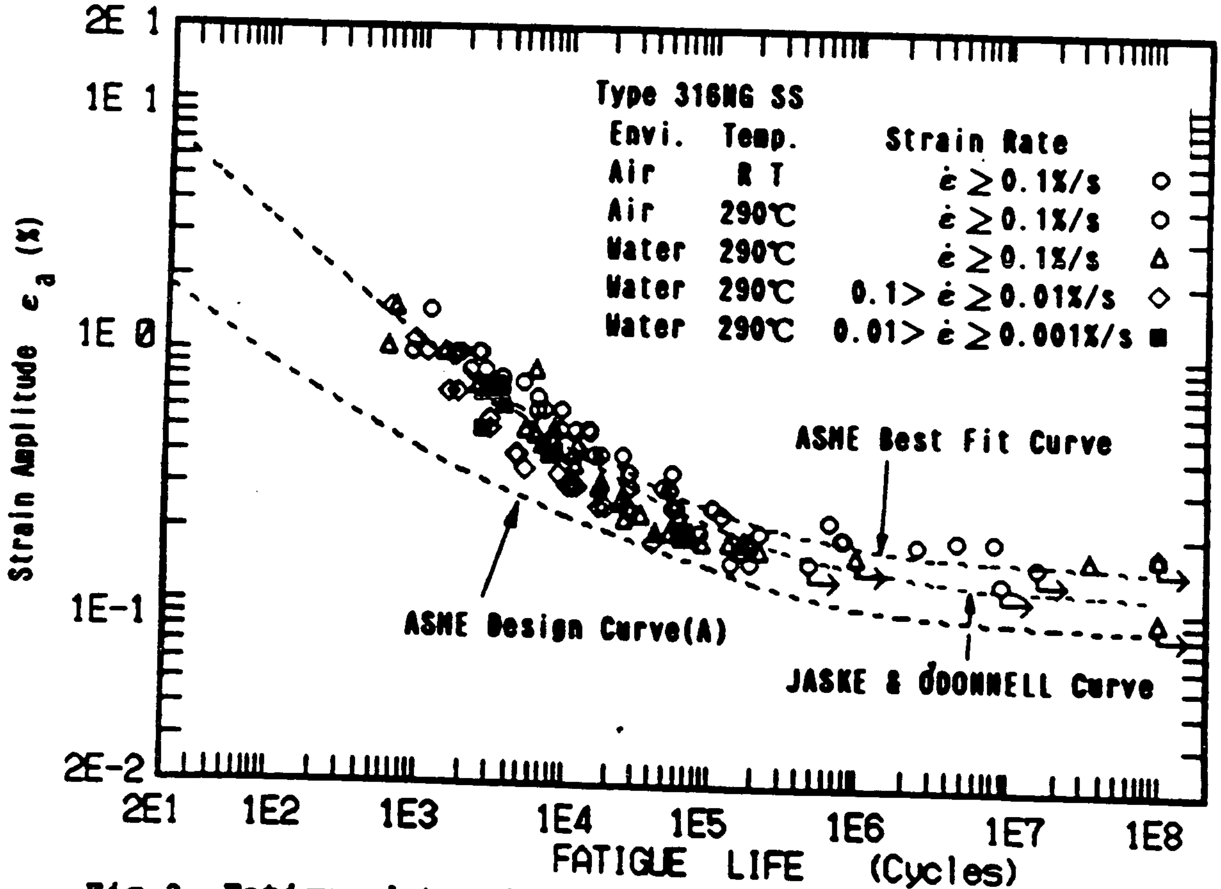


Fig.2 Fatigue data of type 316NG stainless steel in air and simulated BWR water environment

Higuchi, M & Iida, K.