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PRELIMINARY

NRC Research and Technical Assistance Report

Accession No. _____

Contract Program or Project Title: Environmentally Assisted Cracking in LWR Systems

Subject of this Document: Same as above.

Type of Document: Monthly Progress Report

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U.S. Nuclear Regulatory Commission
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PRELIMINARY

Monthly Progress Report

Contractor: Argonne National Laboratory

Program: Environmentally Assisted Cracking in LWR Systems

189a: A2212

B&R No: 60-19-11-05 (NRC)
40-10-01-06-1 (DOE)
8M443 (ANI

Reporting Period:
5/1/81 thru 5/31/81

Task Manager:
R. W. Weeks/W. J. Shack

Financial Summary

	Baseline	Actual	Monthly Variance	Cumulative Variance
Oct.-March	$ 421K	421K	-	-
April	129K	129K	-	-
May	135K	101K	34K	34K
June	148K			
July	160K			
August	160K			
Sept.	336K*			
FY 81 TOTAL	$ 1489K			

Variance: The level of effort required during construction and check-out of test facilities for this program has been somewhat less than anticipated due to delays in receiving parts. The effort is expected to increase as these facilities are brought on-line and become fully operational.

*Includes approximately $175K carryover into FY 82.

Administrative Report

Subcontracts are currently being negotiated for 1) the analysis of residual stress relaxation during cyclic loading of pipe weldments, and 2) for fabrication and testing of full-scale pipe weldments. In order to minimize costs, we are attempting to utilize sources with proven computer programs and existing pipe testing facilities.

An updated draft copy of the report "Environmentally Assisted Cracking in Light Water Reactors: Critical Issues and Recommended Research" was submitted to the NRC for final review on June 2, 1981.

The milestone progress charts included in this report include only major milestones for each Task. Additional minor milestones are included in the 189a.

Technical Progress

Subtask A: Leak Detection and NDE (D. S. Kupperman)

Stainless steel reflector insulation and a section of 10" 304SS schedule 80 piping has been received. The pipe is being prepared for integration into the leak detection system. Three field induced cracks, potentially leakers, are currently being tested using helium leak detection methods to determine if the cracks are through the wall. The through-wall crack samples will be welded into the SS pipe for leak detection studies. The design of the acoustic leak detection system is now finished. More welding has been completed on the 10 inch pipe run. Assembly of the control panel and associated piping and valves for the leak detection system has been initiated. A special calibration plate with artificial flaws of varying shape and orientation is currently being fabricated. The plate will be used with the three element transducer for ultrasonic scattering experiments.

Subtask B: Analysis of Sensitization (J. Y. Park)

EPR measurements were performed on Type 304 SS (Heat No. 30956) after a furnace heat treatment at 1050°C for 1/2 hr followed by water quench. No detectable sensitization was observed, as expected. CERT experiments were performed for three LTS-treated Types 304 (Heat No. 30956 and 10285) and 316NG (Heat No. P91576) specimens at a strain rate of $6 \times 10^{-7} s^{-1}$, in high purity water with 8 ppm oxygen at 288°C and 1200 psi. Type 304 SS specimens have failed intergranularly at 6% elongation. Type 316NG SS specimen has failed at 27% elongation, and the fracture surface was predominantly the dimpled type characteristic of ductile fracture.

Subtask C: Crack Growth Rate Studies (W. J. Shack)

The MTS system to be used for crack growth tests has been calibrated and a few modifications of the electronic control and measurement systems have been completed. Room temperature calibration of the crack opening displacement gage is completed, and the high temperature calibration of the gage has been initiated. The first set of Type 304 stainless steel IT compact test specimens is being fabricated.

Subtask D: Non-Environmental Corrective Actions

The construction of two new CERT stands is nearly completed, and we are ready to calibrate the systems. As-welded CERT specimens are being prepared from butt-welded samples of the 4-in. Type 304 stainless steel piping which will be used for later pipe tests as well as a Type 316 stainless steel plate weldment. Specimens are also being prepared for studies on the stress-strain-strain rate behavior of Type 304 stainless steel. Weldment samples have been received from Battelle PNL and the residual stresses associated with these weldments are now being characterized.

Subtask E: Evaluation of Environmental Corrective Actions (W. E. Ruther) and T. F. Kassner)

The tensile properties and metallography of as-received and solution annealed material, with and without the low-temperature sensitization heat treatment have been determined for the heat of Type 304 stainless steel purchased for this program. A decision on the appropriate heat treatment for the CERT and crack growth specimens will be based on these results as well as the EPR data for material with identical heat treatments.

Assembly of the water loop/autoclave system-II for crack growth measurements has been completed and electrical check-out and calibration of the MTS machine is proceeding. A leak occurred at the load-train seal during initial water pressurization, which necessitated slight modification of the seal in our machine shop. The system will be pressure tested again in several days.

