U.S. DEPARTMENT OF ENERGY

OCRWM

OGR

Nevada Nuclear Waste Storage Investigations PROJECT

Yucca Mountain

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS PROJECT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

MONTHLY REPORT

APRIL 1985

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PDR WASTE
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UNITED STATES DEPARTMENT OF ENERGY

NEVADA OPERATIONS OFFICE

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SUMMARY

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS PROJECT

APRIL 1985

KEY ACTIVITIES

WBS X.2.1, SYSTEMS

Parametric-modeling studies of the unsaturated- and saturated-flow systems at Yucca Mountain continued. A preprocessor is being developed for SAGUARO that will allow a user to easily and quickly change material properties and boundary conditions for rapid parametric assessment of the sensitivity of the unsaturated-flow system. The ISOQUAD groundwater-flow code was used to establish a reasonable steady-state potentiometric surface consistent with observed static water levels in the drillholes at and around Yucca Mountain.

Participants in the near-field hydrological problem calculated the saturation and thermal profiles for the modeled region that would exist at a steady-state without any external heat input.

WBS X.2.2, WASTE PACKAGE

The polarization behavior of three copper alloys is being investigated. For all alloys, in both J-13 water and its 100x concentrated form, the pitting potentials were greater than 200 mV removed (positive) from the corrosion potential.

A stainless steel canister from the Spent Fuel Test - Climax was examined to determine whether observable corrosion had occurred during the three years it was used to store a spent-fuel assembly. The examination showed no observable corrosion or cracking in weld regions or at an arc strike. This speaks well for the likely performance of 304L stainless steel in the tuff repository environment.

WBS X.2.3, SITE

The thermodynamic model for the analcime solid solution was revised. The model is consistent with calorimetric determination of the free energy of analcime, but constrains the free-energy difference between albite and analcime much more closely than is possible with calorimetric data. There is excellent agreement between the model and field observations reported in the literature.

Additional TRACR3D modeling of the Exploratory Shaft tracer experiment was completed. A comparison was made between diffusion in the Calico Hills and the Topopah Spring members and the effect of a vertical fracture in the rock was evaluated.

WBS X.2.4, REPOSITORY

Mechanical and physical properties were investigated of an aged sealing material sample that had been exposed to elevated temperatures to simulate the heat generated by a waste package. The results showed an increase in porosity, but the newly formed pores were an extremely fine size and will not enhance the permeability significantly.

Analytical calculations of the flow to a shaft from the alluvium were completed. Other calculations examined the time required for surface recharge to saturate a fault zone, leading to convergent flow to a drift.

WBS X.2.5, REGULATORY/INSTITUTIONAL

The NNWSI Site Characterization Plan (SCP) Management Plan was approved and issued. All participants began work on their sections of the SCP. Work began on the the Comment/Response Appendix to the Environmental Assessment.

WBS X.2.6, EXPLORATORY SHAFT

The Exploratory Shaft Test Plan (ESTP) Committee met to review available portions of the ESTP Rev.1.

Review was started of the revised design for the first shaft (ES-1) and stations at the 520- and 1200-ft depths. Review of design specifications was completed for the ES-2 shaft boring, liner shotcrete, hoist, headframe, cage, and hoist rope.

WBS X.2.7, TEST FACILITIES

Core-logging activities from the Spent Fuel Test - Climax (SFT-C) were completed with the determination of joint orientations in 70 m of core from instrumentation boreholes.

Post-processing of the results of three ADINA/ADINAT calculations of the thermomechanical response of the SFT-C is essentially complete. Preliminary analyses indicate that the elastic parameters and in situ stress values measured post-test provide somewhat better results than were obtained using pretest values.

The initial suite of seven post-test heat transfer calculations were completed that examined conductivity and heat capacitance of the rock mass, conductivity of materials lining the floors of the drifts, convection coefficients of the drift surfaces, and the ventilation flowrate. The level of agreement between measured and calculated temperatures (which was already very good) was improved substantially.

All E-MAD fuel assemblies are now stored in the Hot Bay lag storage pit with the exception of fuel assembly B02, which is in the Fuel Temperature Test assembly. The Metal Cask Simulation Test was completed.

WBS X.2.8, LAND ACQUISITION

No activity was reported this month.

WBS X.2.9, PROGRAM MANAGEMENT

The NNWSI Earned Value System Study proceeded as planned. An interim report was issued that provides a summary of requirements and assumptions and a strawman estimate of the proposed approach.

The final Project Plan was sent to DOE/NV for approval.

ESI has been requested to implement a QA Records Management pilot program at the USGS.

APRIL 1985

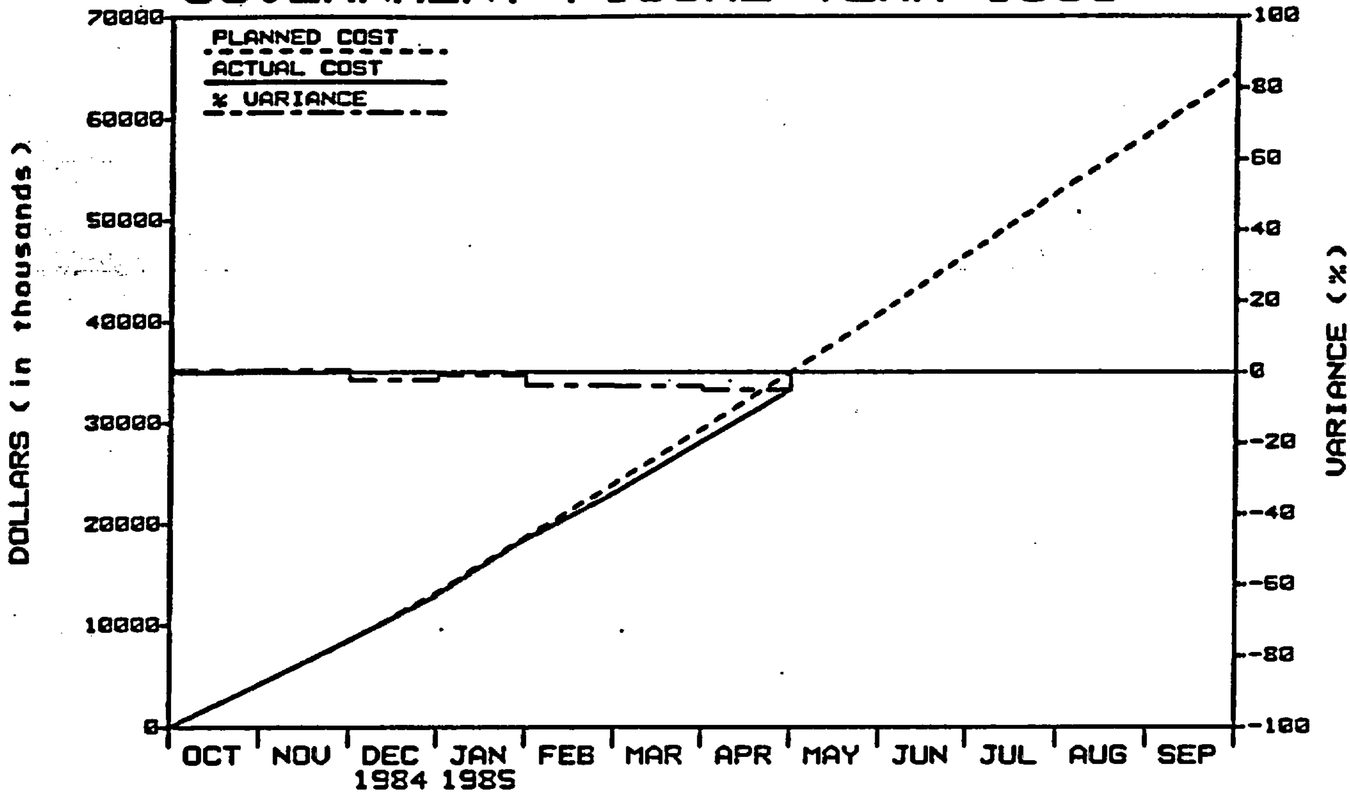
FUNDING OVERVIEW

The month-end programmatic estimated costs were $33,266,000 against a plan of $35,016,000 resulting in a cost underrun of $1,750,000 through the month of April. The total FY 85 budget for the NNWSI Project was $69,664,000 which breaks down to $64,390,000 in operating funds and $5,274,000 in Captial Equipment funds.

The following are the year-to-date plans, costs, and variances:

		PLAN	COST	VARIANCE
X.2.1	SYSTEMS	$ 2,164,000	$ 2,179,000	$ <15,000>
X.2.2	WASTE PACKAGE	3,157,000	2,799,000	358,000
X.2.3	SITE	10,393,000	9,939,000	454,000
X.2.4	REPOSITORY	6,374,000	5,876,000	498,000
X.2.5	REGULATORY/ INSTITUTIONAL	3,387,000	2,734,000	653,000
X.2.6	EXPLORATORY SHAFT	3,061,000	3,095,000	<34,000>
X.2.7	TEST FACILITIES	1,048,000	1,191,000	<143,000>
X.2.9	PROJECT MANAGEMENT	5,432,000	5,453,000	<21,000>
	TOTAL	$35,016,000	$33,266,000	$1,750,000

WBS X.2 NNWSI PROJECT
GOVERNMENT FISCAL YEAR 1985



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	4217	8482	13238	18656	23973	29355	35016	40740	46569	52623	58278	64390
COST (X1000)	4241	8543	12955	18478	23077	28203	33266	0	0	0	0	0
VARIANCE (X1000)	-24	-61	283	178	896	1152	1750	0	0	0	0	0
% VARIANCE	1	1	-2	-1	-4	-4	-5	0	0	0	0	0

NNWSI PLANNING AND SCHEDULING
BUDGET BASELINE

APRIL 1985

CONTRACTORS	($000) BEGINNING FUNDING	CHANGE	($000) ENDING FUNDING
SNL	$18,334	-	$18,334
LLNL	8,565	-	8,565
LANL	10,130	-	10,130
USGS	9,922	-	9,922
SAIC	7,775	-	7,775
REECo	4,424	184	4,608
H&N	753	-	753
F&S	1,212	-	1,212
WSI	200	-	200
PAN AM	50	-	50
STATE GRANT	1,883	16	1,899
MISCELLANEOUS	541	<11>	530
NTS ALLOCATION	412	-	412
RESERVE	200	<200>	-0-
SUBTOTAL	$64,401	<11>	$64,390
CAPITAL EQUIPMENT	5,074	200	5,274
TOTAL	$69,475	189	$69,664

U.S. DEPARTMENT OF ENERGY

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Nevada Nuclear Waste Storage Investigations PROJECT

YUCCA MOUNTAIN

PROJECT STATUS

X.2.1 SYSTEMS

OBJECTIVE

The objective of this task is to apply the concept of systems to the development and design of the repository, both the surface and subsurface facilities, and to the evaluation of the effectiveness of the geologic and hydrologic environment in isolating radionuclides.

ACTIVITIES

Systems Management and Integration

Proposed NNWSI Project systems-engineering procedures were discussed with WMPO staff in early April and with OGR at the OGR-SEMP workshop April 29-30, 1985. Review of the OGR Systems Engineering Management Plan (SEMP), coordination of an NNWSI Project-OGR SEMP review workshop, and coordination of NNWSI Project comments on the OGR SEMP are affecting progress on revision of the System Description.

On April 3-4, representatives of LANL, SAIC, WMPO, and SNL met in Las Vegas to discuss the preparation of the Performance Assessment Plan (PAP). After the participants had commented on the draft outline, the group began making revisions to it. Tentative writing assignments were made; SNL and LNLL staff agreed to provide nearly all of the draft material. Continuing revision of the PAP outline during April 1985 produced a decision to issue the document in two parts dealing separately with preclosure and postclosure assessments. This procedure will allow the two sections to be prepared without a necessity for intense coordination between the two separate groups of authors.

Cost Schedule

A search for updated software to be used in cost estimating for the repository is underway. Several prospective codes appear to be appropriate, including the fast estimating series developed by the DOE.

Tuff Data Base

The semiannual audit was completed of TUFFDB. The Quarterly Data Base Document 10 was completed which will include an additional section on calculated matrix porosities and hydraulic conductivities. This new addition is intended to demonstrate the capabilities of SYSTEM 2000. Work on the TUFFDB Interface continued on schedule.

The development of a "reference properties" data base was discussed. The concept of a "reference property" has been expanded to include design-related information and accepted ranges of values for a given property, where needed. A tentative list of such properties is being prepared.

"Version I of the Users Manual for the Tuff Data Base" (SAND84-1643) was published.

Computer Graphics

The GE CALMA system has been accepted and is now the primary system supporting the Interactive Graphics Information System. Active model data which have been supported on the APPLICON system are being transferred to the CALMA. After proper verification procedures, these models will be given product numbers which identify them as being resident on the CALMA graphics system.

Flow and Radionuclide Transport

A report entitled "Preliminary Bounds on the Expected Postclosure Performance of the Yucca Mountain Repository Site" (SAND84-1492) was published. This report provides a basis for concluding that the Yucca Mountain site will be able to comply with all regulatory requirements for expected postclosure conditions, assuming that current understanding about site conditions is not significantly changed by data gathered during future characterization activities.

A contractor report from Lawrence Berkeley Laboratory (LBL) entitled "Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured, Porous Tuff at Yucca Mountain" (SAND84-7202) was submitted for printing. The report presents a conceptual approach to modeling the effects of discrete fractures on water movement through the unsaturated zone at Yucca Mountain.

Parametric-modeling studies of the unsaturated and saturated flow systems at Yucca Mountain continued using two finite-element meshes digitized on the Interactive Graphics Information System during December 1984. Studies of the unsaturated zone progressed in the area of developing a preprocessing package for use with the finite-element code, SAGUARO. The preprocessor will allow a user to easily and quickly change the material properties and boundary conditions needed as input for the SAGUARO code. This, in turn, will allow the rapid parametric assessment of sensitivity of the unsaturated-flow system to various material properties and boundary conditions. The studies of saturated flow continued by performing runs of the ISOQUAD groundwater-flow code to establish a reasonable steady-state potentiometric surface consistent with observed static water levels in the drillholes at and around Yucca Mountain.

Radionuclide Source Term

Participants in the near-field hydrological problem calculated the saturation and thermal profiles for the modeled region that would exist at steady-state without any external heat input. While these profiles showed a similar trend, it was decided that the deviations were signficant enough between the various results that an even simpler problem needs to be solved, specifically, the geothermal temperature gradient based only on conduction. In this revised preliminary problem, the flow of water has been turned off. The full, thermally-driven problem will be solved only after these differences have been resolved. This activity will probably delay the next group meeting until mid-June 1985.

A copy of the one-dimensional, two-phase flow code, PETROS, that was developed at SNL, was delivered to LLNL. Both SNL and LLNL will use this code for performing the simpler calculations involving strongly heat-driven flow in the rock surrounding the waste package.

The report entitled "Effect of Water Flux on Uranium Dioxide Dissolution in a Potential Radioactive-Waste Repository in Tuff" (SAND84-1007) has completed the review process and is being prepared for printing.

Development and Certification of Computer Codes

A brief study to investigate the role of effective stress in the capacitance of partially-saturated rocks was completed using hydrologic data from Peters et al. (1984). The study, which is being reviewed, showed that changes in the capacitance coefficient as a function of capillary pressure of the tuff rocks at Yucca Mountain is dominated by changes in saturation, except at complete saturation and levels near residual saturation where solid deformation affects the liquid storage. Thus, solid deformation is expected to have minimal effect on flow calculations.

Work on the interactive driver for SAGUARO and FEMTRAN continued. A routine to accept strategy descriptions from the CALMA graphics system and generate zones of grid has been completed. The material-properties input routines have been formatted.

A one-dimensional infiltration problem has been defined for use in the HYDROCOIN benchmarking project. Results from the COVE3 vapor transport problem initiation run have been received and are being reviewed for consistency.

PLANNED WORK

Systems Management and Integration

A tentative schedule for writing the PAP was set; it calls for the authors to prepare precis of their sections by the end of May 1985 and to submit first drafts by the end of September 1985. The date of publication will coincide with the publication of the Site Characterization Plan in March 1986.

System Description

Revision of the System Description continued in April 1985 with emphasis on eliminating nonapplicable requirements and redundancies, improving readability, and improving consistency with the OGR document "Generic Requirements for a Mined Geologic Disposal System." The document will be revised and submitted to SNL management for review by June 1, 1985, and submited to WMPO for NNWSI Project baselining by June 30, 1985 (Milestone M120).

Flow and Radionuclide Transport

Work during May and June 1985 will focus on continued modeling of the movement of fluids through the Yucca Mountain site, based on the studies of the unsaturated and saturated zones. The finite-element mesh for the saturated zone will be assigned material properties and boundary conditions for continuing runs of the ISOQUAD groundwater-flow code. The preprocessor for the SAGUARO code will be further developed so that initial runs of SAGUARO can be made.

Radionuclide Releases from Total System

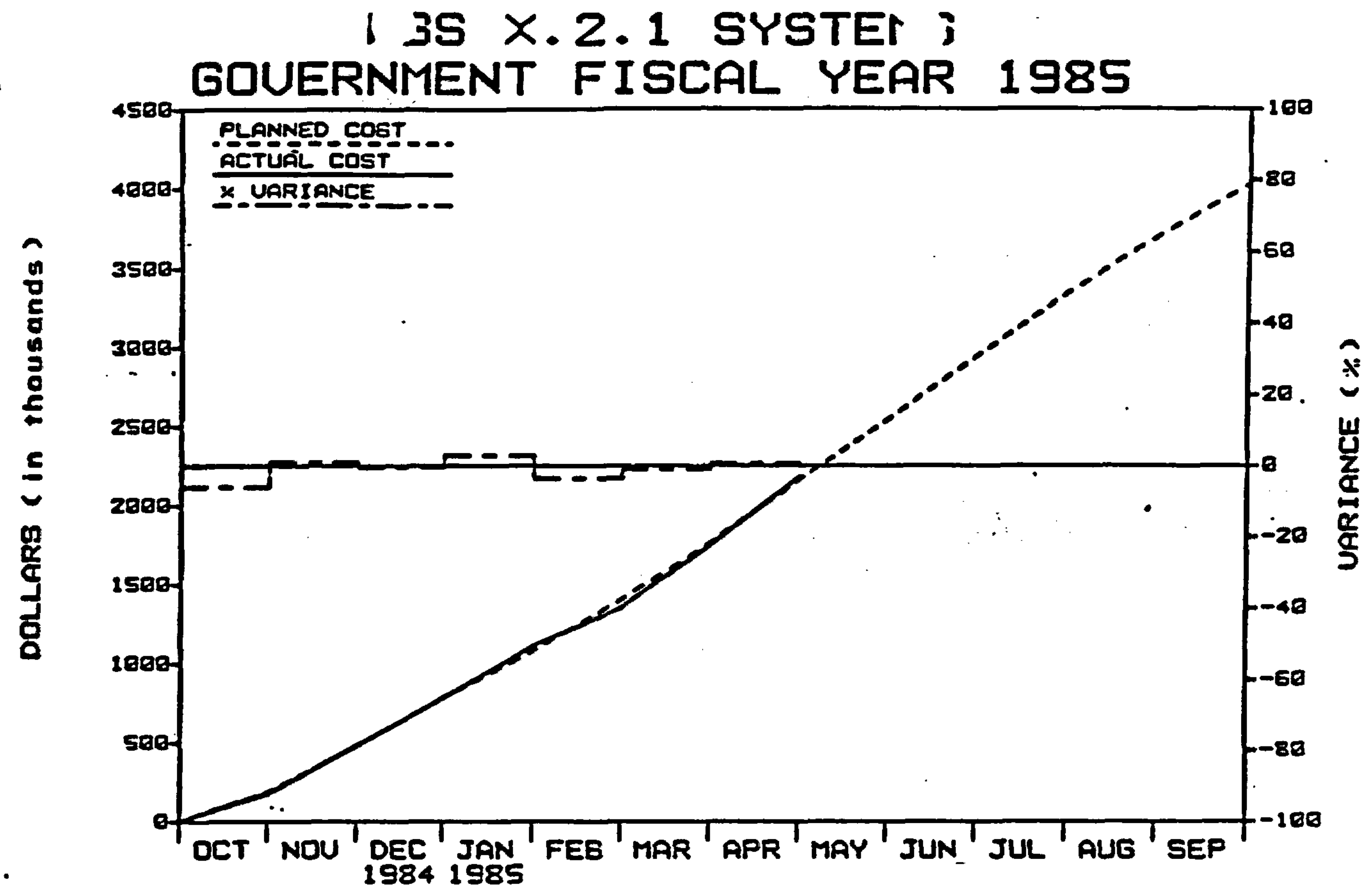
The paper entitled "The Effect of Percolation Rate on Water-Travel Time in Deep, Partially Saturated Zones" (SAND85-0854A) is complete and in peer review along with the paper entitled "Fluid Flow in Fractured Rock Masses" (SAND85-0855A). These papers are to be presented at a joint DOE/NRC meeting on hydrology to be held in Albuquerque, NM, on May 15, 1985.

PROBLEM AREAS

Radionuclide Source Term

The priority commitment of the staff to preparing the SCP, PAP, and System Description documents and potentially to the rewrite of the EA may soon result in more significant delays in meeting technical milestones.

Milestone M111, "The Effect of Heat and Excavation on Water Flow in the Vicinity of the Waste Package" will be rescheduled to March 30, 1986.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	185	477	786	1078	1401	1761	2164	2540	2941	3335	3690	4024
COST (X1000)	174	482	781	1108	1349	1741	2179	0	0	0	0	0
VARIANCE (X1000)	11	-5	5	-30	52	20	-15	0	0	0	0	0
% VARIANCE	-6	1	-1	3	-4	-1	1	0	0	0	0	0

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M120	SNL	1.2.1	YM Mined Geologic Disposal System Description (System Requirements)										△		
M108	SNL	1.2.1	System Engineering Management Plan											△	
M113	SNL	1.2.1	Performance Assessment Plan												△

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.2 WASTE PACKAGE

OBJECTIVE

The primary objective of this task is to develop a technical basis and engineering capability to design, test, and fabricate a waste package that is compatible with the hydrological conditions and geochemical environment in the unsaturated zone beneath Yucca Mountain.

ACTIVITIES

Waste-Package Environment

Work continued on the two long-term (303 day) core wafer tests (DB12 and DB13). Fluid analyses are complete and the data have been plotted. These tests were:

DB12 = USW G-1 core wafer, J-13 water, 90°C, plan 300 days, terminated normally at day 303.

DB13 = USW G-1 core wafer, J-13 water, 150°C, plan 300 days, terminated normally at day 303.

The trends in solution composition with time are in good agreement with those developed during the short-term (66 day) tests run under identical conditions (DB14 and DB8, respectively). The characterization by scanning electron microscope/electron microprobe (SEM/EMP) of the solid core wafers from these long-term tests continued.

Preliminary examination of secondary phases produced during the 303-day DB13 test at 150°C revealed that a calcium-rich, high-silica zeolite containing significant water was the dominant run product. The analyses of phenocrysts present on DB12 and DB13 continued this month prior to making an effort to remove them from the surface of the wafer for X-ray diffraction identification and determination of cell constants and to prepare a grain mount for quantitative analyses using the EMP.

During this month all SEM/EMP analyses were completed for core wafers from tests DB14, DB16, and DB17. These tests were:

DB14 = USW G-1 core wafer, J-13 water, 90°C, plan 64 days, terminated at day 49.

DB16 = USW G-1 polished wafer, distilled water, 150°C, plan 64 days, terminated normally at day 64.

DB17 = USW G-1 polished wafer, distilled water, 90°C, plan 64 days, terminated normally at day 64.

The results of phenocryst analyses are being plotted in histograms and ternary diagrams.

Sample characterization was begun for three Topopah Spring vitric tuff samples received from LANL. These samples are to be used in hydrothermal interaction tests run in the Dickson-type, gold-cell rocking autoclaves being done in conjunction with LANL to investigate the hydrothermal stability of vitric tuff from the Topopah Spring and underlying units. This cooperative research effort will complement previous field studies to evaluate the susceptibility of vitrophyre to thermal alteration by emplacement of HLW in Yucca Mountain.

The first two short-term tests in the Dickson bombs described above were started last month and one of them continued uneventfully. The other was terminated prematurely by the effects of a laboratory-wide power failure and accompanying voltage surge. The conditions for these tests are:

DB20 = USW G-4 1362' core wafer, J-13 water, 150°C, plan 64 days, currently at day 43.

DB21 = USW GU-3 1226' core wafer, J-13 water, 150°C, plan 64 days, terminated permanently at day 28.

In test DB20 samples were taken at days 16 and 32 during this month. In test DB21 a sample was taken at day 16 and the core wafer was recovered in the normal manner following shut-down. The DB21 test is not a total loss, since aqueous samples were taken on days 0, 1, 2, 4, 8, and 16 prior to failure. These will be a good check on reproducibility because the test was restarted April 20 and was named DB21R.

Technical reviews and WMPO policy review were all completed this month for the report on methods for evaluating the stability of emplacement holes in discontinuous rock. The report, which is entitled "Field Investigation of Keyblock Stability," develops techniques to assess the behavior of underground openings in three-dimensional cases where opening stability is controlled by rock mass structures such as joints. These techniques for evaluating stability complement rather than replace other excavation design approaches. The techniques are suitable for cylindrical openings such as waste package emplacement holes and are good approximations for certain other excavation geometries as well. The report has now gone to publication and distribution, which will take about six weeks.

Permeability was monitored on the large fractured sample of Topoaph Spring tuff to determine if the apparent fracture healing is continuing to affect transport properties of the rock. This rock has been under test since mid-December. Water permeability continued to decline but at a very slow rate. Permeability values now are about what would be expected of an intact sample.

Checkout of the two-phase permeability system continued. A water permeability measurement was made with the system on a fractured tuff sample. The gas flow system is now being tested.

The tests of the impedance camera have been completed. These results better define the strengths and weaknesses of the technique. A brief summary of results follows.

1. Both high conductivity and low conductivity linear anomalies can be detected.

2. Low conductivity linear anomalies are spatially resolved better than high conductivity anomalies of the same type.

3. Linear low conducting anomalies appear as arcs in the image.

4. Intersecting linear anomalies are moderately well resolved.

5. Resolution appears to be limited to about the size of the electric dipole.

6. The image plane appears to be about one dipole size in thickness.

The results indicate that the technique will be useful in the laboratory to characterize core and monitor processes within core during tests.