Fabrication of the first group of CERT and 1-T crack growth specimens has been completed.

Subtask F: Mechanistic Studies (F. A. Nichols)

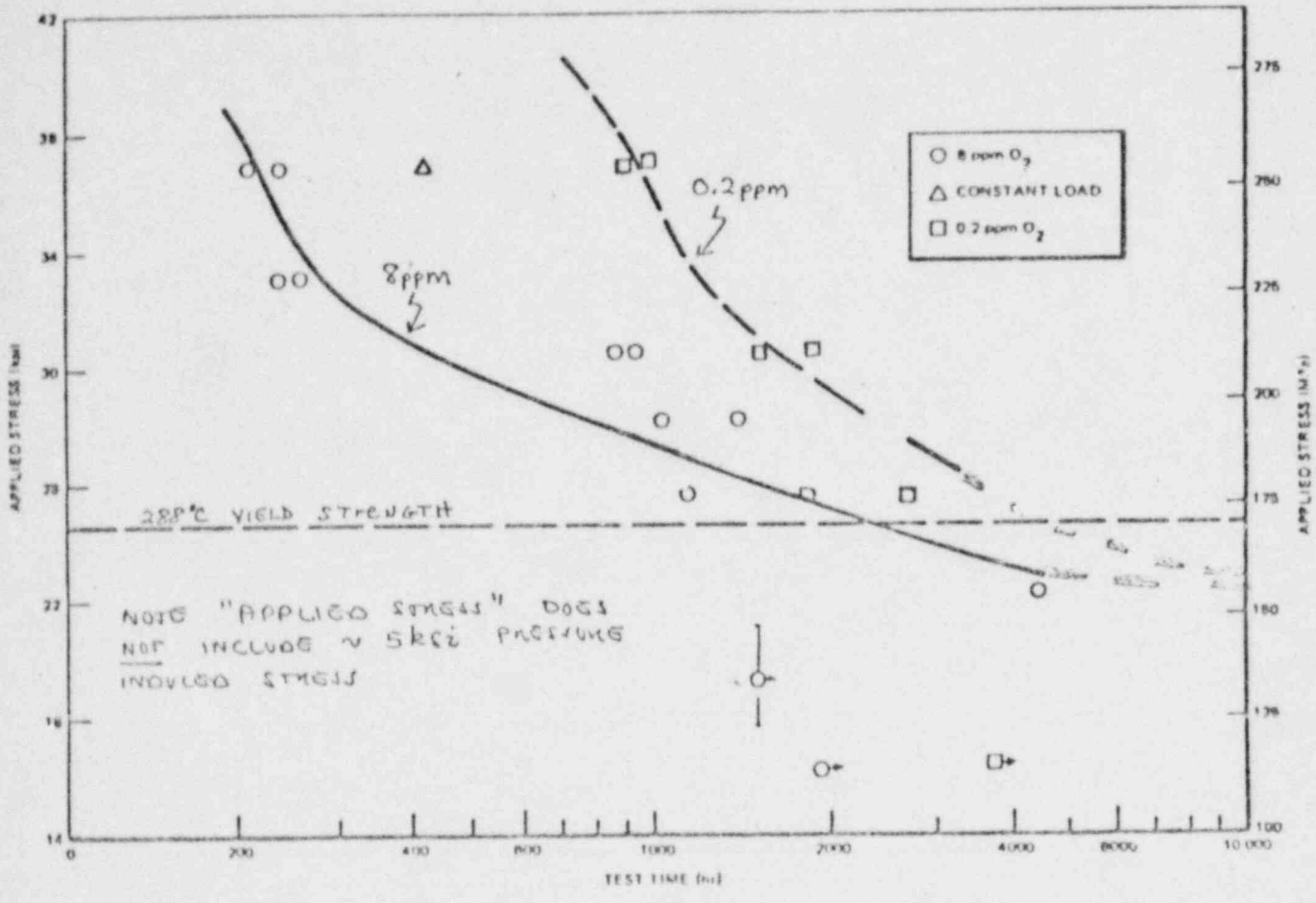
Several small autoclaves have been ordered for electrochemical measurements in BWR-quality water with various impurity additives. These should arrive next month.

Highlights from Related Non-NRC Programs

Current GE pipe test results ("Parametric Studies for Stress Corrosion in Type 304 Stainless Steel Pipe", NEDC-24187-4) show that the relative benefit from lower oxygen becomes less as the applied stress approaches the yield strength (see attached figure). This is an important result in its own right, but also because it shows that the margin of improvement for the remedy (lower oxygen) determined under pipe test conditions (applied stress = 1.36 σ_y) may be different than that applicable to another set of conditions (applied stress $\sim\sigma_y$).