The following reports were sent to WMPO:

April 1 - "Report on the Reaction of Topopah Spring Tuff Cores USW G-1, USW GU-3, USW G-4, and UE-25h#1 with J-13 Water at 150°C"

April 9 - "Report on Geochemical Modeling of Topopah Spring Tuff and J-13 Water Reactions"

April 12 - "Report on Techniques for Stability Analysis of Emplacement Holes in Discontinuous Rock."

Waste-Form Testing

The second run tests using H. B. Robinson and Turkey Point PWR spent fuels in J-13 water continued on schedule. Analyses of the second run 20-day samples were completed and analyses of the 70-day samples are in progress. Two papers were issued recently that summarize the results from the first run of these tests. The first paper (HEDL-SA-3288) was presented at the Waste Management '85 Conference and emphasized radiochemical results. The second (HEDL-SA-3313) emphasizes pre- and post-test fuel microstructural characterization and will be presented at the American Ceramic Society Annual Meeting, May 5-9, 1985, in Cincinnati, OH.

Test vessel design activities are under way for the elevated temperature Series 3 tests. A method for monitoring solution level in the sealed stainless steel vessels is being developed.

The 12-month electrochemical scoping test continued. The temperature drifted to 85°C at one point and was restored to the 90°C test temperature. Measured pH values of 8.77 and 8.45 were within the previously observed operating range. A water level drop that occurred overnight after one of the water samplings for chemistry was restored the next day.

The thermo-gravimetric analysis test at 140°C in air with a 14.5°C dew point continued. After approximately 1700 hours there has been only a 130 microgram weight gain, much lower than predicted from extrapolation of higher temperature data.

Parametric testing is being organized for ATM-12, the "300-year-aged" glass. Characterization of this glass is more time-consuming than previous glasses because of its high specific americium-241 activity. The lot of 86 discs appears to be very uniform in weight and surface area, based on weight and surface measurements made on a six-disc sample. As with the previous two glasses, there will be four series of tests: deionized water, J-13 water, J-13 water plus tuff, and J-13 water plus tuff and stainless steel. These tests will begin the first week of May.

A second series of gamma-irradiation tests was initiated on April 1. These tests are being done using the same DWPF glass compositions used in the earlier tests, and will be done at a dose rate of 1×10^4 R/h. Nine matrices will be done.

The report entitled "Technical Description of Activities to Determine the Potential for Spent Fuel Oxidation in a Tuff Repository" was sent to WMPO on April 1.

Metal-Barrier Testing

The series of tests designed to survey the relative stress-corrosion-cracking tendencies of four austenitic stainless steels (304, 304L, 316L, and 321) in a J-13 water/steam environment continued. As of 9,000 hours, no failures have been reported. A very thorough inspection is planned for early May. The similar set of four-point bend tests in unsaturated steam at 150°C generated from deionized water has reached 6,000 hours with no failures.

Slow-strain-rate tests are being performed at Battelle Pacific Northwest Laboratory (PNL) under the joint direction of PNL and LLNL. Specimens of 304 and 316L stainless steel which had been processed as detailed in the monthly report for March 1985 are being tested in both air and 95°C J-13 water, in the presence and absence of gamma radiation; the strain rate is 1×10^{-6}/s. Preliminary results indicate that the test conditions employed do not provide sufficient sensitivity to detect a decline in material properties due to sensitization. Other strain rates are being investigated to determine the sensitivity of sensitization to strain rate.

A series of analyses for hydrogen peroxide and NO_3 were made on 0.5 Mrad/hr irradiated J-13 water with and without copper or 316L stainless steel present. The hydrogen peroxide analyses for the blanks (J-13 water alone) were consistent, averaging approximately 137 μM. The value for hydrogen peroxide where 316L is present was similar to this when measured on March 8, but anomalously higher when measured on April 15. Noticeably low values were obtained when CDA 102 was present (6 and 37 μM). This is consistent with the known catalytic behavior of copper with respect to the decomposition of hydrogen peroxide.

An analysis also was done for NO_3. In this experiment, a two-phase system of 2:1 volume ratio air-to-J-13 was used. Prior to irradiation the value of NO_3 was 17 ppm as determined by a selective ion electrode. After irradiation, the value was 34 ppm. The Burns et al. equation (Nature 295, 130 [1982]) predicts 38 ppm net NO_3 production for these conditions. Therefore, it was concluded that there is detectable production of HNO_3 under these conditions. Precise comparison of measured and calculated values awaits a more thorough error analysis.

An x-ray diffraction analysis was completed of the oxide film formed on CDA 102 in the irradiated vapor phase. The diffraction pattern of the vapor-phase oxide was obtained and the oxide was identified as Cu_2O. The fact that basic cupric nitrate was not observed in the vapor-phase film may be due to dissolution of the radiolytically produced fixed nitrogen in the liquid phase.

LLNL is in the process of determining the corrosion potential behavior of copper alloys in 100x concentrated J-13 water under gamma irradiation. It appears that gamma irradiation generally has a larger effect (greater positive potential shifts) on the corrosion potential in these experiments on CDA 102 and CDA 613 than in the previous ones, which were performed in non-concentrated J-13. When the gamma field is removed, the corrosion potentials decline to more negative values. This is probably due to the catalytic decomposition of hydrogen peroxide.

LLNL investigated the polarization behavior of the three CDA (CDA 102, CDA 613, CDA 715) alloys in unirradiated J-13 and 100x concentrated J-13 at temperatures ranging from 23° to 80°C. In these environments the copper alloys show a small active-passive transition and a hysteresis loop. The location of this hysteresis loop indicates the tendency toward pitting. For all alloys, in both J-13 and its 100x concentrated form, the pitting potentials were generally greater than 200 mV removed (positive) from the corrosion potential. The location of the pitting potential indicates that CDA 102 should not spontaneously pit under these environmental conditions. The CDA 613 alloy generally showed pitting potentials that were more positive than those of the other two alloys. A summary of the data will be documented in a topical report to be written by mid-summer.

Three samples each of alloys CDA 110 (electrolytic tough pitch copper), CDA 102 (high conductivity copper), CDA 706 (90/10 cupronickel), CDA 715 (70/30 cupronickel), CDA 613 (aluminum bronze), and Monel 400 (nickel base with approximately 30 percent copper) are being tested for general and localized corrosion in J-13 water at 80°C. At 3336 hours all three samples of each alloy were cleaned and characterized. A certain amount of base metal is lost during cleaning, and the weight loss of the alloy due to this cleaning procedure was measured and recorded at the beginning of this experiment. This weight difference is used as a correction factor; it is added to the actual weight measured after cleaning.

Work continued on formulating a mathematical description of the redox environment of a high level waste container. Attention has shifted to mechanisms of radiolysis of water under continuous rather than pulse radiolysis conditions. Literature data for continuously irradiated systems are being surveyed. Formulation of the model is expected to be completed during the next reporting period.

A stainless steel canister from the Spent Fuel Test - Climax (SFT-C) was examined to determine whether observable corrosion occurred on the canister used to store fuel assembly D34 in the SFT-C and to apply the results to the waste packages for the tuff repository to the degree possible, given the differences in environment. The examination showed no observable corrosion or cracking in weld regions or at an arc strike location on the canister. Comparison of the environment in the SFT-C to that expected in the tuff repository indicates that they are similar in many respects, and that the chemical conditions in the SFT-C were probably more deleterious. The fact that no degradation was observed speaks well for the likely performance of 304L stainless steel in the tuff repository, even though the SFT-C lasted only about three years.

Design, Fabrication, and Prototype Testing

Engineering evaluation of BWR and PWR spent fuel containers continued to assess in further detail the structural integrity of the designs; the current baseline designs are a four- and seven-module space frame manufactured from stainless steel sheet. Both repository-consolidated and reactor-consolidated-spent-fuel-assembly configurations are being evaluated for these designs.

Under the direction of SNL, LLNL fabricated a full-scale cross-sectional model of the most current container/space-frame design. PWR and BWR repository consolidated spent fuel was simulated with 0.375 and 0.562 inch diameter tubing, respectively. This model will be used for scoping analyses of future prototype designs. SNL has done a preliminary analysis for normal handling loads on an 1/8-in-thick space-frame design. A cost analysis of the most current design is also being done by SNL. The LLNL waste-package staff met with SNL on April 9 to discuss a preliminary table of contents of a functional design criteria document. Input was supplied in areas that relate to waste package design.

Thermal analysis has been completed on two of the most recent container designs using the TACO2D and TACO3D computer codes. One design contains three boxes of reactor-preconsolidated PWR spent fuel with a decay heat of 3300 watts at time of emplacement. Each box contains rods from two spent-fuel assemblies and is 22 cm square. Results of the analysis show a peak fuel temperature of 298°C occurring three years after emplacement. The other design contains six boxes of reactor-preconsolidated BWR spent fuel with a decay heat of 2280 watts at time of emplacement. Each 16-cm-square box contains rods from two BWR spent fuel assemblies. Results of the analyses show a peak fuel temperature of 200°C occurring three years after emplacement. For each container design, the peak fuel temperature is well below the maximum allowable temperature criteria of 350°C.

Performance Assessment

During the past month, most activities within the Waste Package Performance Assessment Subtask have focused on the preparation of input for the NNWSI Project SCP. Completed documentation includes a description of the system model and status report ("NNWSI Waste Package Performance Assessment Modeling") for Section 7.4 (Research and Development Status - Waste Package Design and Geochemical Interactions). Still in preparation is an outline for Section 8.3.4 (Waste Package Program) consistent with the characterization, design, and performance issues identified in the NNWSI Project Draft Issues Hierarchy. Detailed plans for pre- and post-closure analyses of the waste package subsystem will be contained in the NNWSI Project Performance Assessment Plan (PAP), currently under development.

Work continued to model hydrothermal flow within the waste package emplacement environment. As part of the code comparison study with LANL, LBL, LLNL, and SNL, a number of minor modifications were required to adapt WAFE to the analysis of the common near-field test problem. These changes include increasing the boundary condition capabilities and standardizing the method for data retrieval from look-up tables.

WAFE is also being used to attempt to simulate the permeability experiments (WBS 2.2.2.L). This effort involves simulation of flow through a Topopah Spring tuff core containing one large fracture. The modeling will attempt to explain observations of moisture movement based on electrical resistivity measurements.

PETROS, a one-dimensional hydrothermal code developed by SNL has been obtained and is being implemented at LLNL. The code is a finite element solution for unsaturated thermally and hydraulically driven porous media flow. This code will be used to perform preliminary scoping calculations for a variety of flow problems.

PLANNED WORK

The autoclaves for the 170°C, 120 psia electrochemical corrosion tests will be checked out in May. The spent fuel has been delivered from the MCC and fabrication of the experimental test bundles will be initiated in May.

An interim report dated April 29, 1985, was received from Lee Daniel of the MCC in response to the request for a fabrication report covering the MCC glass test materials. The cover letter states, "The content of this report is included in the individual fabrication and characterization reports in preparation by the MCC for ATM-1c (NNWSI-I), ATM-8 (NNWSI-II), and ATM-12 (NNWSI-III). Similar full reports are being prepared for all other ATMs and ARMs as well. Therefore, the document accompanying this letter is designated as an interim report only to distinguish it from the formal reports which will be issued later. The information provided here is complete relative to the subjects addressed." LLNL was given no information concerning the schedule for the formal reports. The interim report will be reviewed for adequacy in May.

PROBLEM AREAS

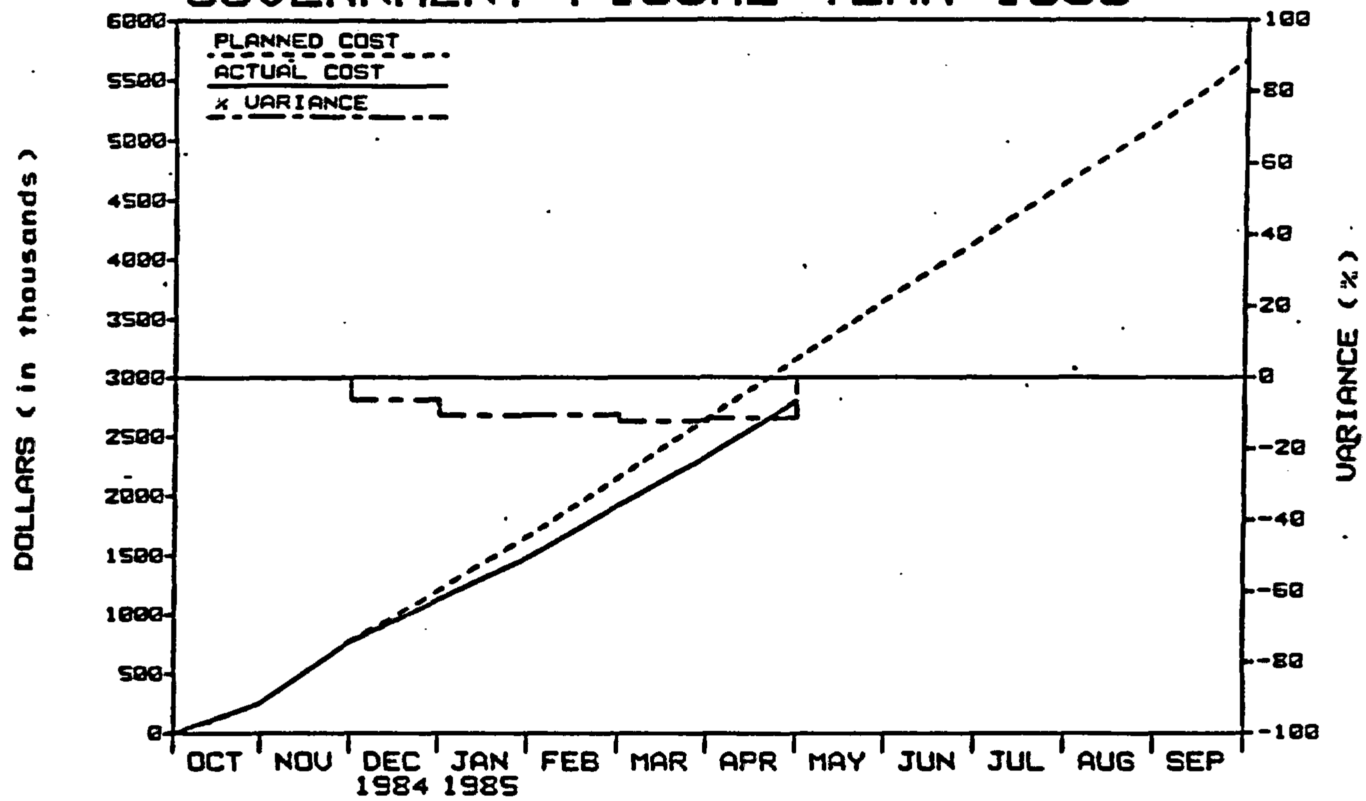
Waste-Form Testing

The formal inspection of MCC-fabricated specimens for use in the unsaturated test method was completed. The specimens are unsuitable for use because of gas bubbles in the glass and chipped and scratched surfaces. Negotiations are in progress with the MCC to arrange for recasting of the specimens. All milestones involving these materials are in jeopardy.

Metal-Barriers Testing

As a result of unexpected delays, the long-term radiation-corrosion tests on copper-based alloys at HEDL (described in the February monthly report) will not begin until early May. There have not been any technical changes in the experimental plans.

WBS 1.2.2 WASTE PACKAGE
GOVERNMENT FISCAL YEAR 1985



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	252	771	1200	1657	2152	2657	3157	3651	4143	4631	5113	5662
COST (X1000)	252	769	1124	1480	1926	2333	2799	0	0	0	0	0
VARIANCE (X1000)	0	2	76	177	226	324	358	0	0	0	0	0
% VARIANCE	0	0	-6	-11	-11	-12	-11	0	0	0	0	0

VARIANCE EXPLANATION: Subcontracts have not been costed as planned. Staff assigned to this activity have been working in other areas of the program. Variance should decrease in the next three months.

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M250	LLNL	1.2.2	Establish Interim Product Specifications			◆									
M222	LLNL	1.2.2	Input to DOE/HQ Rpt. to Congress on Copper for WP											△	
M251	LLNL	1.2.2	Pre-closure Analysis of selected Conceptual Designs			◆									
M231	LLNL	1.2.2	Complete WP Conceptual Design Criteria						△						
M233	LLNL	1.2.2	Initiate WP Advanced Conceptual Design							△					

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.3 SITE

OBJECTIVE

The objective of this task is to determine whether Yucca Mountain is a suitable location for a high-level waste repository. The effort is divided into two areas of study. The first is understanding the characteristics of the rock mass that lies below the surface of Yucca Mountain. This encompasses the geology (structure and stratigraphy), hydrology (both saturated and unsaturated zone), geochemistry (chemical reactions that can be expected when waste is emplaced), and mineralogy and petrology (the study of the materials that will control the isolation and engineering characteristics of the rock). The second is understanding the processes and events that could occur in the area surrounding Yucca Mountain that could serve as potential disruptive forces. These efforts include the study of tectonics, seismicity, and volcanism, and the regional hydrologic, paleohydrologic, and paleoclimatologic systems.

ACTIVITIES

Geology

A compilation is being made of surface fractures read from low-level air photographs (scale approximately 1:8400) of the area in the vicinity of the Exploratory Shaft site. Vegetation trends and bedrock lineaments were transferred directly to a high-precision photogrammetrically compiled topographic base (scale 1:6000, contour interval = 1 meter).

Progress in the Project to investigate fracture systems on Yucca Mountain included: 1) field identification of potential sites for producing washed rock pavements for fracture study; 2) acquisition by helicopter of low-level air photographs of natural pavements exposed by torrential rainstorms last summer; 3) preparation of an open-file report on fracture patterns exposed on washed pavements #1, #2, and #3 in the vicinity of the Exploratory Shaft; and 4) preparation of a report on the fracture characteristics of the Topopah Spring tuff section sampled by cores from borehole USW G-4 (this will be a refinement of work previously published as OFR84-789).

Work continued on the compilation of the two-meter contour maps at the NTS. Preparation of six maps for submission for open-file approval is nearly complete.

The gravity survey is being added to the geologic compilation of the Beatty, NV 100,000-scale map. Computer plots are being made of existing gravity and magnetic data from the 1:100,000-scale maps of NTS and vicinity.

Modeling continued of the Spring Mountain magnetic and gravity anomaly in order to establish the regional tectonic setting for Yucca Mountain. A domal model was developed for the anomaly source which has a depth of 4 1/2-5 km at the apex, is located approximately under the mining town of Blue Diamond, and generally is coincident with exposures of the autochthon of Aztec sandstone (Jurassic) bounded by the Keystone thrust (lowest structural unit exposed in the Spring Mountain complex). The required magnetization is approximately 0.003 emu/cm^3 for the bulk of the dome and at least twice that for the apical area. The magnetic model also satisfies the general form of the gravity anomaly. This apical zone of anomalous physical properties is markedly elongated in a north-south direction in contrast to the configuration of the dome as a whole. These results are interpreted as suggesting that the Spring Mountains are cored with a metamorphic core complex whose central portion is rock of extraordinarily high magnetization and a density somewhat lower than the Paleozoic and late Precambrian sediments. It is speculated that the core of the dome is an iron-rich granitic rock of late Mesozoic or Tertiary age which produced the domal uplift of the basement and pre-tertiary sediments.

Water permeability measurements continued on USW G-4 samples; currently measurements are being made on samples from the Crater Flat tuff. These determinations show higher permeabilities, and hence yield more rapid results, than earlier measured samples from the stratigraphically higher but highly-welded portions of the Topopah Spring Member and the older, deeper Lithic Ridge samples.

Work continued on the analysis of the temperature cross section across Yucca Mountain for thermal anomalies. Temperature plots were updated of all measured Yucca Mountain boreholes in preparation for assembly of a final USGS open-file report on this project.

Additional sediment samples and carbon have been collected for uranium-trend-dating radiocarbon analysis of deposits in the Beatty Trench 1. Uranium-trend results are now completed on 37 samples representing five depositional units in this trench. The uranium-trend ages are stratigraphically consistent and should represent a reliable geochronologic history for deposits exposed in this trench.

Hydrology

USGS and LBL personnel discussed the single-well falling-head injection tests that were conducted in test hole UE-25c#1 in October 1983. An attempt to analyze these tests with the standard Cooper-Bredehoeft-Papadopulos (CBP) method failed. Several analyticals were generated, but none of the solutions could match the response observed in the c#1 tests. One probable cause for the observed test response is that turbulent flow may be occurring in the fracture plane. If turbulent flow were present in the c#1 injection tests, it was also present in most injection tests on Yucca Mountain. As a means of investigating this problem further, the USGS will attempt to numerically model 1) turbulent flow at the intersection of the fracture and well bore and 2) turbulent flow in the fracture plane. The results of this work will have a direct impact on virtually all of the injection tests performed on Yucca Mountain and the permeabilities determined from them. Without an adequate model to describe the behavior of these tests, it will be difficult to defend and use the results of single-well injection tests. If the hypothesis of turbulent flow in the fractures is correct, the majority of the permeabilities determined from single-well injection tests will be suspect and will have to be re-examined.

Automated water-level data-acquisition systems have been installed at nine sites near Yucca Mountain. The systems generate output in the form of voltage from downhole pressure transducers. Programming has begun to enable plotting graphs of the data and compute water-level changes, depths, and altitudes.

LBL reported on the results obtained for the Yucca Mountain conceptual-model simulation when (1) the hydrologic-property characteristics curves for the welded units were modified to account for the dominance of matrix flow over fracture flow at low saturations; (2) bounding, fractured fault zones are present on both the east and west sides of the modeled Yucca Mountain block; and (3) heat transport under the prevailing geothermal gradient is included together with liquid-water, water-vapor, and bulk-air transport. Only highly provisional, preliminary results, which do not yet reproduce the thermal and flow regimes, have been obtained. It seems likely that the problem lies with the somewhat artificial boundary conditions that were imposed for these preliminary simulations.

LBL has begun to model the effects of surface-water infiltration into non-stratal-bound vertical fractures of variable apertures and spacings. Of interest is the proportions of the input liquid-water flux that moves downward through the fractures and that which is drawn into storage within the rock matrix.

Five samples from Walker Lake core #4 were sent to the USGS Water Resources Division (Reston) for carbon-13 nuclear magnetite resonance analysis. The carbon-13 data analysis for Walker Lake core #4 is about 90 percent complete. Ostracodes from Walker Lake core #8 were sent to Brown University for oxygen-18 and carbon-13 determinations. Ostracodes from core #4 are being selected for the same purpose and diatoms for core #4 are being separated for oxygen-18 determination. The diatom counts on core #4 and core #8 are about 80 percent complete.

Two-hundred samples from Walker Lake core #4, core #5, and core #8 were sent for grain size analysis, and sample depth logs for core #4 and core #5 were completed and mailed to NNWSI project scientists. Magnetic susceptability anomalies in core #4, core #5 and core #8 are being correlated with core lithology and core catcher fragments. The photography of cores #4 and #5 is complete.

The trenching of Yucca and Frenchman flats to obtain paleoclimate data from the playa deposits has been arranged. A synoptic climatology contract to the Nevada Desert Research Institute was prepared and should be in place May 1.

A precipitation collection station was set up on the east flank of the Sheep Range on April 17. Five redundant stations were closed on or about April 18. The data were observed to be essentially identical to those being obtained at other stations. Precipitation amount, duration, time, and air temperature data for Yucca Mountain are being obtained from Sandia and USGS records.

Geochemistry

The first experiment on the filtration of particulates from Well J-13 water has been completed. The fraction containing particulates between the sizes of 0.4 micrometers and 5 nanometers has been collected by backflushing the Amicon hollow-fiber filter following two successive filtrations of a large volume of J-13 water. The solutions from various stages of this process were brought to LANL for analysis. The solids filtered out by the 0.4 micrometer Nuclepore membrane are being analyzed by X-ray diffraction analysis. Several of the concentrates are also being studied by laser scattering techniques to obtain particle-size distributions.

The chlorine-36 data that were obtained from Yucca Mountain soil samples are being analyzed to quantify the fraction of the global chlorine-36 bomb pulse observed at each of the two sites. This analysis will help in interpreting the infiltration characteristics at each location. The YW-6 trench, one of the two sites from which soil samples were obtained for these analyses, was revisited to document the topology of the site.

An abstract of a paper entitled "The Use of ^{36}Cl for Infiltration Measurements at Yucca Mountain, Nevada" was submitted for presentation at the Accelerator-based Mass Spectrometry Symposium that is part of the American Chemical Society meeting to be held in Chicago on September 8-13.

The thermodynamic model for the analcime solid solution was revised and a manuscript detailing the model and its implications for mineral formation and stability at Yucca Mountain has been completed. The model is consistent with calorimetric determination of the free-energy of analcime, but constrains the free-energy difference between albite and analcime much more closely than is possible with calorimetric data. Comparison of the model with field observations from the literature has shown excellent agreement. The model suggests that the analcime present in Yucca Mountain formed as a result of elevated thermal gradients in the past, which promoted the recrystallization of metastable silica phases to quartz (at least locally in the deeper portions of the mountain). Temperatures of formation of authigenic albite in the mountain are estimated to be 175°C or greater. The model implies that the silica activity at which clinoptilolite breaks down to analcime is slightly above chalcedony saturation but below cristobalite saturation.

Work continued on determination of formation constants of Pu(IV) with carbonate and of the solubility product of hydrous plutonium oxide. These quantities are needed to calculate plutonium solubility in Yucca Mountain water.

A draft report describing LBL solubility measurements on americium, plutonium, and neptunium was received by LANL and forwarded to WMPO for review.

Three-week sorptions with plutonium were completed. Discussions on the results of the most recent Pu(V), Pu(VI), and dried plutonium sorption measurements led to the search for a core sample with a somewhat different mineralogic assemblage. The selected core is in the Topopah Spring just below the bedded tuff. The core was open along a natural fracture. Part of the core is being ground to 150-500 micrometers and will be washed in the same manner as was used for the core prepared for the most recent set of sorptions using Pu(V) and Pu(VI) spiked feeds. Another set of sorption measurements using plutonium feeds is planned and will be started soon in order to verify the results obtained in the set finished last month. Fast-flow crushed rock columns will be run for comparison.

Final results of the neptunium isotherm batch sorptions done in the controlled atmosphere box (CO_2) are now available and will be reported in the next quarterly report.

Anion elutions were completed on the crushed tuff columns of G2-1951, on a Calico Hills sample principally containing mordenite, and on a zeolitized sample of the Tram Member (G1-2698) principally containing clinoptilolite. These runs will provide quantitative anion-exclusion volumes for the zeolite minerals, mordenite and clinoptilolite. This will enable the modeling of the transport of anionic species.

Additional TRACR3D modeling of the Exploratory Shaft tracer experiment was carried out. In these latest calculations, a comparison was made between diffusion in the Calico Hills and the Topopah Spring members and the effect of a vertical fracture in the rock was evaluated. In the comparison of diffusion in the Calico Hills and Topopah Spring members, the tracer front in the Topopah Spring Member moved much more rapidly, and as a result the tracer concentrations at particular times and distances were significantly higher throughout the Topopah Spring Member than in the Calico Hills Member. Diffusion through the Topopah Spring Member proceeded much more rapidly apparently because of the large porosity difference between the two tuffs (0.094 for Topopah Spring vs 0.33 for Calico Hills). These calculations confirm the correctness of the diffusion testing priorities that are part of the current ESTP.

Sample problems have been successfully run using EQ3/6 on both the PRIME 750 and the Ridge 32C minicomputers. These systems are now being evaluated for their capabilities of rapid, interactive code development and application.

Species revision of the uranium(VI) data base has been completed. Three species were added, 19 species were revised, and 22 species were removed from DATA0. After working out several bugs in the add and replace routines, the new random access data base package was found to be very useful for these revisions.

Mineralogy and Petrology

LANL personnel visited Cane and Topopah springs, the Wahmonie granite site, and Yucca Mountain for further data to evaluate spring localities and fault-associated mineralogy.

Modal petrographic data for the lower Topopah Spring Member, USW G-4, were recollected to test variability on the method used and to provide unified textural categorization. Statistical evaluation of the modal data was begun. A paper on petrochemical variation of the Topopah Spring tuff matrix in drillhole G-4 was reviewed. One model from the stereological literature was used to predict the sampling variability of thin-section modal-counting data; the results were comparable to observations based on replicate slides on G-4 and other holes. Some additional work using other cored holes suggests that differences between holes are insignificant for the three holes within the exploratory block (G-1, GU-3, and G-4), and that the modal counting data successfully distinguish the different zones within the Topopah Spring tuff.

Meteorological Monitoring Program

Dr. Vieth's comments on the Meteorological Monitoring Plan were received, and revisions are being made. Monitoring activities were assigned quality levels and were transmitted to WMPO for approval. The bidders' package was approved by T&MSS QA and the purchase orders were approved by WMPO. Holmes & Narver has completed the monitoring station site construction and electrical drawings. All equipment has been ordered. Towers will be erected and equipment will be EA audited, calibrated, and installed in June. The monitoring system will be operational by August 1, 1985.

Socioeconomic Study Program

The Socioeconomics Working Group provided comments on services, facilities, fiscal, and governmental structure factors to be addressed by the socioeconomic impact analysis; provided information about how Federal agencies handle the assessment of psychological impacts; and provided information on alternative models that have been used to address sociocultural impacts.

Comments were received from WMPO on the Preliminary Nye County Socioeconomic Profile on Community Services that had been submitted to WMPO for policy review. Revisions were made to that report in response to DOE comments. Revision of the Preliminary Clark County Socioeconomic Profile on Community Services was completed. This report will be submitted to WMPO for policy review early in May.

Development of a plan to investigate the social impacts of locating a repository at the Yucca Mountain site centered on the completion of a survey of alternative methods for social-impact analysis. Experts from throughout the United States were contacted to identify alternative methods so that the completed plan will take into account recent progress in the growing field of social-impact analysis.

SAIC has recommended that work to investigate the potential impact of repository development on tourism be deferred because of the need to reallocate efforts within the NNWSI Project. SAIC has a consultant preparing a detailed outline of a report that will describe empirical work that has been done for other projects. A preliminary draft was submitted this month by the consultant. The draft is being reviewed internally by SAIC socioeconomic staff.

PLANNED WORK

Drilling of RF-9 is expected to begin in mid-June 1985, somewhat later than had been predicted. Depending on the results of RF-9, deepening of hole RF-3 will be considered, in addition to the drilling of an intermediate hole (RF-10). This will provide a cross section across the presumed alluvial wedge east of Exile Hill. Seismic velocity determinations and reflection feasibility studies will begin after completion of the borehole program.

The analysis of cation elutions through the fractured tuff columns will be performed using TRACR3D and will be compared with analytic solutions. Fluorescent particles will be eluted through the fractured columns. Column elutions will continue for crushed and fractured tuff.

The Kinetics Assessment Report (M317) is ready for distribution. The Radionuclides Transport Report (M318) is expected to be out at the end of June.

A survey continued of existing literature concerned with field tracer tests to aid in the design and interpretation of scheduled and proposed tracer tests. Early field tracer experiments usually were carried out to determine direction of flow, velocity of flow, and the presence or absence of natural circulation between wells. Only in recent times have the tests been exploited to give information such as porosity, fracture aperture width, and hydraulic conductivities. Most of the recent results reside in reports and preprints and have yet to reach the referred literature.

Work has been started on up-dating the americium thermodynamic data in the data base.

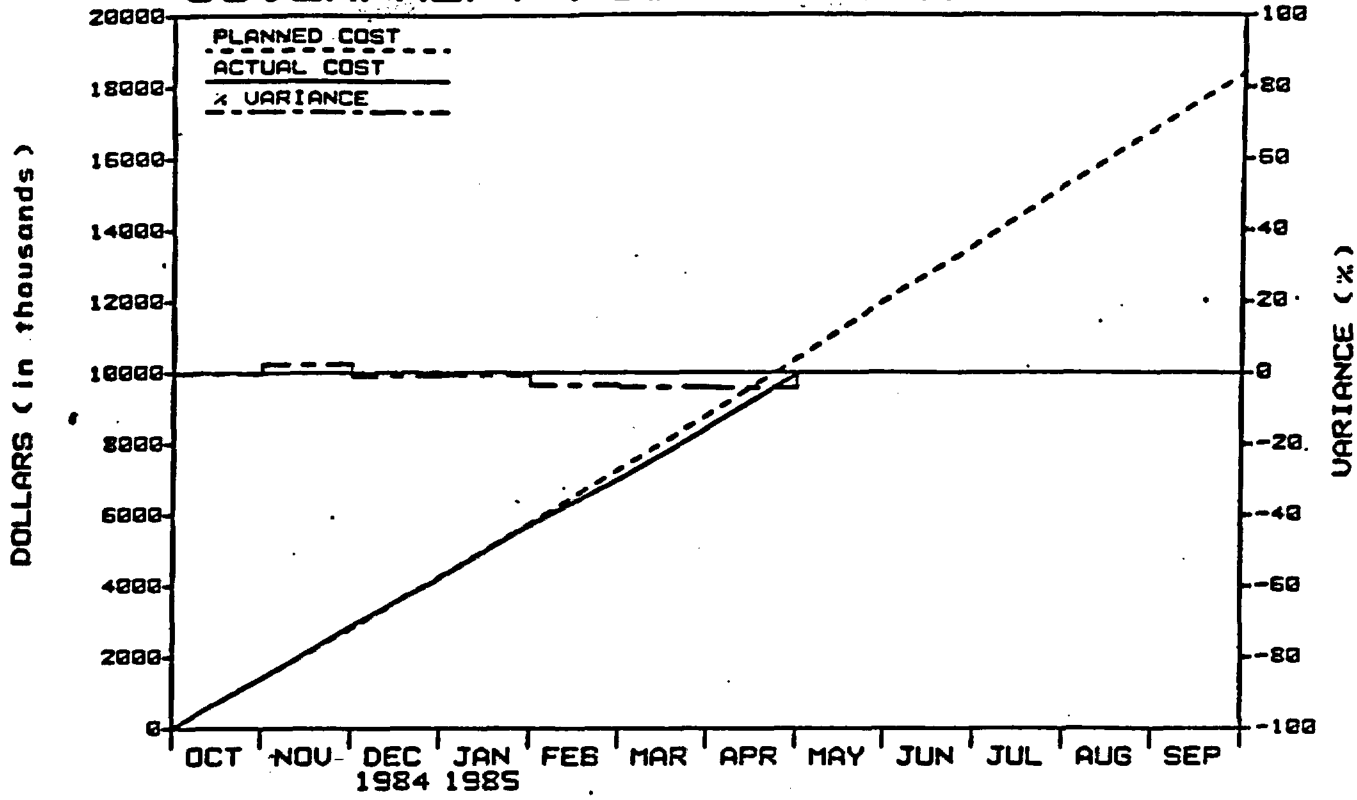
The working committees on sorption and solid solution are meeting biweekly to discuss models to be incorporated into geochemical modeling code. Evaluation of a Langmuir-type isotherm for dilute solutions is in progress for the sorption module.

In May a meeting will be held in Denver to lay out the full scope of joint USGS and LANL work required to resolve the question of possible spring deposits at Yucca Mountain.

PROBLEM AREAS

Due to late starting date of the RF-9 drilling, field geophysical observations have been delayed, crowding the schedule for timely completion of Milestone N448, "Preliminary Validation of Subsurface Conditions for Repository Surface Facilities", due 9/30/85.

WBS X._.3 SITE INVEST_GATIONS
GOVERNMENT FISCAL YEAR 1985



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COST (X1000)	1386	2861	4200	5685	6996	8423	9939	0	0	0	0	0
VARIANCE (X1000)	6	-64	44	48	266	372	454	0	0	0	0	0
% VARIANCE	0	2	-1	-1	-4	-4	-4	0	0	0	0	0

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M354	LANL	1.2.3	Letter Rpt. on Groundwater Chemistry along Flow Path	◆											
M357	SNL	1.2.3	Weapons Test Seismic Rpt.				△								
M356	LANL	1.2.3	Complete Rpt. on Volcanic Hazards Analysis		◆										
M355	LANL	1.2.3	Progress Rpt. on 3-D Mineralogic Model of YM	◆											
M364	SAIC	1.2.3	Implementation of Meteorological Monitoring Plan									△			

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.4 REPOSITORY

OBJECTIVE

The objective of this task is to develop the engineering capability to design, construct, operate, and decommission a repository in tuff. Four specific technical areas are involved that include (1) determination of the physical and mechanical properties of the rock matrix and rock mass that are important to the design and construction of an underground structure;. (2) engineering analysis and evaluation of technical details that are important to the design and operation of a repository; (3) development of the techniques of sealing a repository as part of decommissioning; and (4) preparation of a site-specific design that will be accommodated within the development of the equipment to construct the repository, handle the waste and waste package, and transfer the waste and waste package within the repository system.

ACTIVITIES

Management and Integration

A data catalog for NRC was updated in April. The data catalog addressed (1) laboratory data pertaining to thermal, mechanical, physical, mineralogic, hydrologic, seal material, evaluation, backfill properties, surface soil properties, and radiometric testing; and (2) field tests including G-Tunnel in situ experiments, G-Tunnel borehole logs, weapons test seismic studies, and surface facility subsurface borings collected by SNL for the NNWSI Project.

Rock Mechanics

The contract with RE/SPEC for thermomechanical calculational support expired, and work from this contractor ended in April. A new contract was written, and RE/SPEC has prepared and submitted a proposal for the work. The proposal is currently in review. This affects WBS X.2.4.2.1.1 and WBS X.2.4.6.1.

A problem-definition memo (PDM) that defines a series of calculations in support of the pressurized-slot test has been completed and approved by SNL. It is planned that PDMs will become routine exercises within the Geotechnical Analysis Division in order to standardize the initiation, tracking, and completion of calculations performed for the division.

A 1-m by 1-m flatjack was successfully removed from a slot in the G-Tunnel Underground Facility. This opens up the potential for using removable flatjacks in slots cut by a diamond-tipped chain saw. The flatjack will be subjected to post-removal instrumentation checks.

Work began on the drilling of the 12 holes from the U12g.12 drift up to the welded tuff mining (WTM) area in G-Tunnel. Work also started on installing the data acquisition system. A small alcove was mined so that the instrumentation leads could be terminated near the start of the WTM in order to protect the instrumentation leads from damage that might occur from planned blasting in the welded tuff.

SNL successfully designed and fabricated an automated data-monitoring system for IRAD sonic-operated, multiple-point borehole extensometers. Previously these extensometers had to be read manually and now they can be incorporated into the HP 9845-based data acquisition system.

Work on the statistical analysis of laboratory properties of tuff began. A statistical package available on the SNL 823 VAX computer system has been selected. Data files have been initiated for mechanical and bulk properties, and preliminary analysis of a portion of the mechanical data has been performed.

Testing to determine parameter effects (pressure, temperature, strain rate, and saturation) on the mechanical properties of the Topopah Spring Member has begun. Approximately 30 of the 63 planned tests are complete.

The permeability of a sample of densely welded Topopah Spring tuff was measured at temperatures ranging from 20° to 90°C. The results show that, within the accuracy of the data, there is essentially no dependence of permeability on temperature up to 90°C (boiling temperature approximately equal to 97°C).

The paper entitled "Fluid Flow in a Fractured Rock Mass" was completed and peer review comments were incorporated. The paper will be presented at the DOE/NRC Symposium on Groundwater Transport Modeling to be held in Albuquerque, NM on May 20-21, 1985.

A request for quotation of bids to measure relative hydraulic conductivities as a function of saturation for welded and nonwelded tuffs has been issued. Sixteen core samples were requested from the Core Library Committee, with 11 core samples approved.

Equipment and Instrumentation Development

A contract was placed with Seven-K Corp. This contract calls for a report on the methods, machinery, and historical data pertinent to the installation of steel liners into horizontal boreholes.

A report prepared by Foster-Miller entitled "Conceptual Engineering Studies and Design for Three Different Machines for Nuclear Waste Transporting, Emplacement, and Retrieval" (SAND83-7089) was published.

A study has been initiated to investigate the feasibility of using a totally electric waste transporter. Power would be supplied by trolley wire or powered rail if this approach proves feasible.

A draft of the strategy for conducting borehole-liner corrosion studies has been developed and is currently in review. The outlines for conducting borehole-liner grout studies is being developed. It includes the identification of potential grout applications, evaluation of the desirability of grout for each of the potential applications, identification of candidate grouts, evaluation of potential design impacts, and discussion of required supportive studies.

Sealing

The report entitled "Repository Sealing Plan for the Nevada Nuclear Waste Storage Investigation - Fiscal Years 1984 through 1990" (SAND84-0910) was published and distributed.

Parallel to the studies on geochemical and phase stability of candidate grouts/mortars, questions concerning the change in physical properties associated with change in the phase composition of a cement resulting from elevated temperature exposure have been examined in a preliminary manner. This and subsequent studies will provide useful input to the degradation model.

Mechanical and physical properties were investigated of an aged sealing material sample, that had been exposed to higher temperatures to simulate the condition in which a grout plug is exposed to heat that is generated by the emplaced waste package. A two-in cubic sample of the 82-22 cement formulation that had been cured for 2.25 years at 38°C was slowly heated over an 8-hr period to 150°C at 400 psi, held there for 5 days, and then slowly cooled over 8 hr to room temperature to minimize thermal shock effects. The resulting changes in phase composition, compressive strength, and porosity were evaluated relative to a control sample that was not exposed to the elevated temperature conditions. This very preliminary study supports the notion that the decomposition of the ettringite in this cement and other changes result in an increase in porosity, but most of the newly formed pores are of an extremely fine size and will probably not enhance the permeability significantly. Although the alteration of the phase composition also was accompanied by a nearly 50 percent decrease in strength, the compressive strength still appears to be adequate for most purposes.

Analytical calculations of the flow to a shaft from the alluvium were completed. These show that the flow could be high relative to groundwater inflow from sources in tuff. Other calculations examined the time required for surface recharge to saturate a fault zone, leading to convergent flow to a drift. This time was found to be sensitive to the porosity of the fault zone as well as to the hydraulic conductivity. Faults that consist of closely spaced fractures with a relatively low fracture porosity are more likely to become saturated than those faults that consist of breccia and gouge and have a relatively high porosity.

The UNSAT2 code has been set up and a simple problem involving matrix flow was run. A first attempt at running the code with the composite fracture-matrix conductivity curve was not successful. At present, major modifications to the code would be required to run a problem with the composite curve.

Operations and Maintenance

A proposal is being drafted for a one-year study of the advantages and disadvantages of fuel-rod consolidation at the Yucca Mountain repository. Results of the study will form the basis for a recommendation as to whether or not consolidation is cost-effective and conducive to radiological safety. The recommendation should be valid for an MRS facility supplying spent fuel to the Yucca Mountain repository, but not necessarily for a utility shipping fuel directly to the repository.

Economic factors to be considered include the cost of developing and building consolidation equipment; hot-cell requirements with and without consolidation; and the effect of consolidation on mining and drilling costs, on staffing requirements and lifetime labor costs, and on canister costs. With regard to health effects, the principal concerns are the effect of consolidation on worker exposure, plant effluents, off-site health effects, and the availability of radionuclides for uptake in groundwater.

Repository Performance Assessment

The first version of a reference design memo to document current layout criteria and guidance to PBQD and the resultant SCP design has been completed and is in review. This memo will form a checklist for the Functional Design Criteria (FDC) document and will establish the baseline design for use in calculations of thermomechanical effects.

Problem definition work is in progress to establish the allowable thermal loading for advanced conceptual design. A range of values will be evaluated and sensitivity to parameters will be tested.

PLANNED WORK

J. A. Blume and Associates' final Seismic Study report is being modified following an oral presentation at SNL on March 29,1985 and an SNL peer review. The final report with comments incorporated from the review will be available to SNL on May 20, 1985.

Preparation of the final Seismic Position Paper is expected to begin in May 1985, following receipt of NRC feedback.

Drilling of 12 holes from U12g.12 drift up into the WTM area will continue and installation of lead wires for the data acquisition system will be completed. Preliminary testing will start with instrumented flatjacks to determine if there are any unexpected rock-mass responses. Work will be performed in the l-m-square slot.

Work to determine the laboratory properties of tuff planned for May through July 1985 includes: (1) completion of parameter effects testing at RE/SPEC and SNL, (2) completion of a draft report on the mechanical properties of the Topopah Spring Member in USW G-2, (3) continued work on Chapter 2 of the SCP, and (4) preparation of a draft report on the thermal conductivity and thermal expansion of lithophysae-rich Topopah Spring Member.

Mercury intrusion and/or extrusion testing is planned for 40 to 60 tuff samples to determine pore size distribution characteristics. The data will be used to estimate saturation as a function of pressure-head curves for the samples.

The completion of the equipment development program plan is scheduled for May 1985.

Sealing Materials

The report entitled "Compatibility Between Select Cementitious Material and the Topopah Spring Member Tuff" is under final review at PSU; the expected completion date is May 15. The letter report on the identification of mineral phases compatible with sealing material is expected to be completed by June 1.

The analyses for the LANL Milestone N411, Reponse to LANL on QA Levels for Exploratory Shaft, will be modified during May 1985 in preparation for the NRC workshop in June 1985.

The following seal concepts development work is planned: (1) complete analytical hydrological calculations, particularly ramp and borehole analyses; (2) complete documentation for airflow analyses; and (3) continue preparation of preliminary recommendations for the field tests.

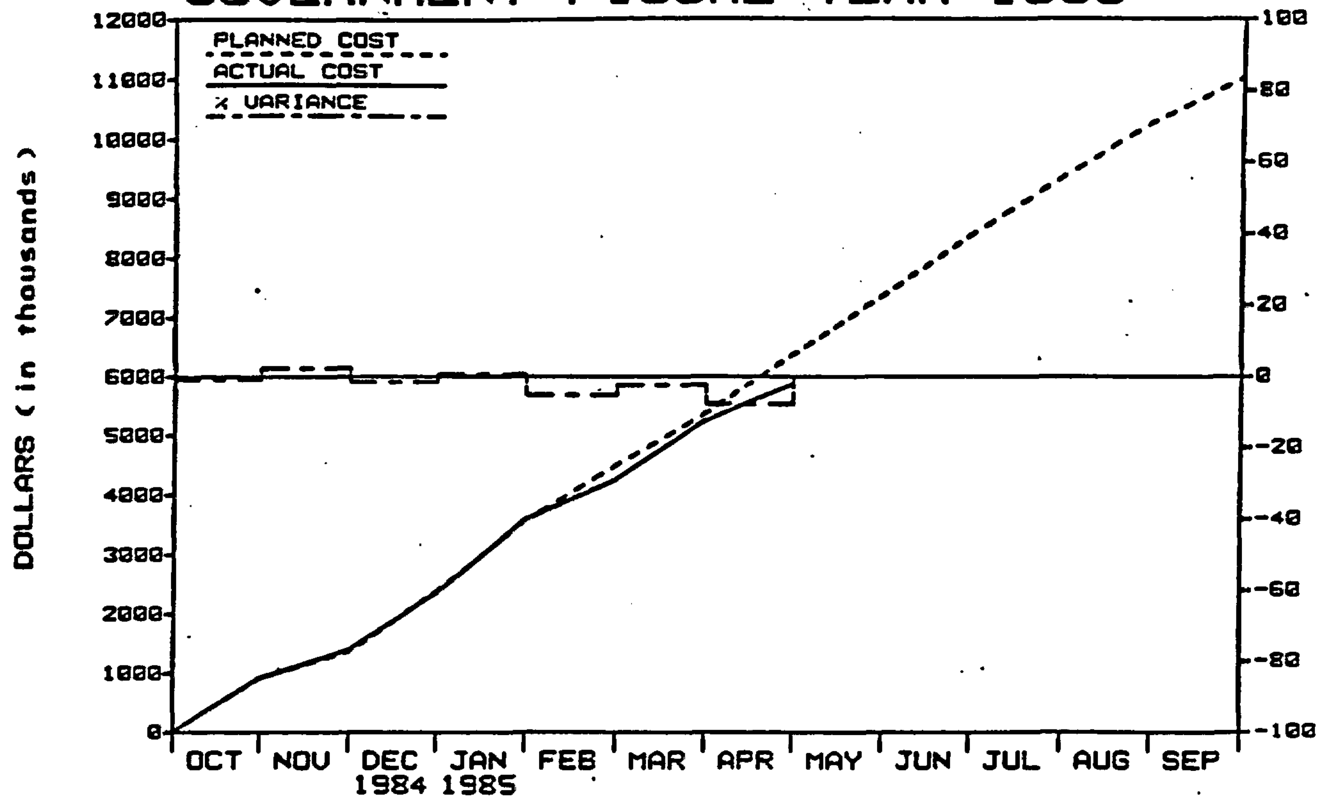
Efforts in May will be directed towards providing support for responses to EA comments and the writing of the SCP.

PROBLEM AREAS

The network indicates that work will not be completed to meet Milestone N432, the NNWSI Conceptual Design Report in support of the SCP. Delivery will be about one month late. The reason for this delay is that the DOE/HQ generic outline (draft) was not received until mid-April 1985. Some replanning was required and additional detail must be developed to comply with this outline.

A delay is expected in completion of the summary report on thermomechanical analysis as an SCP reference (M491), currently due 9/30/85.

WBS X.2.4 REPOSITORY INVESTIGATIONS
GOVERNMENT FISCAL YEAR 1985



PLAN (X1000)	917	1359	2380	3565	4492	5380	6374	7362	8384	9329	10253	11011
COST (X1000)	909	1392	2344	3592	4256	5256	5876	0	0	0	0	0
VARIANCE (X1000)	8	-33	36	-27	236	124	498	0	0	0	0	0
% VARIANCE	-1	2	-2	1	-5	-2	-8	0	0	0	0	0

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
N406	SNL	1.2.4	Horizontal Waste Emplacement Equipment Development Plan									△			
M447	SNL	1.2.4	Seal Development Plan for Repository		◆										
M430	SNL	1.2.4	Start Repository Conceptual Design												△
M432	SNL	1.2.4	NNWSI Project Site Specific Repository Design Concept Rpt.												△

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.5 REGULATORY/INSTITUTIONAL

OBJECTIVE

The objective of the Regulatory/Institutional task is to provide the capability for interfacing with all the institutions and to meet the requirements identified in various laws and regulations pertaining to the siting, design, and construction of a nuclear waste repository and a test and evaluation facility. The principal laws and regulations which govern the licensing of these include the Atomic Energy Act of 1954, the National Environmental Protection Act (NEPA) of 1969, and the Nuclear Waste Policy Act (NWPA) of 982, 10 CFR Part 60 and 40 CFR Part 191.

ACTIVITIES

In addition to the creation of a Data Records Management System (RMS) at SNL as outlined in the March 1985 monthly report, procedures have been established to facilitate the creation, maintenance, and closing of data sets for the RMS for NNWSI Project test data. The DRMS underwent its first full-scale test with the production of the quarterly update to the Data Catalog. The update to the Data Catalog, to be used by the NRC in accordance with the site-specific agreement, was provided to WMPO on April 15, 1985.

Site Characterization Plan (SCP)

The NNWSI Project SCP Management Plan (SCPMP) was approved and the final version was issued on April 10. SCP Work Instructions, which provide additional detailed guidance on SCP preparation, were officially distributed to the task leaders following the formal issuance of the SCPMP. The Management Group will be meeting on a regular basis every other Monday.

The SCP Annotated Outline, Section 8.3, was expanded to include subsections for the Issues and Information Needs and provisions for detailed explanations of the Information Needs.

All participants began work on their sections of the SCP.

Environmental Assessment (EA)

The NNWSI Project Environmental Assessment Management Plan for preparation of the final Environmental Assessment, which was drafted last month, is being reviewed and will be completed in early May. The EA Comment/Response Appendix is being written. A computerized comment-response tracking system was developed to follow each comment through preparaton of the EA Comment/Response Appendix and final EA publication. Several EA meetings were held in April to plan responses to the comments. The EA Finalization Workshop was held on April 16-18 in Washington, D.C. The draft Comment/Response Appendix for the EA is scheduled to be issued to HQ on June 3, 1985.

Environmental Compliance

Work began on the Environmental Permitting Plan that is being prepared to identify permits, detail permit requirements, and explain the procedures necessary for WMPO to follow to obtain each permit. Emphasis will be placed on permits for site characterization activities and long-term scheduling difficulties expected for repository permits. A status report was prepared and transmitted to WMPO on April 15. A draft of the plan will be sent to WMPO for review by May 31, 1985.

Regulatory Compliance

WMPO approval was received to proceed with preparation of the NNWSI Project Regulatory Compliance Plan as reflected in the annotated outline submitted for approval in March 1985. Drafting of the plan was initiated based on the WMPO approved guidance.

Consulting arrangements were made with D. D. Tillson to initiate planning for briefings on nuclear power industry licensing experience. The briefings will be directed toward WMPO and selected key participant staff members and will emphasize applicant, intervenor, and NRC responsibilities and strategies during the licensing process based upon past utility experience. Experts who have been involved in past licensing proceedings will participate in the presentations. An initial planning meeting between Dr. Tillson, WMPO, and SAIC representatives was held on April 23, 1985.