Highlights from Related Non-NRC Programs

Data from the latest semiannual report on the "Investigation of Benefits of BWR Oxygen Control", SRD-80-130 show that deaeration appears to be beneficial to the inhibition of IGSCC in Type 304 stainless in the startup or shutdown mode in high purity water. However, addition of 1 ppm of sulfuric acid erased the benefits due to deaeration [Sulfuric acid is an expected product of resin decomposition and other EPRI work ("Evaluation of BWR Resin Intrusions on Stress Corrosion Cracking of Reactor Structural Materials", Battelle PNL) shows that the 1 ppm concentration is not unreasonable for a resin intrusion].



Effect of stress, cyclic rate, and oxygen on the time to failure of 4-inch schedule 80 Type 304 stainless steel pipe (heat #04836). This figure summarizes the status of this project as of February 1981. Note that the benefit of lower oxygen becomes less as the applied stress approaches the yield strength.

169A IDENTIFICATION NUMBER

TITLE
Environmentally Assisted Cracking in LWR Systems

SUB-TASK IDENT. NO. (A)	SUB-TASK TITLE	DATE
	Leak Detection and NDE	

MILESTONE / ACTIVITY IDENT	TITLE
A.	Review of acoustic leak detection work to date
B.	Define requirements for leak test system
C.	Design and fabricate pipe leak test system for acoustic leak characterization diagnostic experiments
D.	Test leak generation system and carry out preliminary experiments (on frequency spectra and cross correlation techniques) to determine effect of leak geometry, pressure and temperature on leak signature
G.	Establish requirements for field demonstration
J.	Develop and test ultrasonic testing concept for special probes
K.	Evaluate special probes for ultrasonic tests

FY 1980 | FY 1981 | FY 1982

O N D J F M A M J J A S | O N D J F M A M J J A S | O N D J F M A M J J A S

(Will begin in FY 83)

LEGEND: ▽ SCHEDULED ▼ COMPLETED ◇ ANTICIPATED SLIPPAGE ◆ ACTUAL SLIPPAGE

189A. IDENTIFICATION NUMBER

TITLE

Envivornmentally Assistec Cracking in LWR Systems

DATE

SUB-TASK IDENT. NO. (B)	SUB-TASK TITLE Analysis of Sensitization

MILESTONE / ACTIVITY IDENT	TITLE	FY 1980 O N D J F M A M J J A S	FY 1981 O N D J F M A M J J A S	FY 1982 O N D J F M A M J J A S	
C.	Effect of stress improvement remedies			a ▽ b ▽	1
	on LTS				2
	a. Heat sink welding				3
	b. Induction heating stress improvement				4
	c. Corrosion resistant cladding (Estimated completion FY 83)				5
				a ▽	6
D.	Effect of LTS on IGSCC susceptibility				7
	a. Preliminary results				8
	b. Long term test (Estimated completion FY 83)				9
				▽	10
E.	Evaluate and modify current EPR procedure for alternate materials				11
					12
					13
					14
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189A IDENTIFICATION NUMBER

TITLE

Environmentally Assisted Cracking in LWR Systems

SUB-TASK IDENT. NO.	SUB-TASK TITLE	DATE
(C)	Crack Growth Rate Studies	

MILESTONE / ACTIVITY IDENT	TITLE	FY 1980												FY 1981												FY 1982											
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
A.	Effect of Loading History																												▽									1
a.	Constant load tests																																					2
b.	Cyclic load tests																																					3
c.	Hold time tests																																					4
																																						5
B.	Effect of Specimen Geometry																																					6
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189A IDENTIFICATION NUMBER