A DOE/OGR proposed revision to Appendix 78 of the site-specific agreement (NRC-OR responsibilities) was reviewed and comments were transmitted to OGR. The DOE-proposed revision was based on comments to an NRC version, which was reviewed in March.

NNWSI Project staff representatives participated in several DOE/HQ-NRC meetings relating primarily to SCP concerns. Topics discussed included Performance Allocation on April 17 and Repository Conceptual Design on April 18. In addition, NNWSI Project representatives attended several DOE/HQ-NRC meetings as observers.

A meeting was held in Las Vegas on April 3 to finalize the annotated outline for the Seismic/Tectonics position paper. In addition to the NNWSI Project, representatives of DOE/HQ, Weston, and BWIP were present. The revised outline generated during the meeting, however, retained a NNWSI Project-specific orientation and was subsequently revised at the request of DOE/HQ to be more generic. Copies of the generic outline were distributed to the other projects and to DOE/HQ. A meeting to discuss the outline with NRC will be arranged by DOE/HQ in the near future.

Draft 5 of 40CFR191 was reviewed and comments were submitted to DOE/HQ. The draft, as proposed by EPA, addressed some of the NNWSI Project comments made on earlier versions. However, certain of the radionuclide release rates have been made more restrictive and the consideration of the unsaturated zone is still inadequate.

Comments were provided to WMPO on the results of the OGR Licensing Information System study and on a position from the DOE perspective on the protection of proprietary information.

PLANNED WORK

The Records Management System (RMS) will be maintained and Tech. Reps., Inc. (TRI) will continue software development for the creation of the data catalog. The data catalog will index information presently filed in the RMS and will identify missing information required in the data set before it can be completed. Once operational on an AT&T PC, the data catalog can be used to locate quickly any information needed from the RMS. Updated versions will be transmitted to WMPO on a quarterly basis.

Work will continue on preparation of the SCP and revision of the EA.

PROBLEM AREAS

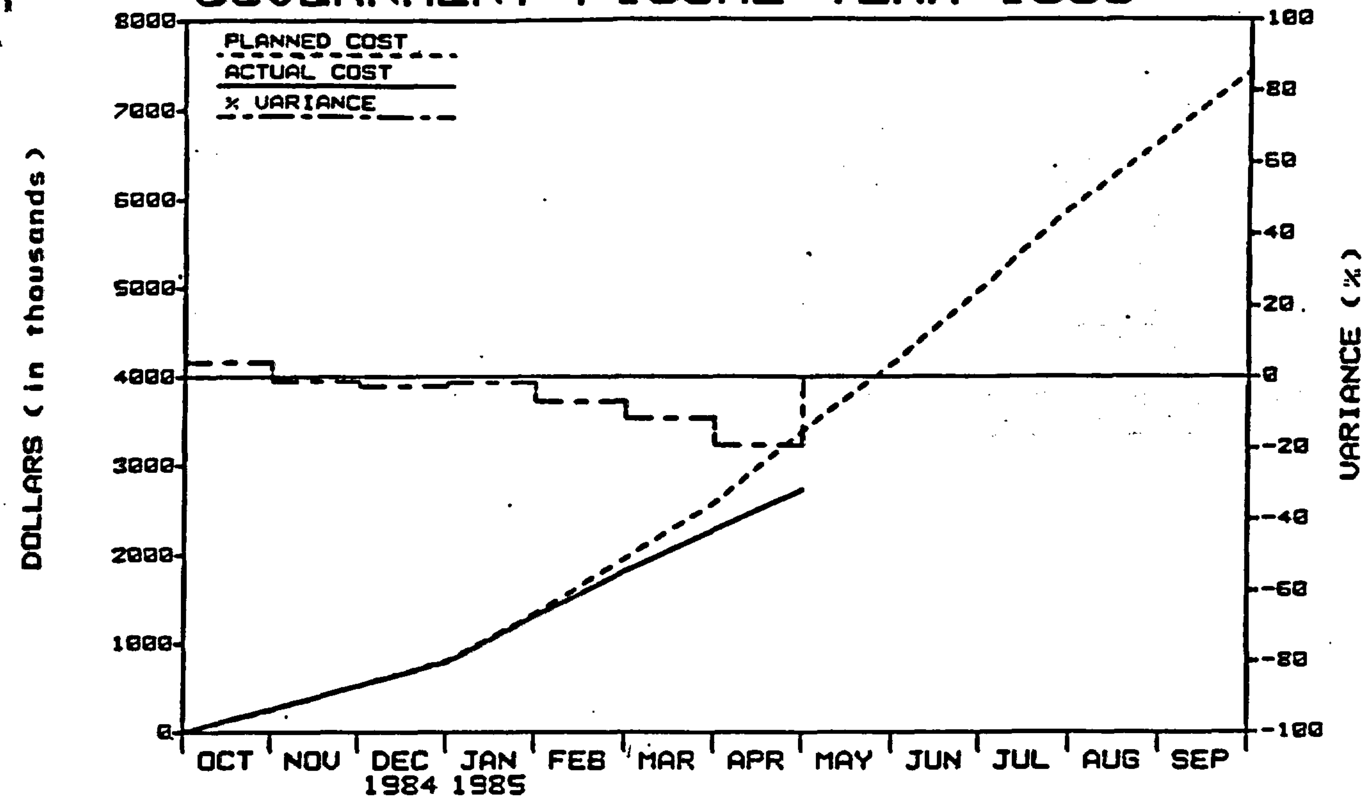
SCP

It is expected that work on the EA tasks may cause a slip of three to six weeks in the initial submittal of some SCP chapters and sections.

EA

Late comments from the State and the amount of work anticipated to finalize the EA do not appear to be consistent with the existing schedule.

WBS X.2.5 REGULATORY & INSTITUTIONAL GOVERNMENT FISCAL YEAR 1985



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	245	522	805	1328	1953	2576	3387	4149	4979	5880	6635	7410
COST (X1000)	255	515	783	1306	1816	2275	2734	0	0	0	0	0
VARIANCE (X1000)	-10	7	22	22	137	301	653	0	0	0	0	0
% VARIANCE	4	-1	-3	-2	-7	-12	-19	0	0	0	0	0

VARIANCE EXPLANATION: Costs for the SCP and Nevada State Grant efforts were well under the planned amounts. However, EA costs were well above the planned amounts. Replanning needs to be done.

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M523	SAIC	1.2.5	NNWSI Project References for EA Complete		◆										
M502	SAIC	1.2.5	Draft Environmental Assessment		▲										
M504	SAIC	1.2.5	Final Environmental Assessment								△				
M503	SAIC	1.2.5	EA Comment/Response Document								△				

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.6 EXPLORATORY SHAFT

OBJECTIVE

The objective of this task is to identify and plan the tests that need to be conducted at the repository horizon as a part of detailed site characterization and to design and construct the Exploratory Shaft (ES) and the underground test area in Yucca Mountain. The primary focus of this effort will be to establish the basis for evaluating the unsaturated zone in a welded tuff formation. In addition, an effort will be made to define the nature of the unsaturated zone with regard to water content and water movement, and the nature of the natural barriers between the repository horizon and the static water level.

ACTIVITIES

Exploratory Shaft Test Plan (ESTP)

Trials continued this month of alterant high frequency electromagnetic (HFEM) geotomography methods in a sand pit. Alterant HFEM geotomography is a promising technique for measuring water saturation constrasts within a rock mass and may be applied in the three Exploratory Shaft (ES) Waste Package Environment tests. Contacts have also been established with sources of other geophysical equipment that may be suitable for determining rock mass moisture content with high geometric resolution, so as to obtain redundancy in these ES test measurements.

Contacts have been established with several researchers who have worked with the performance of USBM borehole deformation gauges that are subjected to heated and moist environments. This instrument may be used in the Waste Package Environment Tests to monitor stress changes.

The latest draft of the Waste Package Environment Test conceptual test plan is being revised in response to comments from LANL and other reviewers. Changes will be finalized as technical and programmatic LLNL reviews are completed. Scoping calculations using a thermomechanical finite element code were begun this month to support development of engineering test plans. These calculations will supersede analytic solutions used in preparation of initial drafts of the conceptual test plan.

A letter was prepared at WMPO request regarding post-license application testing and its coordination with ES activities. Several questions were raised about long-term testing, including questions about planning and coordination, test initiation and timing, and possible use of radiation sources. The importance of distinguishing between test results leading to a License Application and test results that may subsequently lend support to a License Application was emphasized. Potential NNWSI Project needs for long-term testing were introduced as well.

The ESTP Committee met on April 17-18 at SAIC in Las Vegas to review the available portions of ESTP Rev. 1. The descriptions of individual tests in Part II of the ESTP had been sorted into a topical grouping system developed by LLNL and reviewed by the other ESTP principal investigators. The introduction for the fourth group of test descriptions (Near Field and Thermally Perturbed

Tests) in Part II of the ESTP was revised and sent to LANL for use in Rev. 1; this introduction summarizes and compares the six ES tests that will examine thermally perturbed portions of the rock mass.

Several items requiring action were identified at the ESTP committee meeting:

(1) Document for the design staff the arguments for minimum shaft penetration into the Calico Hills.

(2) Provide P. Aamodt with introductory remarks that show how the ESTP and PAP are related to each other and to the SCP by describing what information regarding Performance Assessment will be contained in the documents.

(3) Develop comments and suggestions for a revised ESTP rationale, Chapter 5.

(4) Review the ESTP glossary.

(5) Provide documentation of how PA will use specific data obtained during ES testing and the schedule for using the data in analyses and reports.

Items (2) and (3) have been completed. It was suggested that Chapter 5 parallel the outline of SCP Chapter 8.3. Items (1), (4), and (5) are to be completed before the next ESTP meeting on May 14, 1985.

The section on shaft-wall mapping was completed for Revision 1 of the geologic sections of the ESTP. The hydrology sections of Revision 1 of the ESTP were completed and submitted for colleague review. The USGS met with LANL and SAIC to review the nine ESTP sections and to draft a flow net showing scheduled mining and testing activities.

Drafts of ESTP Part I, Chapters 1-6 were updated or rewritten to reflect ESTP Committee members' comments. The Executive Summary and introductions to Part II test sections were prepared in draft form. Test write-ups continue to be internally reviewed by the participating organizations; modified drafts are expected to be sent to LANL during May.

The ESTP schedule was updated and expanded to assist with the identification of personnel conflicts with other Project activities. D. Vieth was briefed on the ESTP Rev. 1 status and planned activities.

Exploratory Shaft Facility (ESF)

Review was started on the revised design of ES-1. Included in the design review are the ES-1 collar, shaft excavation, shaft liner, shaft internals, safety barriers, and the shaft bottom. Also being reviewed are the revised designs of the ES-1 stations at the 520- and 1200-ft depths.

Review of design specifications for the ES-2 shaft boring, liner shotcrete, hoist, headframe, cage, and hoist rope was completed. Review is being conducted on a Title I layout of the ES-2 surface slab and ventilation equipment and drawings of the ES-2 excavation and liner.

The schematics for underground water, pump, air, and shaft communications systems are being reviewed.

Work continued on the development of an underground coordinate system for defining the locations of equipment, drillholes, and geotechnical features. Also, detailed planning continued of the interactions of construction and testing.

A meeting was held on April 16 with REECo in Mercury to develop a correlation between the ESF Work Breakdown Structure (WBS) and the REECO work order system at NTS. The work orders are written by H&N and F&S and executed by REECo. The result of the meeting was a strawman addition to the WBS that should correlate the two systems. It will be presented to and discussed with H&N, F&S, DOE/NTSO, DOE/NV, and REECo personnel in the near future.

Personnel from LANL and SAIC met on April 18 to discuss the meteorological needs for the ESF and for the rest of the NNWSI Project. Initial coordination was made with SAIC personnel who have recently planned a weather system to be installed at the ES as part of the Meteorological Monitoring Program. To eliminate duplication of effort, LANL will receive required weather data from the SAIC system where this meets the needs of the ES testing.

Work was completed on the summarization of the ESF Project cost estimates from the NTS support contractors and the Principal Investigators. Three separate sets of budget numbers were prepared for three different dates (June, August, and December 1986) for start of ES-1 shaft sinking (the cost estimate in the Schedule 47 and WPAS is based upon the August 1986 date).

Work was completed on the design status book requested by DOE/HQ (unbaselined Milestone M023). The book is in three volumes and represents the current status of the ESF design and construction efforts. The three volumes contain design criteria, design studies, specifications, drawings, a summary schedule, cost estimates, and minutes of the ESF Project Status meetings. The material is not necessarily final or approved but rather presents a snapshot of the project as it exists in April 1985.

ES Integrated Data System (IDS)

Work continued on the production of the IDS portions of ESTP Rev.1. The formal design review of the IDS conceptual design was completed. Only minor comments were received. The record document will reflect changes due to these comments.

PLANNED WORK

DOE/HQ will be briefed on May 3 on the status and plans for the NNWSI Project ESTP Rev. 1 document. Editing and other cleanup work will continue on Part I chapters and Part II test plans as they are received. A completed Rev. 1 document is scheduled to be delivered to WMPO/NV on June 21, 1985; however, there remains a chance that EA and SCP work will impact the ESTP schedule.

A joint NRC/DOE workshop on the ESF is tentatively planned for the week of June 3. In preparation for the workshop, a meeting was held on April 22 with representatives of LANL, SNL, and Stearns-Catalytic Inc. to discuss the workshop content and to discuss responses to NRC comments of April 1983 on the ESF Conceptual Design Report.

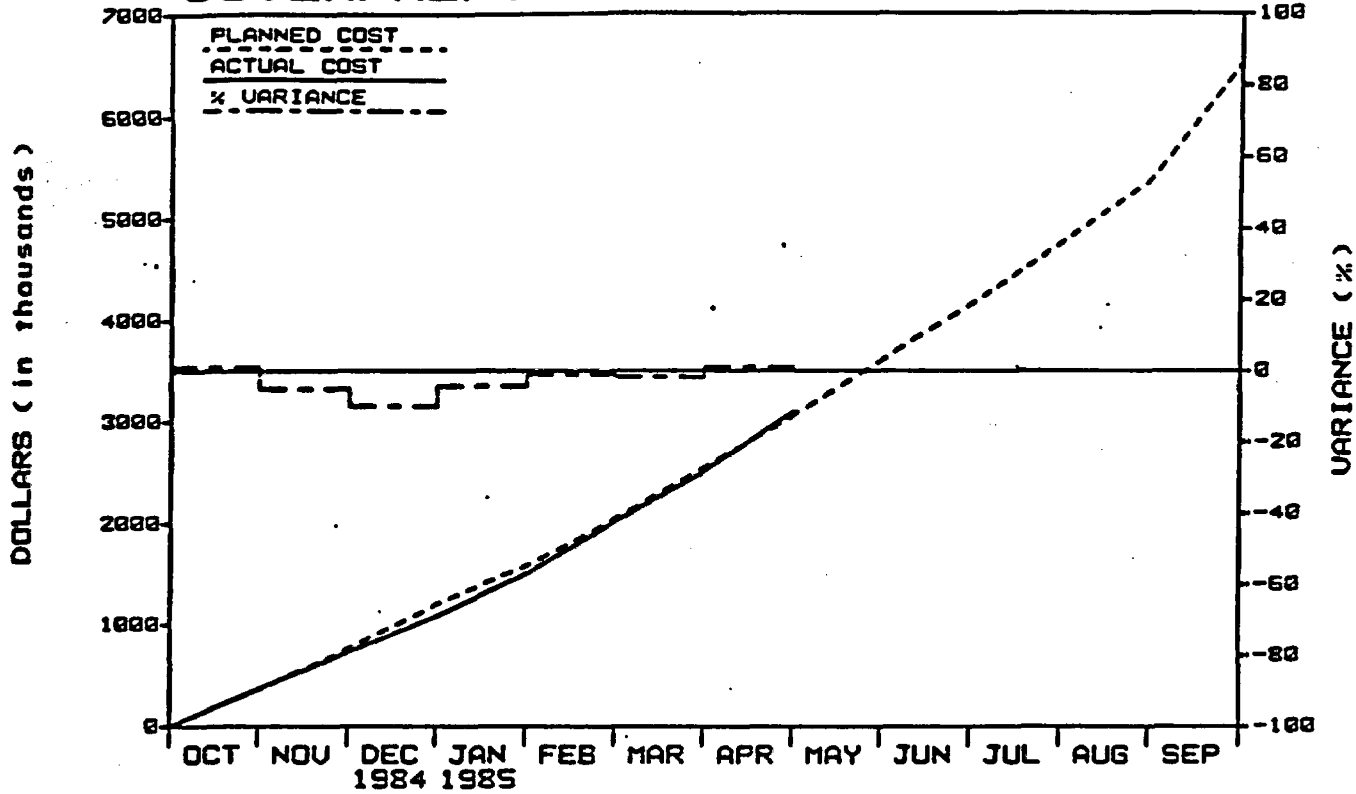
PROBLEM AREAS

It is possible that DOE/HQ will establish a common outline for all ESTPs; if so, its impact on the NNWSI Project ESTP schedule will need to be assessed.

Preparation required for an NRC/DOE workshop on the ESF in June may delay the completion of the Title II design scheduled for the end of June. Also, work has not progressed on the assignment of quality levels to ESF items and activities.

The draft Final Design Report (M661) is dependent on the ESTP, which is expected in June 1985. Expected changes in the details of the IDS will mean a rewrite and a delay until September 30, 1985.

WBS x 2.6 EXPLORATOR) SHAFT
GOVERNMENT FISCAL YEAR 1985



PLAN (X1000)	366	762	1194	1573	2042	2546	3061	3601	4157	4746	5356	6505
COST (X1000)	370	724	1076	1504	2020	2502	3095	0	0	0	0	0
VARIANCE (X1000)	-4	38	118	69	22	44	-34	0	0	0	0	0
% VARIANCE	1	-5	-10	-4	-1	-2	1	0	0	0	0	0

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M666	LANL	1.2.6	Issue Exploratory Shaft Test Plan												△

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.7 TEST FACILITIES

OBJECTIVE

The major objective of this task is the design, contruction, and operation of the test facilities that support technology development for other waste management programs and other geologic repository projects. The two major facilities operated under this WBS element are the Climax Spent Fuel Test Facility and the E-MAD Facility.

ACTIVITIES

Spent Fuel Test-Climax (SFT-C)

Geological Investigations

Preliminary analyses of core-logging data from in situ stress boreholes ISS09 and ISS10 indicated that the joint sets in the regions sampled by these boreholes were markedly different from those observed elsewhere in the SFT-C facility. In an effort to explain the apparent differences in structures, the core was re-examined. It was determined that the reference line which is used to auto-orient the core based on a ubiquitous low-angle joint set was not consistently positioned with respect to that joint set. As a result, the procedure used to determine the orientations of other joint sets introduced errors in the data. Data were acquired to correct the errors in the two ISS data sets and these corrections were completed this month. The resulting data have been used to generate new graphic core logs for the post-test core logging report which has been delayed pending resolution of this problem. The revised draft report was released and submitted for publication processing.

The technique for auto-orienting core was used to determine the true orientations of joints observed in 70 m of core from instrumentation boreholes. This activity completed the core logging effort. Pictorial and tabular presentations of the data from these five boreholes were developed and submitted to the Project files. A decision was made not to publish a complete data base of all pretest and post-test core logging results since all but this 70 m segment are currently contained in a set of LLNL reports.

Post-Test Instrumentation Evaluations

A laboratory study was recently completed of the combined effects of non-ideal borehole diameter and longitudinal bending of the NX borehole jack on the apparent deformation modulus of a rock mass. Data from this study were entered into a data base and checked for accuracy and completeness. Analysis of these data is being delayed in deference to higher priority NNWSI activities.

Post-Test Calculations

Post-processing of the results of three ADINA/ADINAT calculations of the thermomechanical response of the SFT-C is essentially complete. These calculations used as input ranges of deformability and in situ stress values which were based on both pretest and post-test measurements at the site. Plots have been prepared to facilitate intercomparisons of these calculations. In addition, selected field data have been plotted with the calculational results to examine the level of agreement between them. Preliminary analyses indicate that the elastic parameters and in situ stress values measured post-test provide somewhat better results than were obtained using pretest values. Detailed analyses continued.

The initial suite of seven post-test heat transfer calculations were completed. Among the factors examined parametrically in these calculations were conductivity and heat capacity of the rock mass, conductivity of materials lining the floors of the drifts, convection coefficients of the drift surfaces, and the ventilation flowrate. In addition, the effect of cooling the rock mass during the construction phase of the test was examined. After accounting for the precooling, the level of agreement between measured and calculated temperatures (which was already very good) was substantially improved.

To make comparisons between calculated and measured temperatures easier to comprehend, a code was written which plots these paired values against each other, fits a line through the points, and calculates several basic measures of the fit. This graphical presentation allows one to observe the conformance of the points to a straight line with slope equal to one and intercept equal to zero: an indication of perfect agreement between measured and calculated temperatures. The technique has proven to be a valuable way to examine the effects of various changes which are made during parameter studies, such as those outlined above.

A code was written, debugged, and exercised to provide graphical presentations of the results of the three-dimensional finite-length heat transfer calculations which were completed last month. The code generates temperature contour plots in any selected XY, YZ, or ZX plane of the model.

Data Management

The REVERT code has now been used to provide final conversions and temperature compensations for about half the acquired data. Development and testing are in progress of the software which standardizes the format of the acquired data and merges the files into a directory structure containing separate files for each individual instrument. A few relatively minor modifications to the software which processes data from the central data acquisition system resulted in a set of codes which will perform the necessary functions. Merging and testing of the complete data set is planned for mid-May.

The "Instrumentation Report No. 3: Performance and Reliability of Instrumentation Deployed for the SFT-C" was submitted for publication. The report entitled "Post-Test Coring Logging for the Spent Fuel Test-Climax" was sent to the printers.

E-MAD

Data Collection

All E-MAD fuel assemblies are now stored in the Hot Bay lag storage pit with the exception of fuel assembly B02, which remains in the Fuel Temperature Test assembly. Data monitoring of selected fuel assemblies from March 27 through April 16 provided the following maximum temperatures.

The highest center pin temperature for fuel assembly B02, recorded on thermocouple (T/C) #305, was 126.9°C. The fuel assembly remains in the Fuel Temperature Test stand in the West Process Cell, where the Metal Cask Simulation Test was recently completed. Disassembly of the stand is scheduled for mid-May.

In lag storage pit #22, the highest canister temperature recorded for fuel assembly D06 was 51.6°C on T/C #108. In lag storage pit #8, the highest canister temperature recorded for fuel assembly B41 was 40.9°C on T/C #109. No canister temperatures were recorded on fuel assmemblies B03, B43, D01, D04, D09, D15, D16, D18, D22, D34, D35, D40, D46, and D47, and on fuel rods G9 and J8 from fuel assembly B02. With exhaust fans off, the highest lag storage pit exhaust temperature was 32.3°C.

All canisterized fuel assemblies located in the lag storage pit are in a safe configuration. The maximum recorded canister temperatures are well below the canister design limits. All monitored fuel assemblies reflect a normal profile over the past month.

Dry Storage Fuel Integrity Demonstration

The Metal Cask Simulation Test, conducted for the Dry Storage Fuel Integrity Demonstration, has been completed. The Fuel Temperature Test (FTT) disassembly plan describing post-test FTT activities, was prepared and submitted to DOE/NV for approval. Approval was received and the plan was issued. Consolidated Procedure WN-CP-062, for disassembly of the FTT, was prepared and issued.

Fuel Integrity Monitoring

Integrity monitoring of fuel assemblies B03, B43, D01, D04, D06, and D15 was completed for the second half of FY 85. The fuel assemblies were removed from the lag storage pit, contamination swipe samples were obtained, then the fuel assemblies were returned, in canisters, to their storage locations.

The canisters containing fuel assemblies D16 and D18 were removed from lag storage for gas and full volume filtration sampling in preparation for opening the canisters to remove and characterize the fuel assemblies. Characterization was indefinitely postponed until photographic support is available. The canisters were returned to their respective storage locations.

Safety Assessment Documentation

The report entitled "Safety Assessment Document for Spent Fuel Handling, Packaging, and Storage Demonstrations at the E-MAD Facility on the Nevada Test Site" (DOE/NV10250-20) was completed and a copy was transmitted to DOE/NV. This completes activities identified for FY 85 in this task.

PLANNED WORK

SFT-C conversion of the remaining SFT-C data sets should be completed in May and the resulting data files processed into single-instrument files containing data for the entire test period. Draft reports on the post-test thermal and thermomechanical analyses will be prepared. The report on a laboratory evaluation of the USBM overcore cell will be completed.

E-MAD

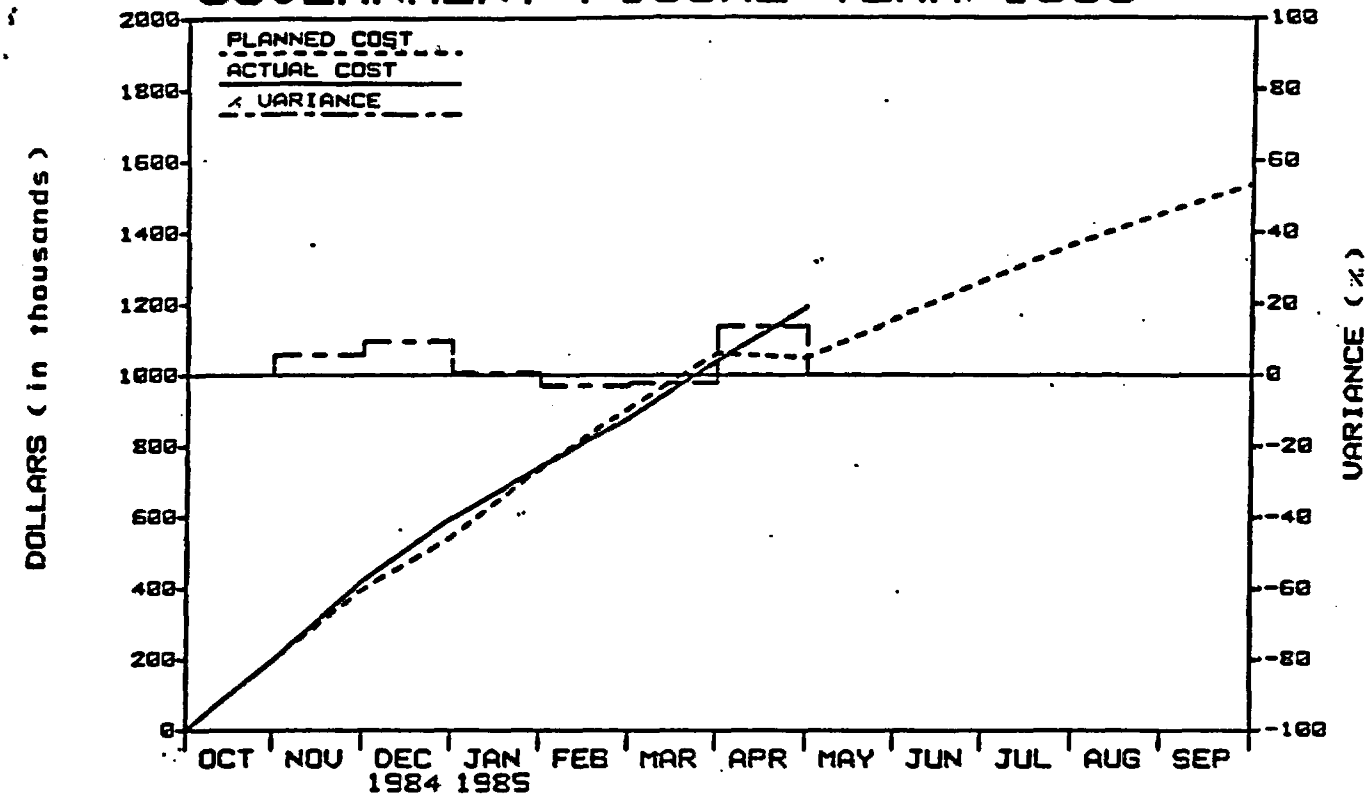
Remote fuel-handling operations, currently scheduled for mid-May, include transferring the FTT test stand from the West Process Cell to the Hot Bay, removing fuel assembly B02 from the stand, installing the fuel assembly in a temporary storage canister, obtaining surface contamination swipe samples from the outside surface of the canister, and transferring the canister to the lag storage pit.

Fuel assemblies D16 and D18 will be decanisterized, characterized, and installed in temporary canisters.

PROBLEM AREAS

The request for augmentation of the FY 85 budget was rejected by WMPO. In an effort to bring anticipated costs into conformance with the approved budget, the following activities will not be completed: "Calculational Study of the NX Borehole Jack" (2.7.2.1-85-III-5); "Effects of Geologic Structure on the In Situ State of Stress" (2.7.2.1-85-IV-4); "Post-test Core Logging Database" (2.7.2.1-85-IV-5); and the measurement of the thermal expansion properties of extensometer components. In addition, the scope of 2.7.2.1-85-III-1, "Shock Effects on the Results of the Climax Mine-by" will be limited to an informal or letter report.

WBS 1.2.7 TEST FACILITIES
GOVERNMENT FISCAL YEAR 1985



PLAN (X1000)	197	397	543	737	907	1061	1048	1157	1265	1365	1452	1535
COST (X1000)	197	420	595	742	879	1038	1191	0	0	0	0	0
VARIANCE (X1000)	0	-23	-52	-5	28	23	-143	0	0	0	0	0
% VARIANCE	0	6	10	1	-3	-2	14	0	0	0	0	0

VARIANCE EXPLANATION: The overrun is due to costs for G-Tunnel. Planning needs to be reviewed.

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M708	LLNL	1.2.7	Final Report on the SFT-C												△

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

X.2.8 LAND ACQUISITION

OBJECTIVE

The objective of this task is to maintain access to land adjacent to the Nevada Test Site that is controlled by the U.S. Air Force and the Bureau of Land Management and to protect land that could be used for a high-level waste repository and the surrounding buffer zones.

ACTIVITIES

None.

PLANNED WORK

To be included in future NNWSI Project Monthly Reports.

PROBLEM AREAS

None.

X.2.9 PROGRAM MANAGEMENT

OBJECTIVE

The objective of this task is to manage all activities of the NNWSI Project by all contractors. The five major areas identified are Project Management, Project Control, Interface Activities, Quality Assurance, and Generic Requirements Document (GRD) Support.

ACTIVITIES

Earned Value (EV)

The NNWSI Project Earned-Value System Study is proceeding as planned. The last two system review visits were made by SAIC/PMS personnel to Fluor in Irvine and to PNL in Richland for the purpose of evaluating their approach to earned value as subcontractors in the repository program. Results of these visits are summarized in the interim report isued on April 29.

The interim report also included the status and strawman proposal for the NNWSI Project Performance Measurement System, provided a summary of requirements and assumptions, listed the limitations of the present system, defined the proposed approach for the Project, provided a strawman estimate of the proposed approach, and described the salient features of comparable systems used by Rockwell and Battelle. This report will be a basic reference for onsite meetings to be held at the laboratories and USGS in May.

A presentation was made at the April TPO meeting that summarized the objectives, the features, and the system elements of the proposed NNWSI Project EV approach. This presentation outlined the responsibilities of each participant to provide a realistic basis for determining the impact on methods and resources. The more substantive parts of the presentation were included in the interim report issued on April 29.

Staff Conflict Schedule

A NNWSI Project staff calendar is being developed to show conflicts between meetings and major NNWSI Project activities to which key staff are assigned. The outputs will be in bar-chart format and will show major conflicts between such activities as the SCP and the EA. Additionally, all meetings and major NNWSI Project activities are listed.

Project Documentation Systems

The final Project Plan was sent to WMPO on April 19 for approval by Don Vieth, Tom Clark, and Bill Purcell. The Project Plan will be distributed to the NNWSI Project participants when an approved copy is returned to WMPO from DOE/HQ.

NNWSI Project Quality Assurance

A letter was received from OCRD regarding its review of the QAP. No changes are required.

A semiannual review of the NNWSI Project QA Plan and SOPs was conducted and recommended changes were sent to WMPO. The documents are being revised with an expected issue data of July 1985.

In regard to NNWSI Project SOP-17-01, QA Records Management, ESI has been requested to implement a pilot program using the USGS. The program will be based on the original specification submitted by ESI in February.

The first committee meeting on NNWSI Project SOP-03-02, Quality Assurance Software, was held on April 11, 1985. The outcome of the meeting resulted in the following: the SOP would be a requirement document; the purpose and scope statements were formalized; and responsibilities for drafting the definition, responsibility, requirements, and documentation sections were assigned. The next meeting is scheduled for May 16, 1985.

The final committee draft of NNWSI Project SOP-03-03, Non-NNWSI Project QA Plan Data or Interpretation Acceptance, was submitted to WMPO and QAD for review and approval; their comments were reviewed and resolved and are being incorporated into the procedure.

A revised schedule for FY 85 audits was issued by WMPO on April 19, 1985.

Internal audit 85-1 of WMPO was performed on April 10-11, 1985; audit findings are in the resolution phase. Internal WMPO audits 85-2, -3, -4, and -5 are scheduled for May 1985.

A meeting was held in Las Vegas among DOE, SAIC, LLNL, SNL, and LANL to discuss the implementation of NUREG 0856. A committee was chosen to work on the implementation and John Dronkers (LLNL QA Specialist) was chosen chairman. A second committee meeting will be held at LLNL later in the month.

Pending WMPO approval of the T&MSS QAPP (Rev.2) and supporting QPs, interim training was conducted on T&MSS QP 2.4, Assignment of Quality Levels, in accordance with the issued schedule, which includes a follow-up session. This training is in compliance with the requirements of NNWSI Project SOP-02-02.

PLANNED WORK

Work Breakdown Structure (WBS)

The WBS was modified by the Change Control Board during April. Updates will be forwarded to all participants during May.

WBS Dictionary

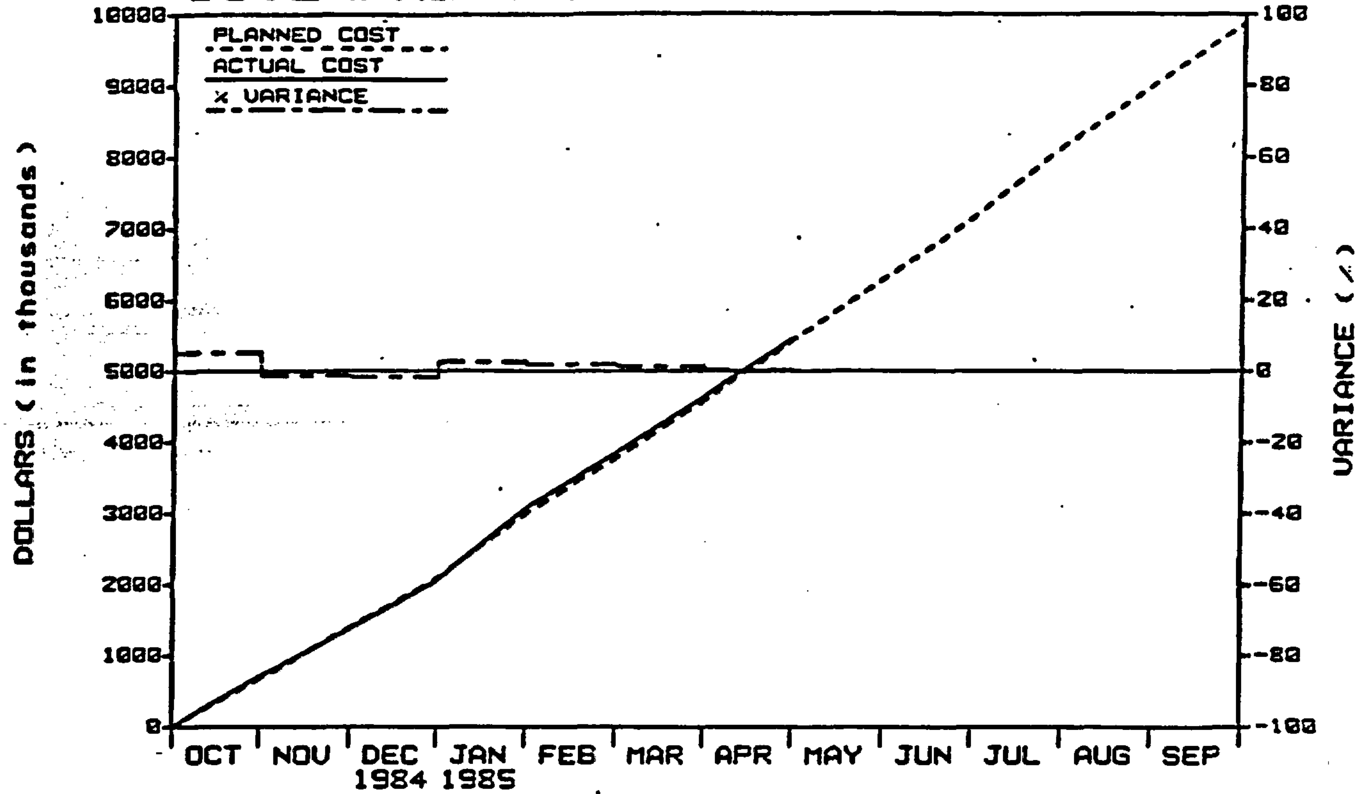
A preliminary draft of the dictionary was reviewed by SAIC staff during March. It is expected that the dictionary will be delivered to WMPO and NNWSI Project participants for their review at the end of May 1985. Baseline approval is expected at the June Change Control Board (CCB) meeting.

PROBLEM AREAS

A delay in receiving comments on the Draft Project Management Plan and work plans, due on April 25, 1985, will affect the expected May 10 delivery date of the final PMP to WMPO for approval.

Surveillances for the remainder of FY 85 will not be performed because of the heavy work load in other higher-priority areas and increased task activities. The elimination of these surveillances will inhibit to some extent WMPO evaluation of the implementation and effectiveness of the NNWSI Project QA system.

WBS X.2.9 PROJECT MANAGEMENT
GOVERNMENT FISCAL YEAR 1985



PLAN (X1000)	663	1397	2086	2985	3764	4579	5432	6285	7148	8141	8999	9865
COST (X1000)	698	1380	2052	3061	3835	4635	5453	0	0	0	0	0
VARIANCE (X1000)	-35	17	34	-76	-71	-56	-21	0	0	0	0	0
% VARIANCE	5	-1	-2	3	2.	1	0	0	0	0	0	0

MILE-STONE	RESP. AGENCY	WBS	MILESTONE DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S
M901	SAIC	1.2.9	Submit FY 1985 NNWSI Project Plan to DOE/HQ						▲						
M915	SAIC	1.2.9	Submit NVO-196-18 (Rev. 2) to DOE/HQ		▲										
M907	SAIC	1.2.9	Draft Project Management Plan						△						

△ PLANNED MILESTONE COMPLETION DATE
▲ COMPLETED AS SCHEDULED

◇ REVISED MILESTONE COMPLETION DATE
◆ COMPLETED AS REVISED

U.S. DEPARTMENT OF ENERGY

OCRWM

OGR

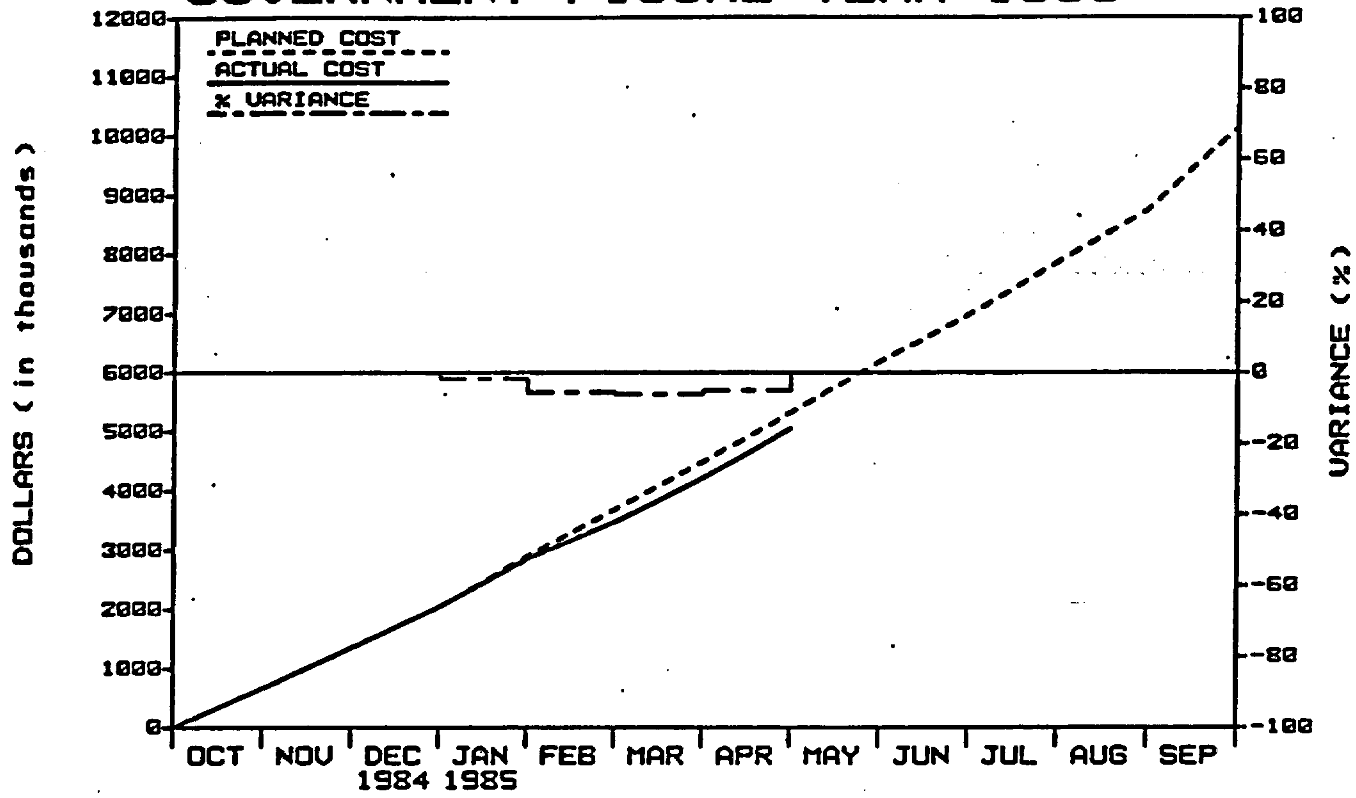
Nevada Nuclear Waste Storage Investigations PROJECT

YUCCA MOUNTAIN

PARTICIPANT

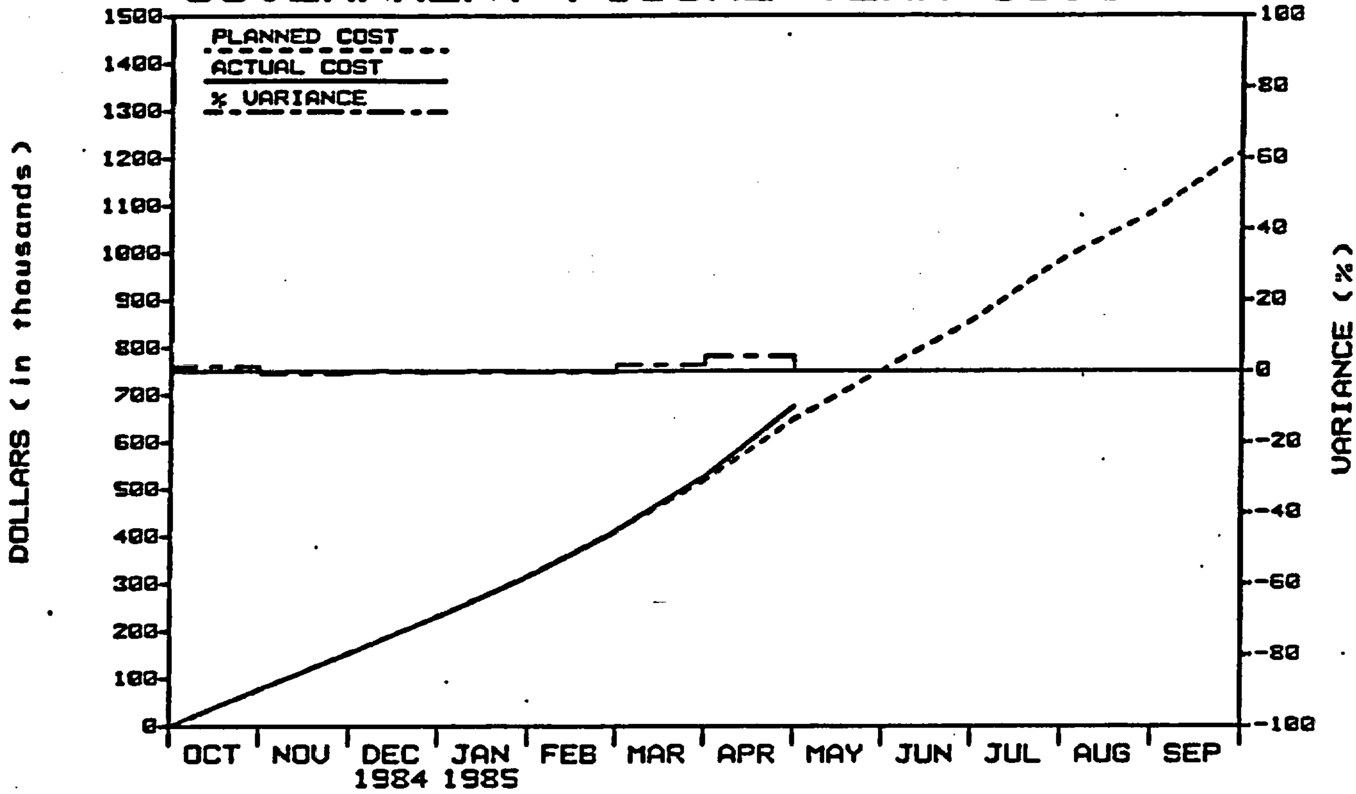
BUDGET vs COST

LOS ALAMOS NATIONAL LABORATORY
GOVERNMENT FISCAL YEAR 1985



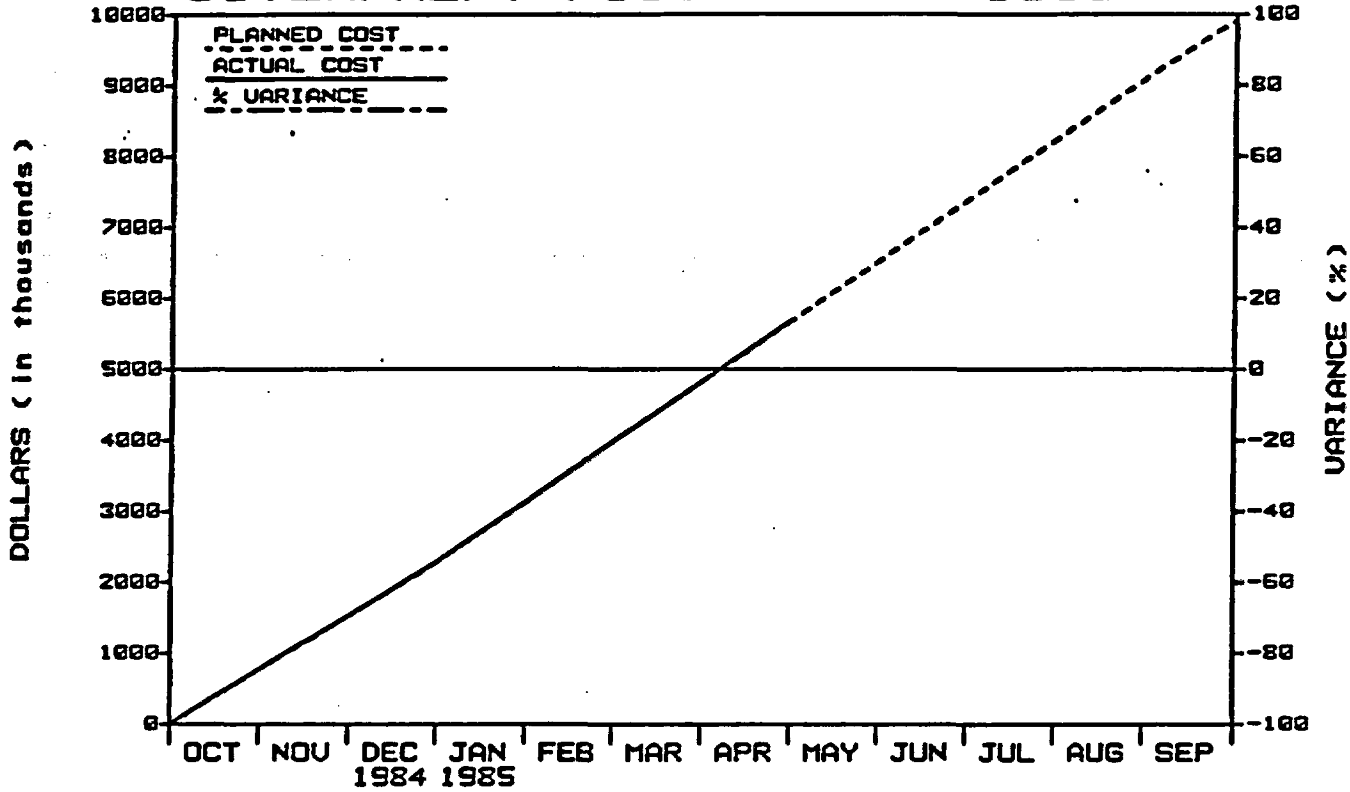
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	656	1354	2039	2892	3678	4491	5328	6187	6983	7859	8741	10130
COST (X1000)	656	1354	2039	2842	3471	4213	5060	0	0	0	0	0
VARIANCE (X1000)	0	0	0	50	207	278	268	0	0	0	0	0
% VARIANCE	0	0	0	-2	-6	-6	-5	0	0	0	0	0

FENIX & SCISSON, INC
GOVERNMENT FISCAL YEAR 1985



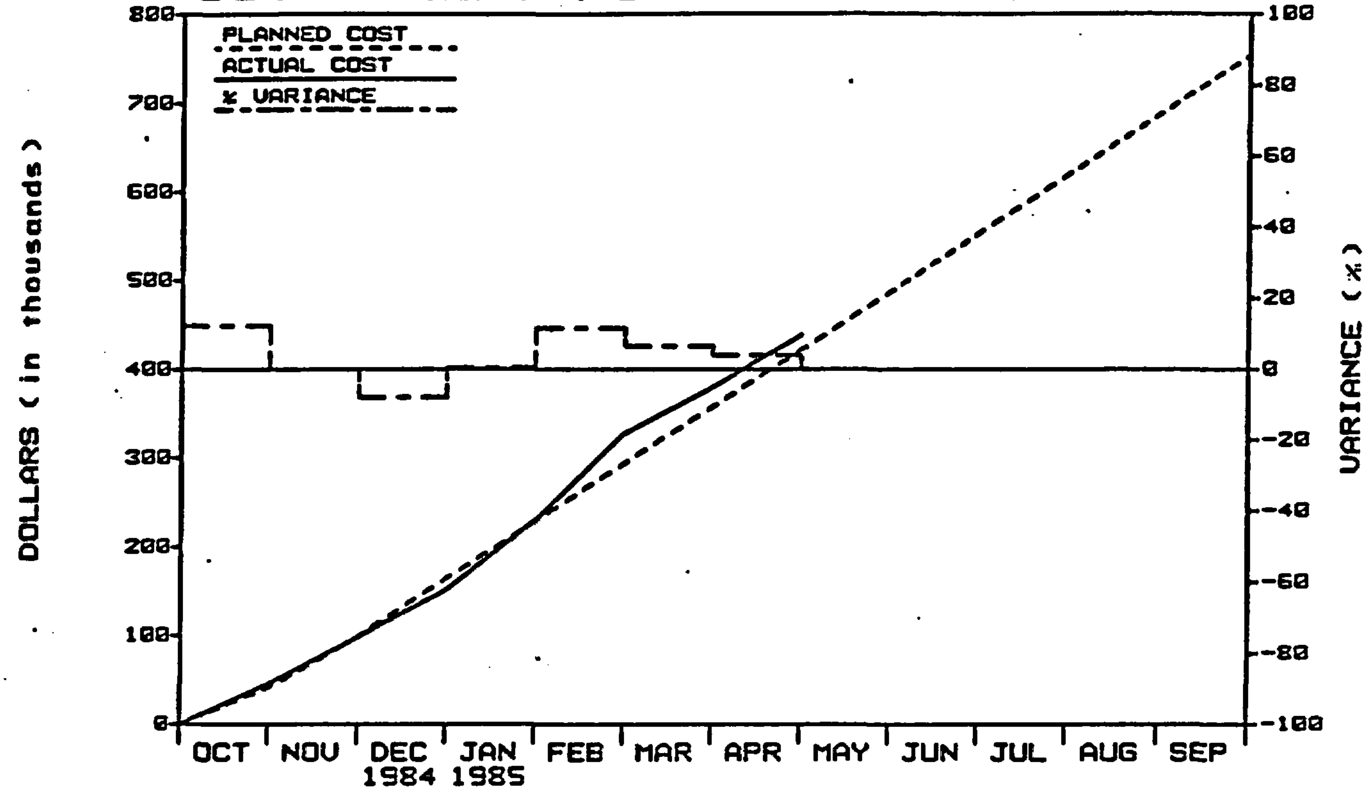
PLAN (X1000)	76	154	232	317	412	519	649	753	857	984	1083	1212
COST (X1000)	77	153	231	316	410	527	676	0	0	0	0	0
VARIANCE (X1000)	-1	1	1	1	2	-8	-27	0	0	0	0	0
% VARIANCE	1	-1	0	0	0	2	4	0	0	0	0	0