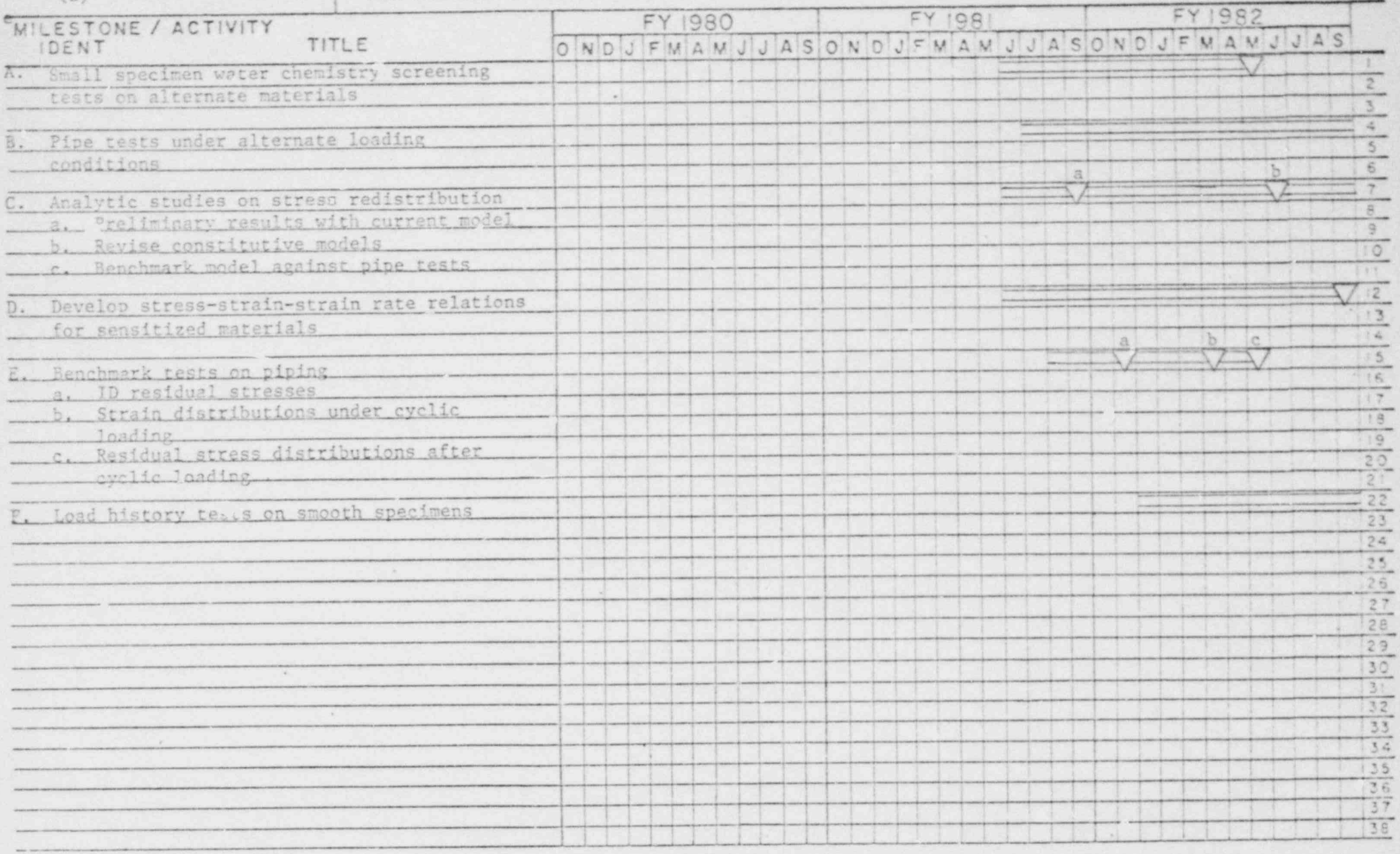
TITLE
Environmentally Assisted Cracking in LWR Systems

SUB-TASK IDENT. NO.
(D)

SUB-TASK TITLE
Non-Environmental Corrective Actions

DATE

MILESTONE / ACTIVITY IDENT	TITLE
A.	Small specimen water chemistry screening tests on alternate materials
B.	Pipe tests under alternate loading conditions
C.	Analytic studies on stress redistribution
a.	Preliminary results with current model
b.	Revise constitutive models
c.	Benchmark model against pipe tests
D.	Develop stress-strain-strain rate relations for sensitized materials
E.	Benchmark tests on piping
a.	ID residual stresses
b.	Strain distributions under cyclic loading
c.	Residual stress distributions after cyclic loading
F.	Load history tests on smooth specimens



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189A IDENTIFICATION NUMBER

TITLE
Environmentally Assisted Cracking in LWR Systems

DATE

SUB-TASK IDENT. NO. (E)	SUB-TASK TITLE Evaluation of Environmental Corrective Action

MILESTONE / ACTIVITY IDENT	TITLE
A.	Construct water loops for use with Instron (1) and MTS (2) loading systems
B.	Perform crack-growth measurements on sensitized Type 304 stainless steel as a function of load ratio, temperature, and oxygen concentration in high-purity water

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189A IDENTIFICATION NUMBER

TITLE

Environmentally Assisted Cracki · LWR Systems

SUB-TASK IDENT. NO. (F)

SUB-TASK TITLE

Mechanistic Studies

DATE

MILESTONE / ACTIVITY IDENT	TITLE	FY 1980 O N D J F M A M J J A S	FY 1981 O N D J F M A M J J A S	FY 1982 O N D J F M A M J J A S
A.	Review models for various microprocesses involved in the stress corrosion cracking of austenitic and ferritic steels in aqueous environments		▽	▼
B.	Assemble small refreshed autoclave systems for electrochemical measurements of passive film breakdown on stainless steels in simulated crack-tip solutions			▽

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