U. S. GEOLOGICAL SURVEY
GOVERNMENT FISCAL YEAR 1985



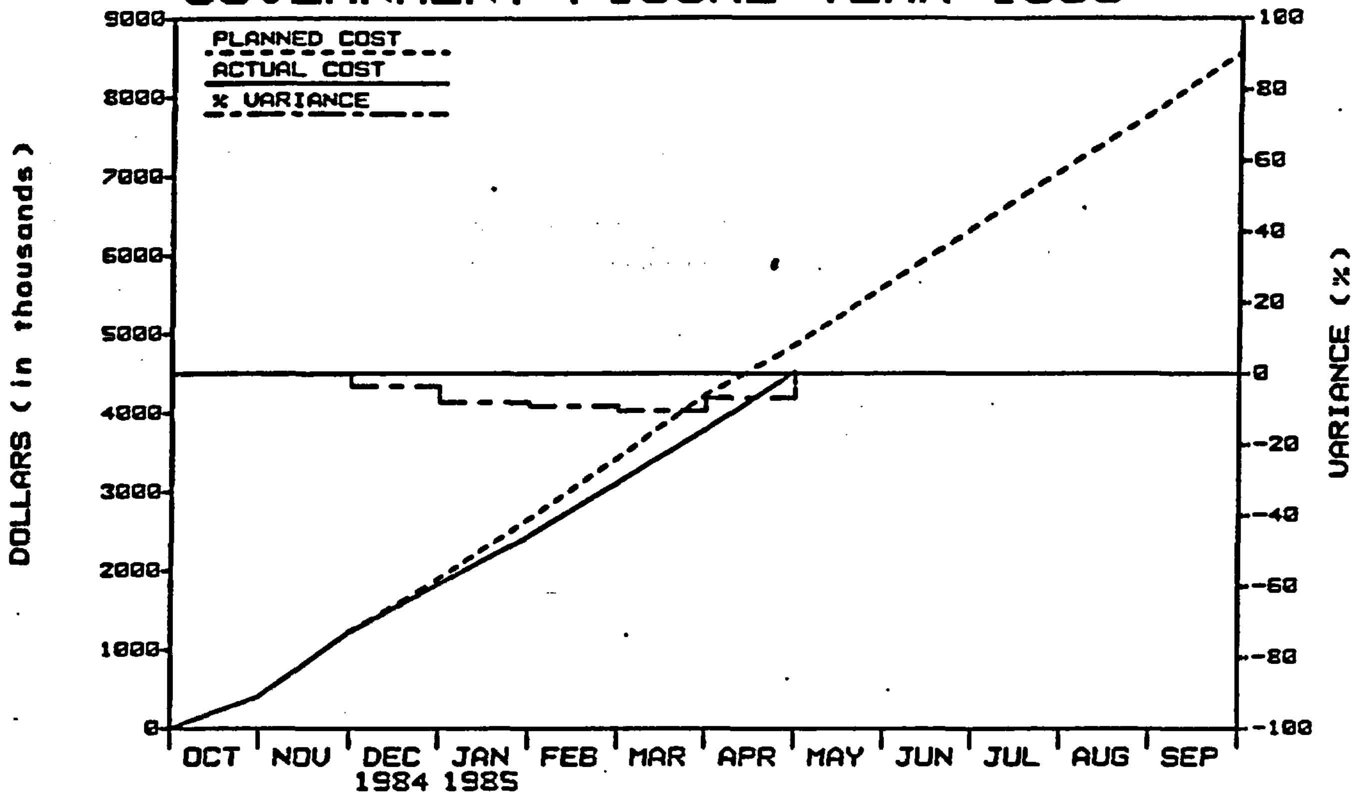
PLAN (X1000)	760	1520	2277	3125	3986	4830	5680	6525	7378	8226	9075	9922
COST (X1000)	760	1520	2277	3125	3986	4830	5680	0	0	0	0	0
VARIANCE (X1000)	0	0	0	0	0	0	0	0	0	0	0	0
% VARIANCE	0	0	0	0	0	0	0	0	0	0	0	0

HOLMES & NARVER
GOVERNMENT FISCAL YEAR 1985



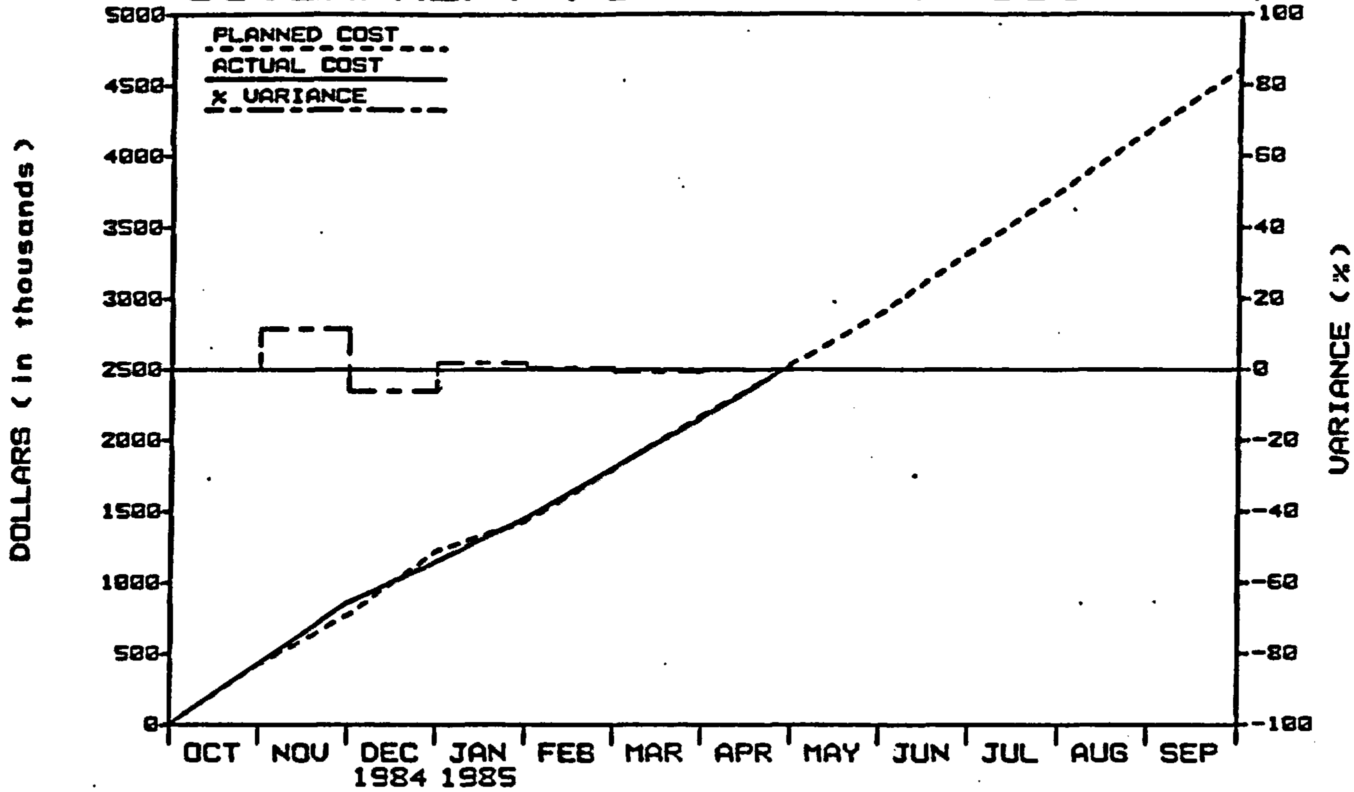
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	41	99	164	228	293	357	422	487	553	618	686	753
COST (X1000)	46	99	151	229	327	380	439	0	0	0	0	0
VARIANCE (X1000)	-5	0	13	-1	-34	-23	-17	0	0	0	0	0
% VARIANCE	12	0	-8	0	12	6	4	0	0	0	0	0

LAWRENCE LIVERMORE NATIONAL LABORATORY
GOVERNMENT FISCAL YEAR 1985



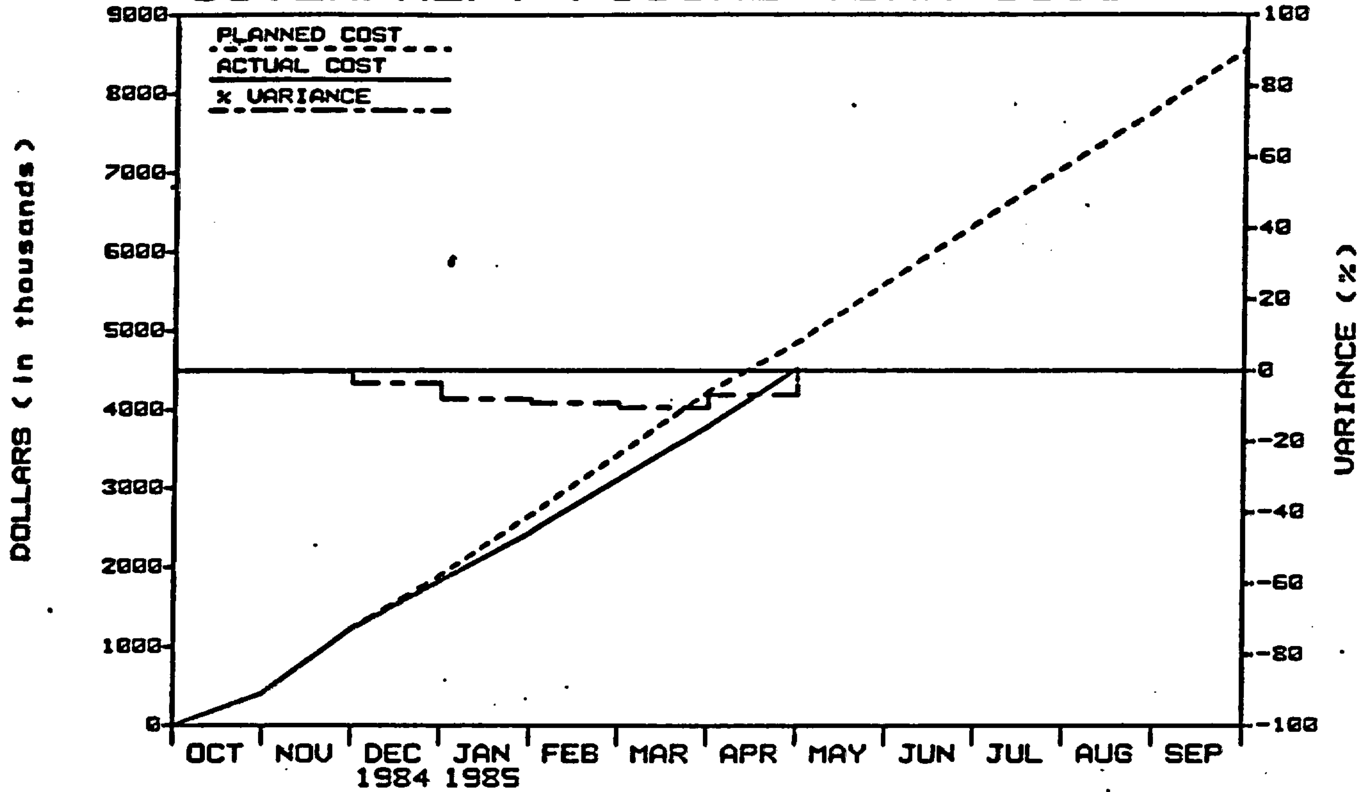
PLAN (X1000)	404	1229	1899	2655	3429	4230	4862	5608	6344	7069	7781	8565
COST (X1000)	404	1226	1829	2437	3113	3785	4526	0	0	0	0	0
VARIANCE (X1000)	0	3	70	218	316	445	336	0	0	0	0	0
% VARIANCE	0	0	-4	-8	-9	-11	-7	0	0	0	0	0

REECO
GOVERNMENT FISCAL YEAR 1985

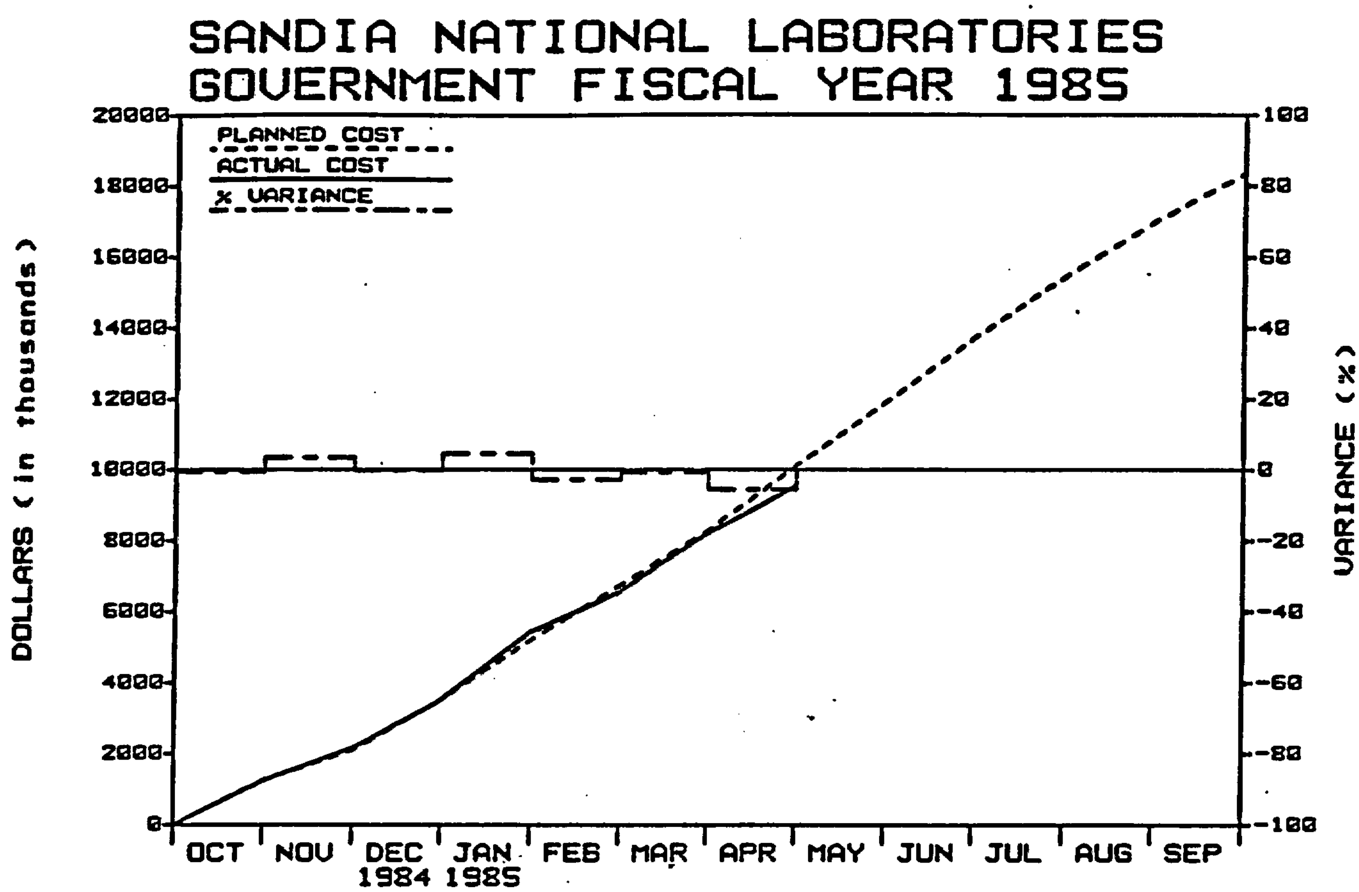


PLAN (X1000)	426	772	1222	1430	1802	2174	2538	2895	3325	3749	4172	4608
COST (X1000)	426	861	1148	1454	1812	2159	2533	0	0	0	0	0
VARIANCE (X1000)	0	-89	74	-24	-10	15	5	0	0	0	0	0
% VARIANCE	0	12	-6	2	1	-1	0	0	0	0	0	0

LAWRENCE LIVERMORE NATIONAL LABORATORY
GOVERNMENT FISCAL YEAR 1985

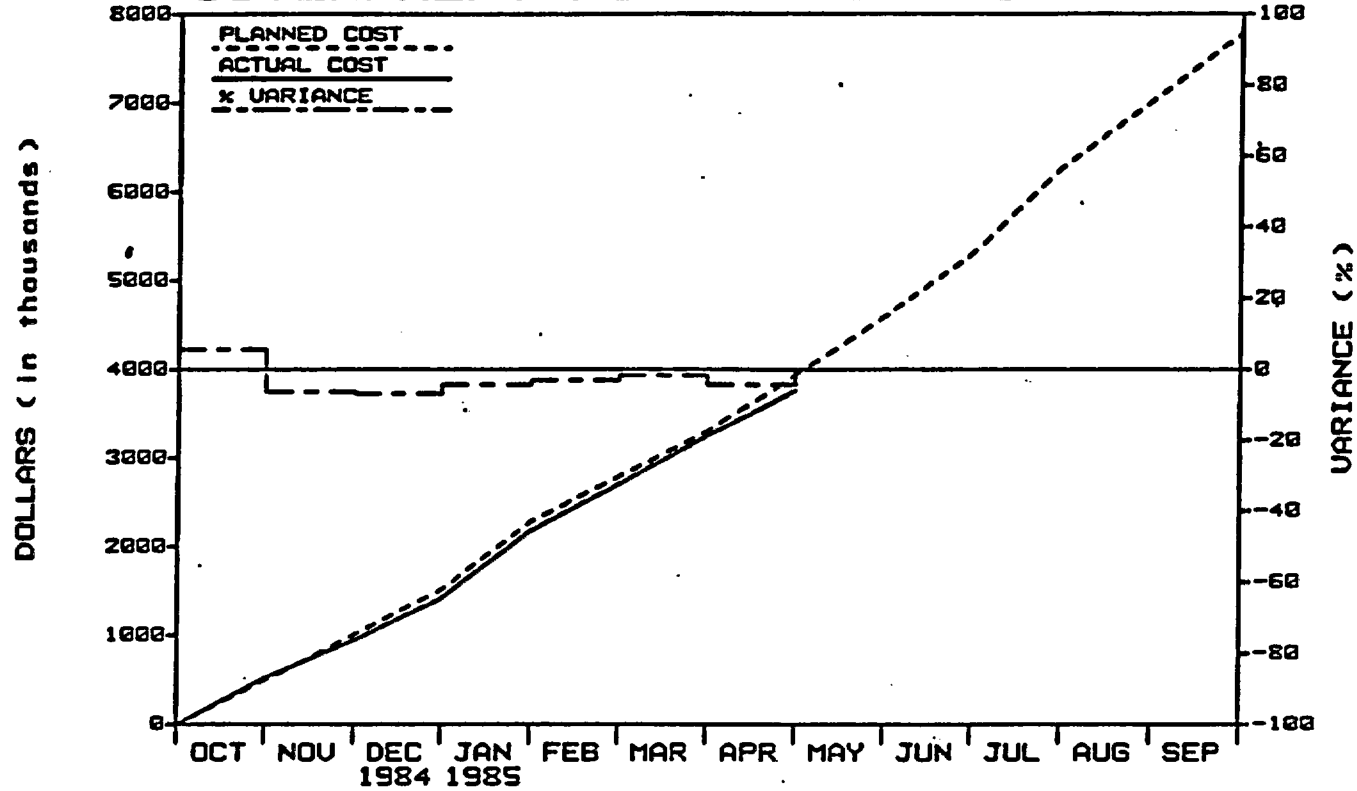


	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLAN (X1000)	404	1229	1899	2655	3429	4230	4862	5608	6344	7069	7781	8565
COST (X1000)	404	1226	1829	2437	3113	3785	4526	0	0	0	0	0
VARIANCE (X1000)	0	3	70	218	316	445	336	0	0	0	0	0
% VARIANCE	0	0	-4	-8	-9	-11	-7	0	0	0	0	0



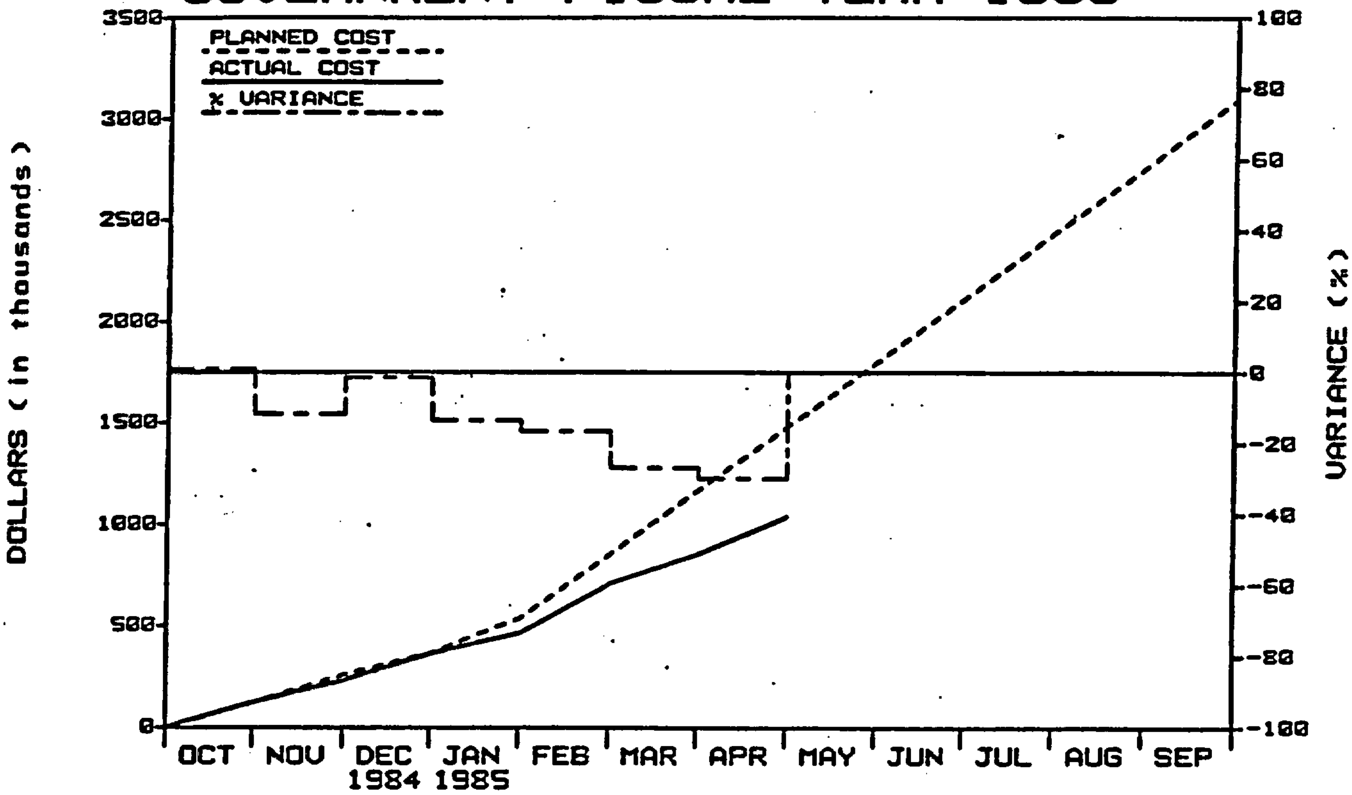
PLAN (X1000)	1240	2091	3527	5197	6736	8289	10115	11898	13722	15429	16976	18334
COST (X1000)	1230	2160	3511	5435	6546	8209	9544	0	0	0	0	0
VARIANCE (X1000)	10	-69	16	-238	190	80	571	0	0	0	0	0
% VARIANCE	-1	3	0	5	-3	-1	-6	0	0	0	0	0

SCIENCE APPLICATIONS INT'L CORP.
GOVERNMENT FISCAL YEAR 1985

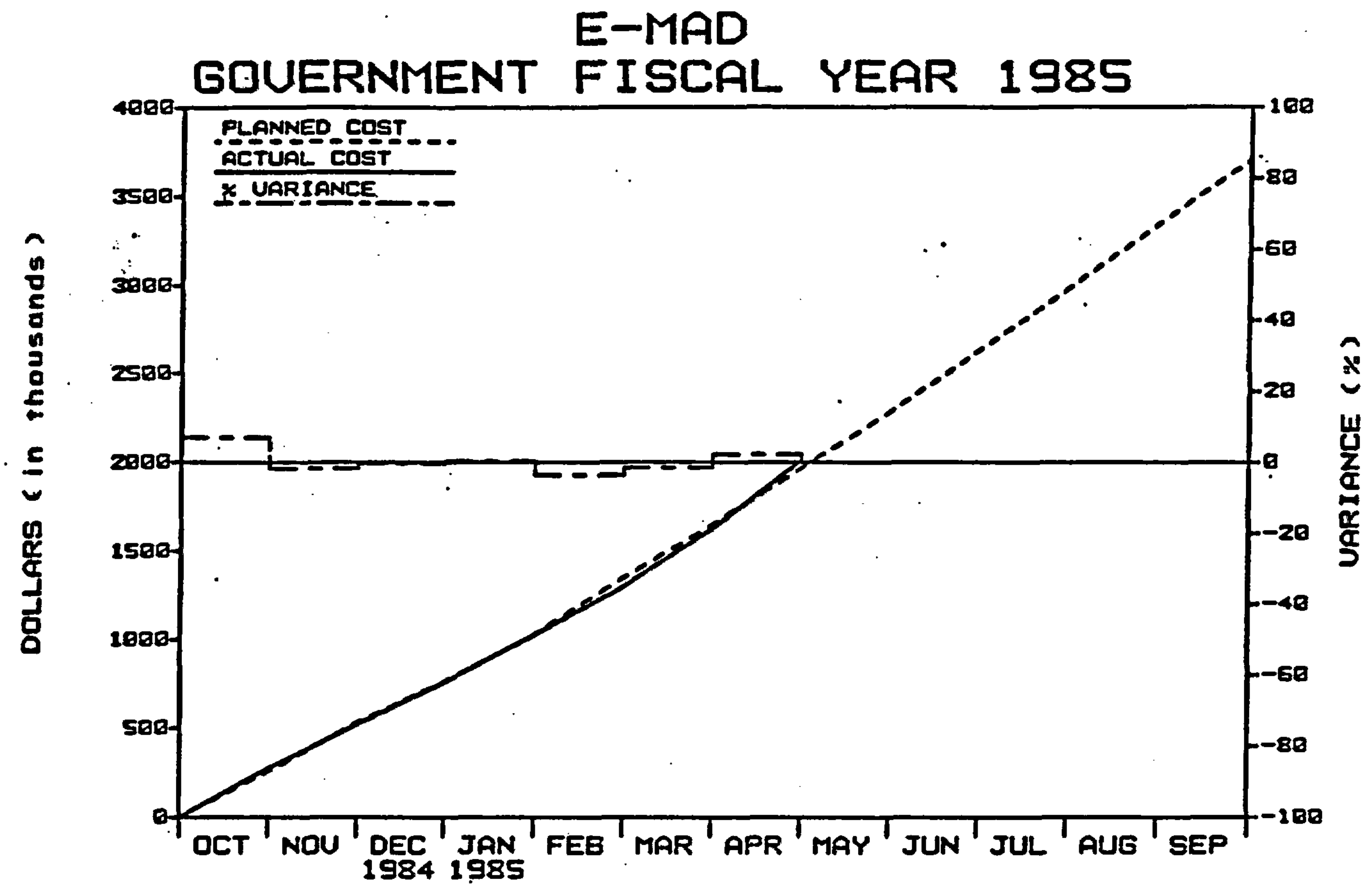


PLAN (X1000)	492	1005	1512	2276	2786	3298	3939	4588	5293	6253	7008	7775
COST (X1000)	519	942	1408	2177	2703	3246	3768	0	0	0	0	0
VARIANCE (X1000)	-27	63	104	99	83	52	171	0	0	0	0	0
% VARIANCE	5	-6	-7	-4	-3	-2	-4	0	0	0	0	0

MISCELLANEOUS CONTRACTORS
GOVERNMENT FISCAL YEAR 1985



PLAN (X1000)	122	258	366	536	851	1167	1483	1799	2114	2436	2756	3091
COST (X1000)	123	228	361	463	709	854	1040	0	0	0	0	0
VARIANCE (X1000)	-1	30	5	73	142	313	443	0	0	0	0	0
% VARIANCE	1	-12	-1	-14	-17	-27	-30	0	0	0	0	0



PLAN (X1000)	255	533	764	1024	1346	1649	1966	2285	2627	2975	3342	3700
COST (X1000)	273	524	761	1028	1296	1624	2009	0	0	0	0	0
VARIANCE (X1000)	-18	9	3	-4	50	25	-43	0	0	0	0	0
% VARIANCE	7	-2	0	0	-4	-2	2	0	0	0	0	0

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
LEVEL 1 MILESTONES IN A TIME WINDOW OF 01 Oct 1984 TO 30 Sep 1985
Run Date: 22 May 1985

MILESTONE DESCRIPTION	WBS NO.	WMPO RESP	LEVEL	RESP ORG	MILESTONE	BASELINED	HQ PLANNED HQ ACTUAL
System Engineering Management Plan	2.1.1.S	Witherill	1	SNL	M108	B	30 Aug 85
Performance Assessment Plan	2.1.1.S	Blanchard	1	SNL	N113	B	30 Sep 85
Yucca Mountain Mined Geologic Disposal System Description (System Requirements)	2.1.2.1.S	Witherill	1	SNL	M120	B	30 Jul 85
Establish Interim Product Specifications	2.2.3.1.L	Valentine	1	WMPO	M250	B	30 Aug 84 12 Apr 85
Input to DOE/HQ Report to Congress on Copper for Waste Packages	2.2.3.2.L	Valentine	1	LLNL	M222	B	01 Aug 85
Complete Waste Package Conceptual Design Criteria	2.2.4.L	Valentine	1	LLNL	M231	B	29 Mar 85
Initiate Waste Package Advanced Conceptual Design	2.2.4.L	Valentine	1	LLNL	M233	B	30 Apr 85
Pre-Closure Analysis of Selected Conceptual Designs	2.2.4.L	Valentine	1	LLNL	M251	B	28 Sep 84 20 Dec 84
Weapons Test Seismic Report	2.3.2.2.4.S	Blanchard	1	WMPO	M357	B	15 Jan 85
Progress Report on 3-Dimensional Mineralogic Model of Yucca Mountain	2.3.2.A	Blanchard	1	LANL	M355	B	31 Aug 84 10 Oct 84
Letter Report on Groundwater Chemistry Along Flow Paths	2.3.4.1.1.A	Blanchard	1	LANL	M354	B	30 Aug 84 14 Feb 85

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
LEVEL 1 MILESTONES IN A TIME WINDOW OF 01 Oct 1984 TO 30 Sep 1985
Run Date: 22 May 1985

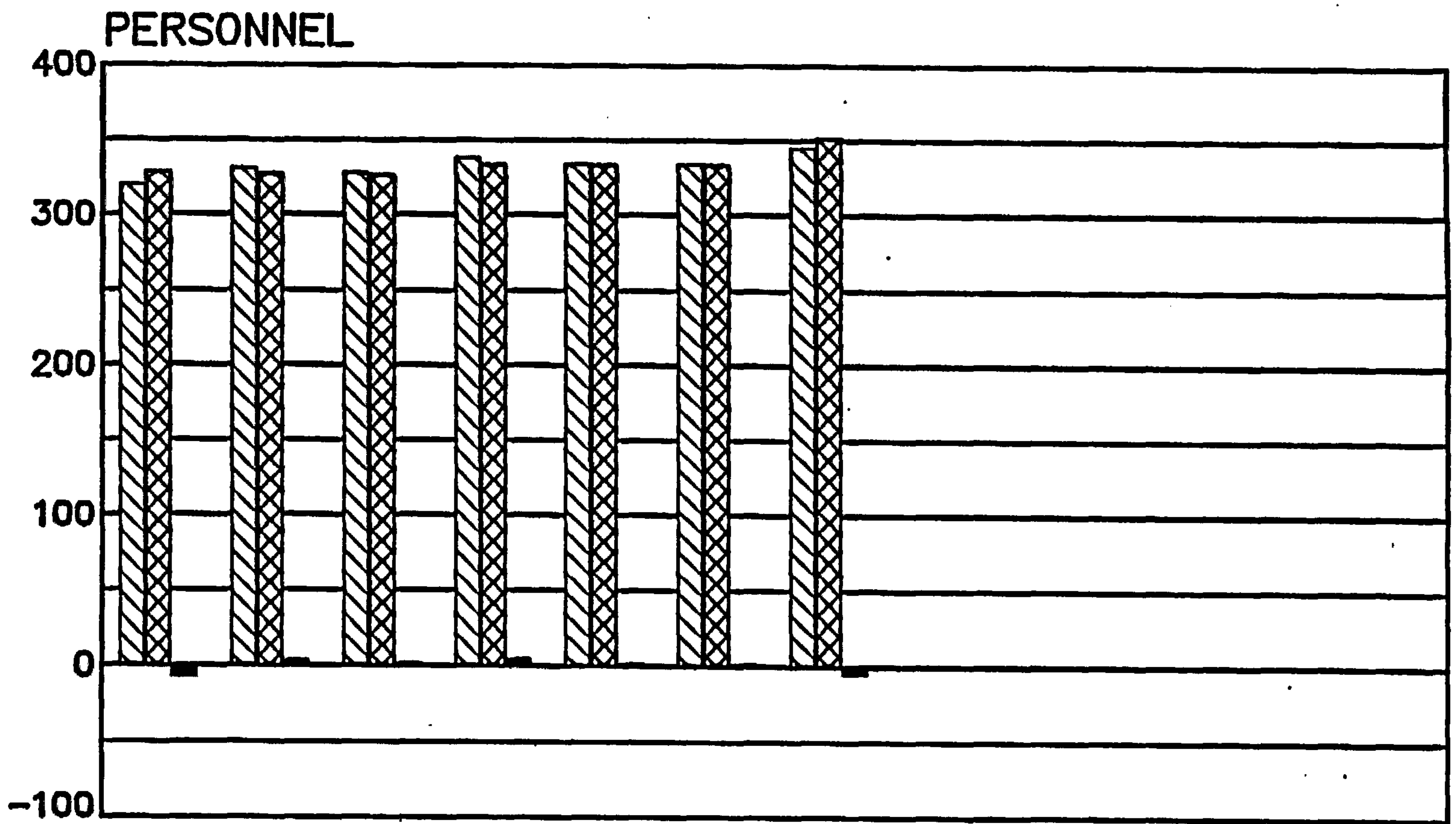
MILESTONE DESCRIPTION	WBS NO.	WMPO RESP	LEVEL	RESP ORG	MILESTONE	BASELINED	HQ PLANNED HQ ACTUAL
Complete Report on Volcanic Hazards Analysis	2.3.6.1.A	Blanchard	1	LANL	M356	B	28 Sep 84 22 Jan 85
Implementation of Meteorological Monitoring Plan	2.3.6.1.T	Blanchard	1	SAIC	M364	B	01 Jun 85
Start Repository Conceptual Design	2.4.1.S	Skousen	1	SNL	N430	B	30 Sep 85
NNWSI Project Site Specific Repository Design Concepts Report	2.4.1.S	Skousen	1	SNL	N432	B	30 Sep 85
Horizontal Waste Emplacement Equipment Development Plan	2.4.2.2.1.S	Skousen	1	SNL	N466	B	30 Aug 85
Seal Development Plan for Repository to OCRWM for Review	2.4.2.3.1.S	Skousen	1	SNL	M447	B	12 Nov 84 17 Dec 84
Draft Environmental Assessment (Camera ready)	2.5.3.1.T	Blanchard	1	SAIC	M502	B	30 Nov 84 29 Nov 84
EA Comment/Response Document	2.5.3.1.T	Blanchard	1	SAIC	M503	B	30 May 85
Final Environmental Assessment	2.5.3.1.T	Blanchard	1	SAIC	M504	B	20 Jun 85
NNWSI Project References for EA Complete	2.5.3.1.T	Blanchard	1	SAIC	M523	B	01 Aug 84 06 Mar 85
Issue Exploratory Shaft Test Plan (ESTP) (NVO-244)	2.6.9.1.A	Witherill	1	LANL	M666	B	27 Sep 85

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
LEVEL 1 MILESTONES IN A TIME WINDOW OF 01 Oct 1984 TO 30 Sep 1985
Run Date: 22 May 1985

MILESTONE DESCRIPTION	WBS NO.	WMPO RESP	LEVEL	RESP ORG	MILESTONE	BASELINED	HQ PLANNED HQ ACTUAL
Complete Decision Analysis on Use of Climax Facility	2.7.1.L	Kunich	1	LLNL	M706	B	15 Oct 84 06 Jul 84
Final Report on the SFT-C	2.7.2.1.L	Valentine	1	LLNL	M708	B	30 Sep 85
Submit FY 85 NNWSI Project Plan to DOE/HQ for Approval	2.9.1.1.T	Vieth	1	SAIC	M901	B	15 Mar 85 09 Jan 85
Draft Project Management Plan	2.9.1.T	Kunich	1	SAIC	M907	B	29 Mar 85
Submit NVO-196-18 (Rev. 2) NNWSI Project Quality Assurance Program Plan and Implementing Procedures to DOE/HQ for Approval	2.9.3.T	Blaylock	1	SAIC	M915	B	30 Nov 84 30 Nov 84

NO. MILESTONES IN THIS REPORT: 27

- NNWSI PROJECT STAFFING -
FISCAL YEAR 1985



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
B	321	332	329	339	335	335	346					
A	329	328	327	334	334	334	352					
V	−8	4	2	5	1	1	−6					

Listed below are mini-agendas for the June 26-27 PM-TPO meeting.

What	Who	Time
Earned Value Presentation - Macdonald... June 26, 10:15-11:00 a.m.		
Review findings from final report --System impact factors --Results of participant cost estimate --Pivotal issues --WMPO concurrence	Don	15 min.
Discussion of implementation plan --Sequence of events - training and support to be provided in August and September - cost account plans - cost performance report --Budget Planning: Possibility of establishing interim budget/baseline for first four months of FY 86 --Software support - network processes/output - baseline detail - data and variance reporting	Don	30 min.

OUTCOME: Understand Status of Earned Value Progress

Waste Package Presentation - LLNL... June 26, 1:00-5:00 pm

Waste Package Task Overview	Virginia	15 min.
Metal Barriers Selection and Testing		
--Conceptual Model for Corrosion under Yucca Mtn. Conditions	Dan	10 min.
---Questions and Answers	Dan/Don/TPOs	2 min.
--Radiation Effects on Environment	Rich	10 min.
---Questions and Answers	Rich/Don/TPOs	2 min.
--Localized Corrosion Testing	Bob	30 min.
---Questions and Answers	Bob/Don/TPOs	4 min.
--Stress Corrosion Testing	Mary	30 min.
---Questions and Answers	Mary/Don/TPOs	4 min.
--Summary and Future Work	Dan	10 min.
---Questions and Answers	Dan/Don/TPOs	2 min.
Break		15 min.
Spent Fuel Testing		
--Model for Release under Yucca Mtn. Conditions	Virginia	15 min.
--Questions and Answers	Don/TPOs	3 min.
--Test Description for Dissolution Studies	Virginia	15 min.
---Questions and Answers	Don/TPOs	3 min.
--Results of Dissolution Tests	Virginia	30 min.
---Questions and Answers	Don/TPOs	4 min.
--Oxidation of Spent Fuel	Virginia	15 min.
---Questions and Answers	Don/TPOs	3 min.
--Zircaloy Corrosion Studies	Virginia	15 min.
---Questions and Answers	Don/TPOs	3 min.

OUTCOME: Understand Status of Waste Package Progress

SCP - Jorgenson/Voegele... Thursday, June 27, 9:00-10:00 a.m.

Present SCP Working Schedule	Dave or Mike
Present Detailed Review Schedule	Dave or Mike
Discuss need to stick to schedules as presented	Dave or Mike/Don/ TPOs
Identify problem areas and discuss	TPOs/Dave/Mike

OUTCOME: Agree to adhere to the SCP working schedule

NNWSI WASTE PACKAGE - METAL BARRIERS SELECTION AND TESTING

TPO MEETING, LAS VEGAS, 26 JUNE 1985

TIME	TOPIC	PRESENTER
20 MIN.	CONCEPTUAL MODELS FOR CORROSION OF WP CONTAINERS	DANIEL MCCRIGHT
15 MIN.	ENVIRONMENTAL CONDITIONS FOR CORROSION IN TUFF ENVIRONMENTS	RICH VAN KONYNENBURG
40 MIN.	LOCALIZED CORROSION; CORROSION IN IRRADIATED ENVIRONMENTS	ROBERT GLASS
40 MIN.	STRESS CORROSION	MARY JUHAS
5 MIN.	SUMMARY	DANIEL MCCRIGHT
120 MIN.		

OBJECTIVES OF METAL BARRIER SELECTION AND TESTING SUB-TASK

- SELECT CONTAINER MATERIAL THAT CAN MEET 300-1000 YEAR CONTAINMENT OBJECTIVE FOR WASTE PACKAGE -- POSSESS SUFFICIENT CORROSION/OXIDATION RESISTANCE IN TUFF GEOLOGICAL ENVIRONMENT.

- SELECT CONTAINER MATERIAL WHICH CAN BE READILY FABRICATED AND WELDED INTO THE DESIGNED GEOMETRIC SHAPE -- SPECIFY FABRICATION/WELDING PROCESSES AS THESE OFTEN INFLUENCE CORROSION/OXIDATION BEHAVIOR.

- TEST CANDIDATE CONTAINER MATERIALS UNDER EXPECTED REPOSITORY ENVIRONMENTAL CONDITIONS AND UNDER POSSIBLE EPISODIC ENVIRONMENTAL CONDITIONS -- SUPPLIES DATA BASE FOR REPOSITORY LICENSING APPLICATION AND LONG-TERM PERFORMANCE MODELING.

REFERENCE AND ALTERNATIVE CONTAINER MATERIALS FOR TUFF REPOSITORY -- CONCEPTUAL DESIGN LEVEL

- AUSTENITIC STAINLESS STEELS SERVE AS REFERENCE MATERIALS, PARTICULARLY:
  - TYPE 304L STAINLESS STEEL - MOST TESTING SO FAR HAS BEEN FOCUSED ON THIS MATERIAL AS THE REFERENCE GRADE
  - TYPES 316L, 321 STAINLESS STEEL AND HIGH-NICKEL ALLOY 825 - THESE ALTERNATIVE GRADES ARE MORE RESISTANT TO SPECIFIC LOCALIZED/STRESS-ASSISTED FORMS OF CORROSION
- COPPER AND COPPER BASE ALLOYS SERVE AS AN ALTERNATIVE ALLOY SYSTEM TO THE STAINLESS STEELS

Table 7-8. General corrosion rates of candidate austenitic stainless steels and stainless alloys in J-13 water at different temperatures

ALLOY	TEMP (°C)	TIME (HRS)	CORROSION RATE (um/yr)[a] Avg.	Std Dev.
304L	50	11,512	0.133	0.018
316L	50	11,512	0.154	0.008
317L	50	11,512	0.225	0.010
321	50	11,512	0.166	0.007
347	50	11,512	0.185	0.019
825	50	11,512	0.211	0.013
304L	80	11,056	0.085	0.001
316L	80	11,056	0.109	0.005
317L	80	11,056	0.104	0.010
321	80	11,056	0.043	0.008
347	80	11,056	0.085	0.007
825	80	11,056	0.109	0.012
304L	100	10,360	0.072	0.023
316L	100	10,360	0.037	0.011
317L	100	10,360	0.030	0.007
321	100	10,360	0.030	0.008
347	100	10,360	0.056	0.011
825	100	10,360	0.049	0.019

a Average and standard deviation of three replicate samples of each alloy at each test temperature.

Table 7-9. Corrosion rates of candidate stainless steels and alloys in steam

Material	Corrosion Rate[a] (um/yr) in 100°C Saturated Steam (10,456 Hours)	Corrosion Rate[a] (um/yr) in 150°C Unsaturated Steam (3,808 Hours)
304L	0.102	0.071
316L	0.099	0.064
317L	0.211	0.081
321	0.081	0.102
347	0.091	0.122
825	0.102	0.030

a (average of three replicate specimens of each alloy in each condition)

POSSIBLE NON-UNIFORM CORROSION DEGRADATION MODES IN AUSTENITIC STAINLESS STEELS CAN BE PLACED INTO TWO CAUSATIVE CATEGORIES

- DEGRADATION MODES CAUSED BY A "SENSITIZED MICROSTRUCTURE" WHICH DEVELOPS FROM PROCESSING OR STORING THE CONTAINER AT AN ELEVATED TEMPERATURE.
  - RESULT COULD BE INTERGRANULAR CORROSION OR INTERGRANULAR STRESS CORROSION CRACKING.
- CONTACT OF THE CONTAINER WITH AN AQUEOUS ENVIRONMENT WHICH IS SIGNIFICANTLY MORE CONCENTRATED IN ELECTROLYTES THAN IS J-13 WELL WATER.
  - RESULT COULD BE PITTING OR CREVICE CORROSION, OR TRANSGRANULAR STRESS CORROSION CRACKING.

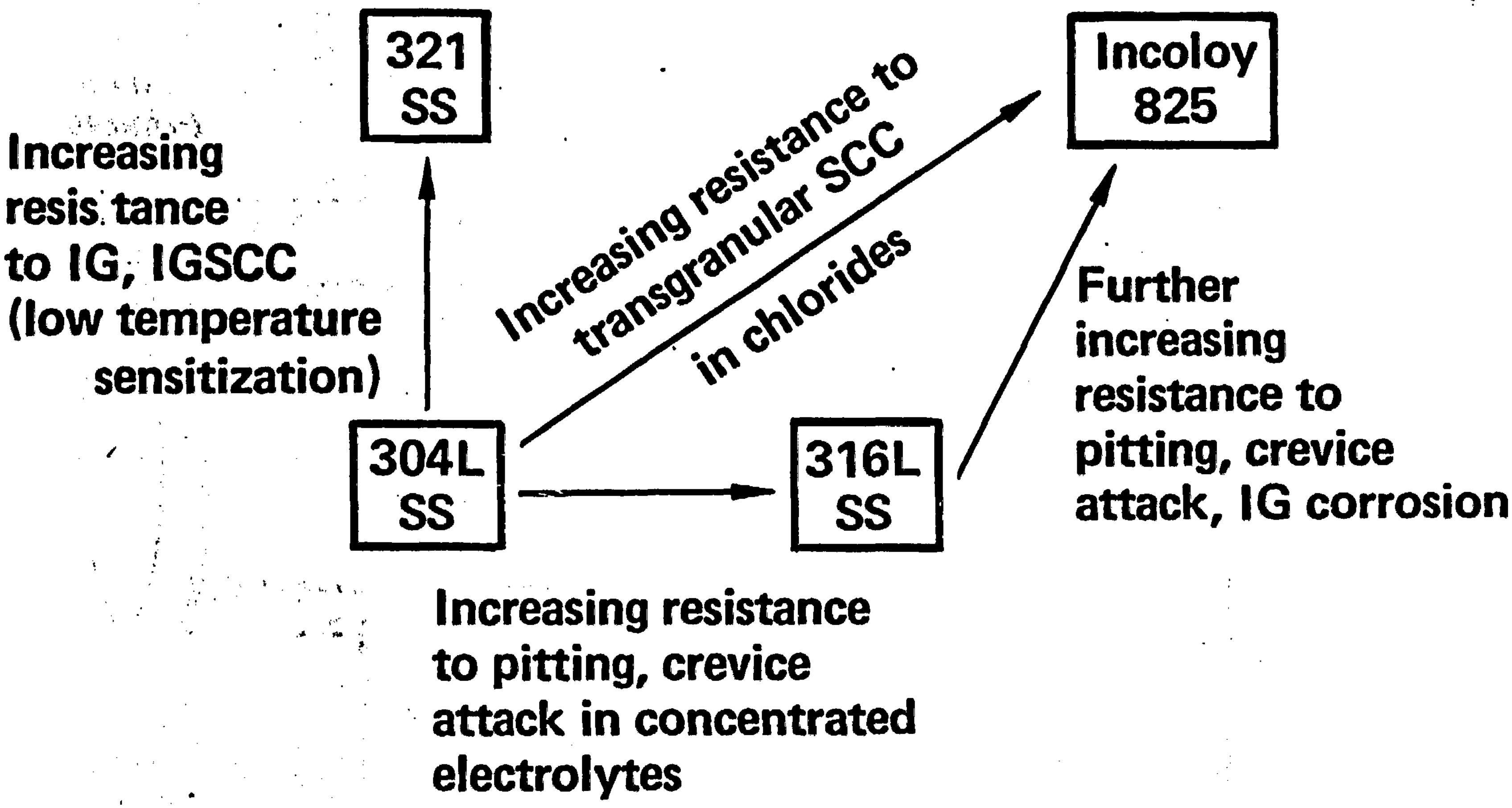
THESE POSSIBILITIES ARE ADDRESSED IN THE NEXT GROUP OF SLIDES.

Alloy composition for reference and alternative canister and overpack materials

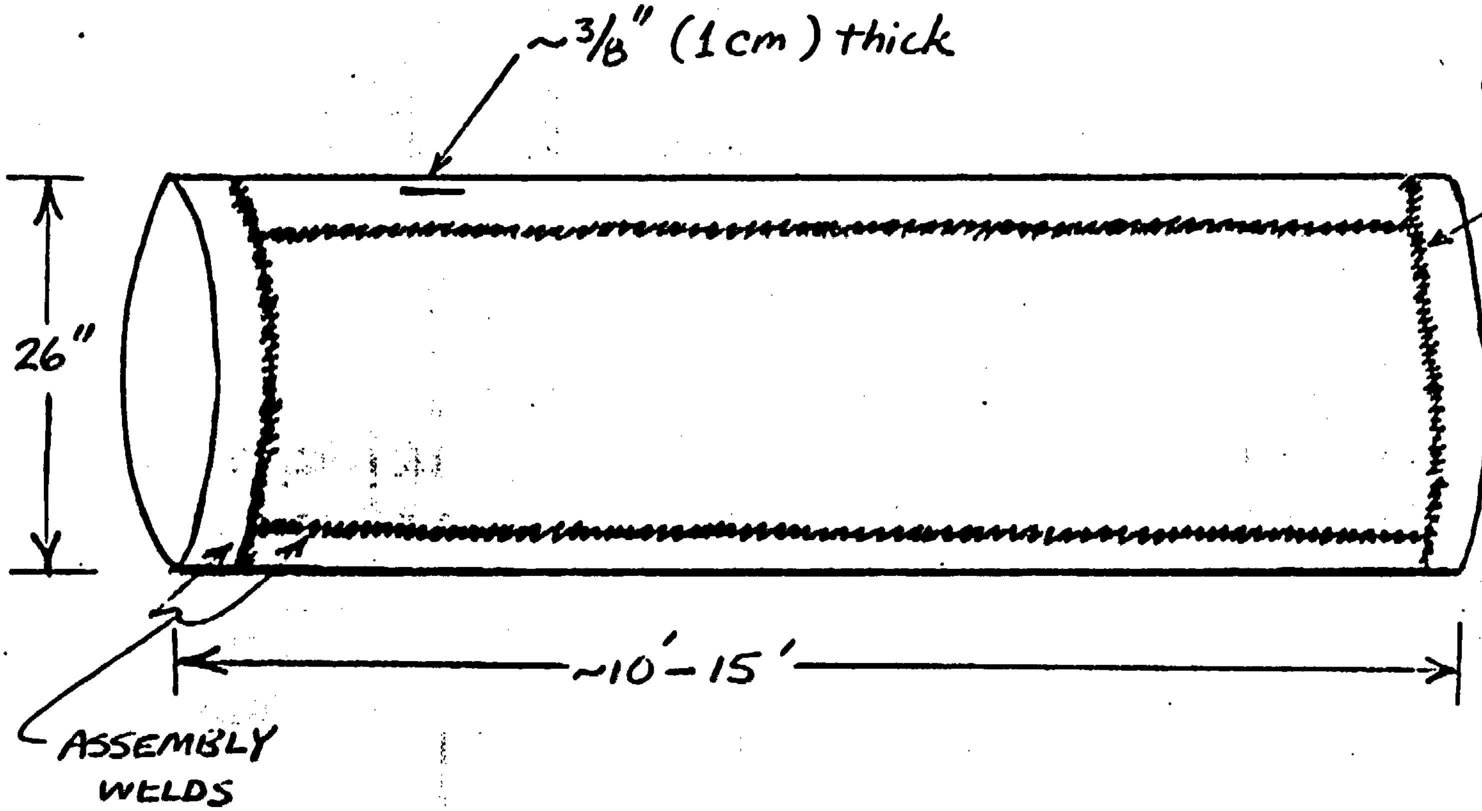
Chemical composition (weight per cent)

Common alloy designations	Carbon (max)	Manganese (max)	Phosphorus (max)	Sulfur (max)	Silicon (max)	Chromium (range)	Nickel (range)	Other elements
304L	0.03	2.0	0.045	0.03	1.0	18-20	8-12	N: 0.1 max
316L	0.03	2.0	0.045	0.03	1.0	16-18	10-14	Mo: 2.0-3.0 N: 0.1 max
321	0.08	2.0	0.045	0.03	1.0	17-19	9-12	Ti: 5 X C min
825	0.05	1.0	not specified	0.03	0.5	19.5-23.5	38-46	Mo: 2.5-3.5 Ti: 0.6-1.2 Cu: 1.5-3.0 Al: 0.2 max

Alloy selection to solve localized/stress corrosion problems with stainless steel



NNWSI CONCEPTUAL DESIGN WP CONTAINERS



CONTAINER CLOSURE WELD PRESENTS TECHNICAL CHALLENGES

- INTEGRITY OF WELD (CRACKS, POROSITY, PENETRATION)
- ADVERSE EFFECT OF HEAT AFFECTED ZONE (HAZ) ON CONTAINER PERFORMANCE

RESTRAINTS IN MAKING CLOSURE WELD

- WELD, POST-WELD INSPECT REMOTELY
- PRECLUDE POST-WELD HEAT TREATMENTS, STRESS RELIEFS

CONSIDERATIONS

- HOMOGENEITY
- DEPTH OF PENETRATION
- H.A.Z. (SIZE, GRADIENT)

POSSIBLE WELD PROCESSES

- GAS METAL ARC (GMA)
- GAS TUNGSTEN ARC (GTA)
- GTA + GMA
- RESISTANCE
- ELECTRON BEAM
- LASER BEAM
- PLASMA ~~BEAM~~ ARC

TECHNICAL ISSUES ON USE OF CU AND CU-BASE ALLOYS AS NUCLEAR WASTE CONTAINER MATERIALS FALL INTO THREE GENERAL CATEGORIES

1. COMPATIBILITY OF CU/CU ALLOYS WITH GEOCHEMICAL ENVIRONMENT
   - RADIATION INDUCED GENERAL CORROSION (EFFECTS OF NITRATE, AMMONIA, HYDROGEN PEROXIDE)
   - LOCALIZED CORROSION (PITTING, CREVICE, SELECTIVE LEACHING OF ALLOYS)
   - STRESS CORROSION (RADIATION INDUCED EFFECTS OF AMMONIA)

2. COMPATIBILITY OF CU/CU ALLOYS WITH PROCESSES PROPOSED FOR FABRICATING AND CLOSING NUCLEAR WASTE CONTAINERS
   - LOWER STRENGTH METALS/ALLOYS, THICKER CONTAINERS
   - WELDABILITY OF COPPER, ESPECIALLY IN THICK SECTIONS
   - ALTERNATIVE FABRICATION TECHNOLOGIES, I.E., HOT ISOSTATIC PRESSING

3. COMPATIBILITY OF CU/CU ALLOYS WITH OTHER COMPONENTS IN WASTE PACKAGE
   - GALVANIC EFFECTS BETWEEN CU AND ZIRCALOY CLADDING (SF)
   - GALVANIC EFFECTS BETWEEN CU AND STAINLESS STEEL POUR CANISTER (DHLW)
   - EFFECTS OF COPPER CORROSION PRODUCTS ON GLASS AND ON SPENT FUEL LEACHING

NNWSI COPPER TEST PLAN

COPPER DEVELOPMENT ASSOCIATION (CDA) -
INTERNATIONAL COPPER RESEARCH ASSOCIATION (INCRA)
RECOMMENDED LIST OF ALLOYS

ALLOY	DESCRIPTOR	COMMENTS
CDA 102	OXYGEN FREE, HIGH-CONDUCTIVITY PURE COPPER	LOW STRENGTH, EXCEEDINGLY DUCTILE MATERIAL, REFERENCE MATERIAL FOR SWEDISH KBS SPENT FUEL CONTAINER PROGRAM IN GRANITE.
CDA 613	ALUMINUM BRONZE	MORE CORROSION RESISTANT THAN CURE Cu IN OXIDIZING ENVIRONMENTS.
CDA 715	70/30 CUPRONICKEL	PROBABLY MOST CORROSION RESISTANT Cu-BASE ALLOY IN OXIDIZING ENVIRONMENTS.

IMPORTANT MILESTONES IN CONTAINER MATERIALS EVALUATION

- END OF FY85, PRELIMINARY EVALUATION ON COPPER AS CONTAINER MATERIAL
- END OF FY86, DECISION ON WHETHER COPPER IS VIABLE CONTAINER MATERIAL
- END OF FY87, SELECTION OF MATERIAL FOR ADVANCED WASTE PACKAGE CONTAINER DESIGNS

CHOICE OF MATERIALS WILL INVOLVE SOME DESIGN OPTIONS

- THICKER CONTAINER SECTION FOR LOWER STRENGTH MATERIALS
- INCREASE RADIATION SHIELDING WITH THICKER CONTAINER SECTION
- THICKER CONTAINER MORE COSTLY: MORE MATERIAL, POSSIBLY MORE EXPENSIVE
- FABRICATION/WELDING PROCESSES, MORE EXPENSIVE HANDLING EQUIPMENT
- BUT ADDITIONAL COSTS MAY BUY INCREASED CERTAINTY IN PERFORMANCE PREDICTIONS

ECONOMIC ISSUES CENTER ON PROBABLY USE OF THICKER SECTIONS
OF GENERALLY MORE-COSTLY MATERIALS (Cu/Cu BASE ALLOYS)
COMPARED TO AUSTENITIC STAINLESS STEELS

ALLOY	COMPARABLE YIELD STRESS (KSI)	$/CU. IN.
CDA 102	10	0.60
CDA 613	30	0.65
CDA 715	17	0.85
304L SS	25	0.40
316L SS	25	0.50
321 SS	30	0.50
IY-825	35	1.20

HOW WILL METAL BARRIER TEST DATA BE USED TO DEMONSTRATE ACHIEVEMENT OF "SUBSTANTIALLY COMPLETE" CONTAINMENT

- NEED TO FORMULATE PLAN/STRATEGY FOR THIS DEMONSTRATION
- PLAN TO SHOW SIGNIFICANCE OF INTERPRETING CORROSION DATA WHICH IS OFTEN GENERATED FROM SEVERE AND AGGRESSIVE CONDITIONS
- PLAN TO SUGGEST WAYS FOR FUTURE DATA ACQUISITION AND HOW TO PRESENT THESE DATA

SOME THOUGHTS ON ITEMS IN THE DEMONSTRATION PLAN

- O PHENOMENA WHICH CAN COMPROMISE CONTAINMENT OBJECTIVE OCCUR ABOVE "CRITICAL THRESHOLDS"
  - O MICROSTRUCTURAL
  - O ENVIRONMENTAL
  - O MECHANICAL
- O NEED TO DETERMINE PROBABILITY OF EXCEEDING THESE THRESHOLDS, LOCALLY OR IN BULK

EXAMPLES:

MICROSTRUCTURAL - NUMBER OF GRAIN BOUNDARIES THAT WILL SENSITIZE, IN WHAT TIME, SURFACE AREA AFFECTED, NUMBER OF CONTAINERS AFFECTED

ENVIRONMENTAL - AMOUNT AND STATISTICAL DISTRIBUTION OF WATER ENTERING WP ENVIRONMENT, DISTRIBUTION ON CONTAINER SURFACE, RESIDENCE TIME, IONIC CONTENT OF WATER, CHANGES OF IONIC CONTENT WITH TIME IN THERMAL AND RADIATION FIELDS

MECHANICAL - MAGNITUDE OF STRESS, STRESS DISTRIBUTION, FABRICATION/WELDING DEFECTS (SIZE, DISTRIBUTION), STRESS-INDUCED CHANGES IN MICROSTRUCTURE

ENVIRONMENTAL CONDITIONS FOR CORROSION IN TUFF REPOSITORY

RICH VAN KONYNENBURG

A TALK PREPARED FOR THE NNWSI TECHNICAL
PROJECT OFFICERS MEETING IN LAS VEGAS
ON JUNE 26, 1985.

ENVIRONMENTAL PARAMETERS IMPORTANT TO CORROSION

1. Physical State of Corrosion Medium
2. Composition
3. Temperature
4. Pressure
5. pH
6. Oxygen Potential
7. Flow Rate
8. Radiation

EXPECTED INITIAL ENVIRONMENT
(BEFORE WASTE EMPLACEMENT)

1. PHYSICAL STATE OF FLUID MEDIUM-

   TWO-PHASE, MOIST AIR-LIQUID WATER, 65 ± 19% SATURATION.

2. COMPOSITION

   A. SOLID

      ROCK - WELDED, DEVITRIFIED TUFF WITH ABOUT 14% POROSITY AND NUMEROUS FRACTURES.

      MINERALS - QUARTZ, CRISTOBALITE, FELDSPARS, AND OTHERS.

      CHEMICAL COMPOSITION (R. A. ZIELINSKI, USGS-OFR-83-480):

OXIDE	APPROX. WT. %
SiO_2	75.2
Al_2O_3	12.4
K_2O	4.8
Na_2O	3.1
Fe_2O_3	1.8
CaO	0.5
MgO	0.2
TiO_2	0.1
MnO	0.06
LOSS ON IGNITION	1.0
TOTAL	99.16

EXPECTED INITIAL ENVIRONMENT
(CONT'D.)

2. COMPOSITION (CONT'D.)

B. GAS — AIR (100% REL. HUMIDITY)

C. LIQUID — VADOSE WATER WITH DISSOLVED SOLIDS AND GASES.

J-13 WELL WATER -
(IC, ICP-OES, & TECHNICON AUTOANALYZER)

SPECIES	(MG/L)	mM
HCO_3	125	2.0
SO_4	19	0.20
NO_3	9.6	0.15
CL	6.9	0.19
F	2.2	0.12
NA	44	1.9
CA	12.5	0.31
K	5.1	0.13
MG	1.9	0.08
SI	27.0	0.96

DISSOLVED GASES (ASSUMED SATURATED):

N_2		0.4
O_2		0.2
CO_2		0.01

EXPECTED INITIAL ENVIRONMENT
(CONT'D.)

3.	TEMPERATURE	29°C
4.	PRESSURE	0.1 MPA (ATMOSPHERIC)
5.	pH	NEUTRAL TO SLIGHTLY ALKALINE
6.	REDOX CONDITION	OXIDIZING (AIR PRESENT)
7.	WATER INFILTRATION RATE	LESS THAN 1 MM/YEAR
8.	GAMMA DOSE RATE	ABOUT 10^{-4} RAD/HOUR (BACKGROUND)

THERMAL AND PHYSICAL CHANGES EXPECTED TO BE CAUSED BY WASTE EMPLACEMENT

1. TEMPERATURE OF PACKAGE SURFACE WOULD RISE TO A MAXIMUM AFTER 9 TO 40 YEARS AND WOULD THEN DECREASE.

2. PEAK TEMPERATURE WOULD NOT EXCEED 270°C.

3. BOILING POINT IS ABOUT 95°C AT REPOSITORY ELEVATION.

4. NO LIQUID WATER COULD EXIST NEAR PACKAGES FOR OVER 100 YEARS FOR DEFENSE WASTES AND FOR OVER 1,000 YEARS FOR 10-YEAR-OLD SPENT FUEL.

5. CORROSION MEDIUM WOULD BE SINGLE-PHASE AIR-STEAM MIXTURE FOR AT LEAST 100 YEARS FOR DEFENSE WASTES AND FOR THE ENTIRE CONTAINMENT PERIOD FOR INITIALLY YOUNG SPENT FUEL.

6. AFTER THE 95°C ISOTHERM MOVED BACK TO PACKAGES, CONDENSATION COULD PRODUCE SOME LIQUID WATER NEAR THEM, AND INFILTRATION OF VADOSE WATER COULD RESUME. A TWO-PHASE AIR-WATER MEDIUM COULD EXIST.

WHEN LIQUID WATER RETURNS, HOW MIGHT ITS COMPOSITION DIFFER FROM THAT OF THE INITIAL GROUNDWATER, AS A RESULT OF THERMAL PROCESSES?

1. POSSIBLY HIGHER CONCENTRATION OF THE MORE SOLUBLE SPECIES, BECAUSE OF RE-SOLUTION WITH LESS WATER OR BECAUSE OF DISTILLATION.

2. HIGHER SiO_2 CONCENTRATION (PERHAPS BY A FACTOR OF 2).

3. HIGHER pH, BECAUSE CO_2 WOULD BE DRIVEN OFF, AND INORGANIC CARBON EQUILIBRIUM WOULD SHIFT. (PRESENCE OF GROUT WOULD ALSO TEND TO INCREASE pH.)

4. LOWER Ca AND Mg CONCENTRATIONS, BECAUSE OF RETROGRADE SOLUBILITIES OF THEIR CARBONATES.

5. <u>POSSIBLE</u> CONSEQUENCES FOR CORROSION:
   - A. HIGHER HALIDE ION CONCENTRATIONS (DETRIMENTAL)
   - B. LOWER "BENIGN" ION CONCENTRATIONS (DETRIMENTAL)
   - C. HIGHER pH (BENEFICIAL)
   - D. DEPOSITION OF CARBONATES ON PACKAGE SURFACE (COULD BE EITHER BENEFICIAL OR DETRIMENTAL)

APPROXIMATE GAMMA RAY DOSE RATES AT CANISTER SURFACE (5 YR. DECAY)

		Rads/hr.
1.	Defense High Level Waste (Baxter, SRP, 1982)	5×10^3
2.	Commercial Spent Fuel (Wilcox & Van K., UCRL-53159, 1981)	1×10^4
3.	Commercial High Level Waste (Slate et al., PNL-3838, 1981)	2×10^5

FOR COMPARISON:

1.	Natural Radioactivity in Earth's crust	2×10^{-4}
2.	Minimum observed dose rate for "noticeable" increase in corrosion rate of iron in humid air in 100-hour test. (Byalobzheskii, 1970)	4×10^3
3.	Typical ^{60}Co facility	up to 10^7
4.	Core of operating reactor	$>10^9$

Calculated Dose Rates in Climax Spent Fuel Test

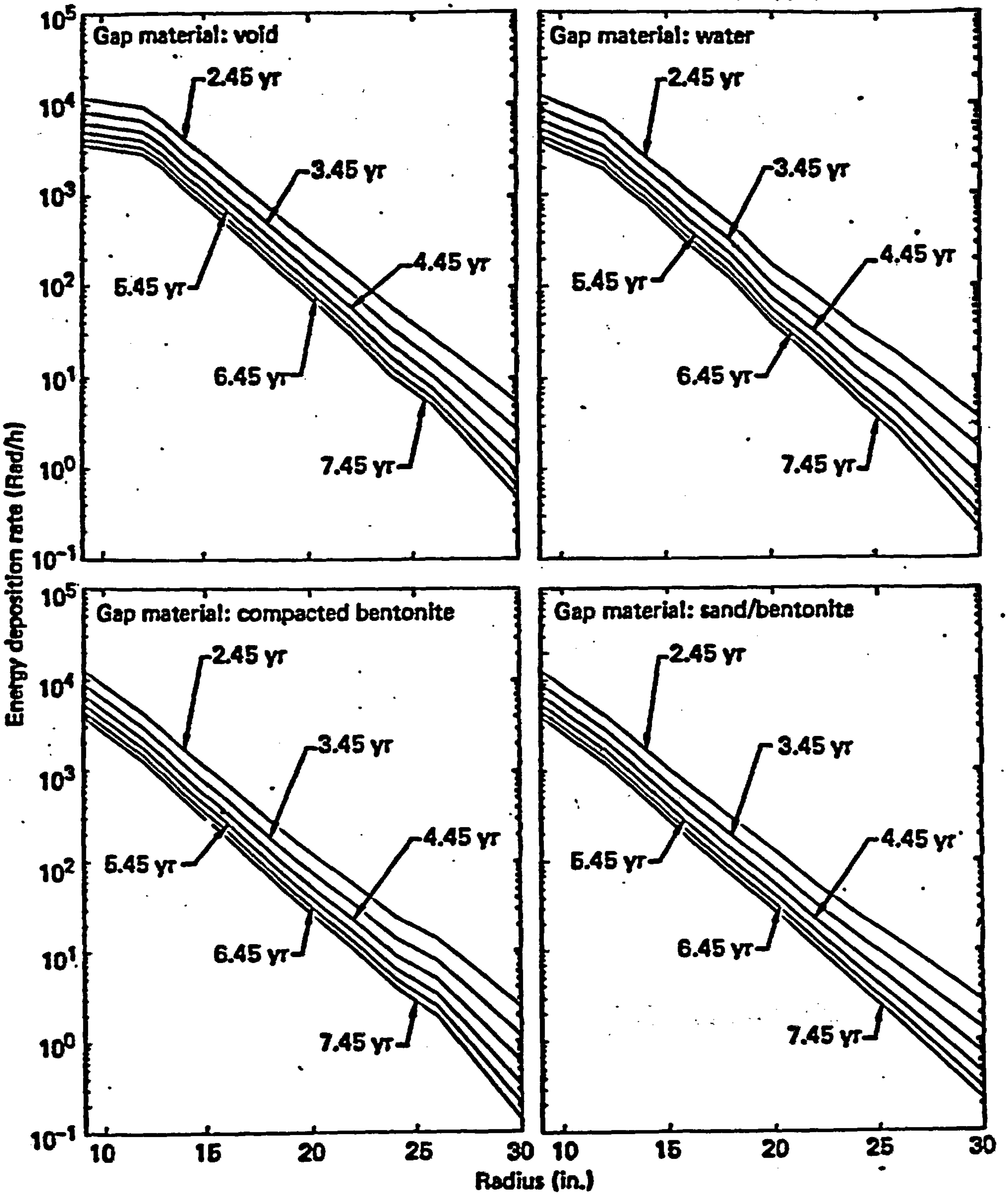


FIG. 5. The absorbed dose rate (rad/h to granite) outside the iron liner as a function of radius from the center line of the fuel assembly. The values plotted are averages over the central 2.44 m (8 ft) of the fuel assembly. The gap between the liner and the granite was assumed to be VOID, or filled with WATER or COMPACTED BENTONITE or a SAND/BENTONITE mixture, as shown in the legends of the plots. The parameter is time elapsed since discharge of fuel from reactor.

(from UCRL-53159)

RADIATION - CHEMICAL EFFECTS EXPECTED

I. SINGLE-PHASE, GASEOUS, WATER VAPOR AND AIR SYSTEMS.

A. PURE WATER VAPOR

1. SMALL STEADYSTATE CONCENTRATIONS OF H_2, O_2, AND H_2O_2.

2. H_2O_2 IS UNSTABLE, AND BOTH CU AND FE ARE CATALYSTS FOR DECOMPOSITION.

3. SCAVENGING COULD CAUSE RADIOLYSIS TO PROCEED, BUT PRODUCTION RATE TOO SMALL TO PRODUCE SIGNIFICANT GENERAL CORROSION. POSSIBLE DEGREE OF HYDROGEN EMBRITTLEMENT OF HOLE LINERS AND PACKAGES REMAINS TO BE DETERMINED.

4. EFFECTS OF H_2O_2 ON STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEELS IN <u>DRY</u> STEAM NOT YET KNOWN.

RADIATION - CHEMICAL EFFECTS EXPECTED
(CONT'D.)

B. AIR - WATER VAPOR MIXTURES

1. STABLE PRODUCTS OF RADIOLYSIS WOULD BE NITRIC ACID (HNO_3) AND NITROUS OXIDE (N_2O) AT TEMPERATURES UP TO ABOUT 120°C. TRANSIENTS: O_3 AND N_2O_5.

2. NITRIC ACID DECOMPOSES ABOVE THIS TEMPERATURE:

$$2\ HNO_3 \rightarrow 2\ NO_2 + H_2O + 1/2\ O_2$$

3. UP TO ABOUT 135°C,

$$2\ NO_2 \rightleftharpoons N_2O_4$$

4. ABOVE 150°C,

$$2\ NO_2 \rightleftharpoons 2\ NO + O_2$$

IN ADDITION,

$$NO + NO_2 \rightleftharpoons N_2O_3$$

5. GASES COULD MIGRATE IN REPOSITORY TO COOLER AREAS AND DISSOLVE IN LIQUID WATER, FORMING HNO_3 AND HNO_2. N_2O WOULD PROBABLY BE INERT AND BUILD UP.

6. H^+ WOULD EXCHANGE WITH NA^+, K^+, AND CA^{++} FROM FELDSPARS, FORMING CLAYS AND BUFFERING THE SOLUTION IN THE SLIGHTLY ALKALINE REGION.

7. NO_2 COULD CHAIN REACT WITH CU (OR FE):

$$2\ Cu + NO_2 \rightarrow Cu_2O + NO$$

$$2\ NO + O_2 \rightarrow 2\ NO_2.$$

8. OXIDATION WOULD PROBABLY BE UNIFORMLY DISTRIBUTED. EXTENT REMAINS TO BE DETERMINED.

RADIATION - CHEMICAL EFFECTS EXPECTED
(CONT'D.)

II. TWO-PHASE, AIR-GROUNDWATER SYSTEM:

1. DOSE RATE WOULD BE MUCH LOWER WHEN THIS EXISTED.

2. MAIN EFFECT - PRODUCTION OF NO_x AND HNO_3 IN GAS PHASE AND DISSOLUTION IN LIQUID PHASE, FORMING HNO_3 AND HNO_2 IN SOLUTION.

3. FOR A SEALED SYSTEM (BURNS ET AL., 1982),

$$N = 2\, C_0 R\, [1 - \exp(-1.45 \times 10^{-5}\, GDT)]$$

WHERE N IS CONC. OF HNO_3 (M)

C_0 IS INITIAL CONC. OF N_2 IN AIR (M)

R IS RATIO OF VOL. OF AIR TO VOL. OF WATER

G IS THE YIELD (= 1.9)

D IS THE DOSE RATE (MRAD/HOUR)

T IS THE TIME (HOURS).

4. NOTE IMPORTANCE OF R, FOR EXAMPLE WITH LARGE AIR VOLUME AND WATER FILM ON METAL.

RADIATION - CHEMICAL EFFECTS EXPECTED (CONT'D.)

II. TWO-PHASE, AIR-GROUNDWATER SYSTEM (CONT'D.):

5. IN THE WATER PHASE, THE IRRADIATION WOULD PRODUCE OH, e_{aq}^-, H_2O_2, H, H_2, AND HO_2 AS PRIMARY PRODUCTS.

6. WITH DISSOLVED O_2 AND NEUTRAL OR ALKALINE PH, e_{aq}^-, H, AND HO_2 WOULD BE CONVERTED TO O_2^-, LEAVING H_2 AND THE OXIDIZING SPECIES (O_2, H_2O_2, OH, AND O_2^-) IN SOLUTION.

7. IF OXIDIZABLE METAL (E.G. FE OR CU) WERE PRESENT, H_2 WOULD SURVIVE. OTHERWISE, IT WOULD BE OXIDIZED.

8. THE N_2O WOULD PROBABLY BE REDUCED TO N_2 BY e_{aq}^- IN THE WATER.

9. FOR WATER IN CONTACT WITH TUFF, ION EXCHANGE AND BUFFERING WOULD OCCUR, LEAVING ALKALI NITRATES AND NITRITES IN THE SOLUTION.

II. TWO-PHASE, AIR-GROUNDWATER SYSTEM (CONT'D.):

10. FOR WATER NOT IN CONTACT WITH TUFF, PH COULD MOVE INTO ACID REGION, PARTICULARLY WITH LARGE R VALUE AND THERMAL GRADIENT, TO GIVE PREFERENTIAL DEPOSITION OF ACID IN SMALL REGIONS ON SURFACES OF PACKAGES.

11. AUTOCATALYTIC OR CHAIN-TYPE REACTIONS OF HNO_3 ON CU AND FE COULD MAKE SMALL AMOUNTS OF ACID MORE SIGNIFICANT.

12. COMBINED EFFECTS OF HNO_3, HNO_2, AND H_2O_2 ON STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEELS UNDER "WET" CONDITIONS NEED TO BE ASSESSED.

13. IRRADIATION OF AERATED BICARBONATE SOLUTIONS CAN PRODUCE OXALIC ACID, $(COOH)_2$. NEAR 100°C, THIS HAS A SIGNIFICANT VAPOR PRESSURE, AND IT DOES NOT DECOMPOSE UNTIL ABOUT 160°C. AT LOWER TEMPERATURES, IT SHOULD PRECIPITATE AS CALCIUM OXALATE. FORMIC ACID FORMS UNDER LOW PH CONDITIONS, BUT APPARENTLY NOT IN AERATED, ALKALINE SOLUTIONS. (DISPLACEMENT IRRADIATION OF SOLID CARBONATES AND BICARBONATES, FOLLOWED BY DISSOLUTION, HAS ALSO BEEN REPORTED TO YIELD FORMIC AND OXALIC ACIDS, AS WELL AS GLYOXYLIC AND GLYCOLLIC ACIDS.)

CONCLUSIONS

1. WE EXPECT A GASEOUS, OXIDIZING, STEAM-AIR ENVIRONMENT DURING AT LEAST A SIGNIFICANT PORTION OF THE REQUIRED CONTAINMENT PERIOD FOR MOST OF THE PACKAGES. IN THIS ENVIRONMENT, THE RADIOLYTICALLY-GENERATED SPECIES OF CONCERN ARE H, H_2, H_2O_2, AND NO_x.

2. AFTER COOLING, A TWO-PHASE, AIR-GROUNDWATER SYSTEM COULD EXIST. ALTHOUGH THE DOSE RATE WOULD GENERALLY BE MUCH LOWER AT THIS TIME, RADIOLYTIC PRODUCTION OF HNO_2, HNO_3, AND H_2O_2 COULD BE IMPORTANT, PARTICULARLY IF DEPOSITION WERE CONCENTRATED IN SMALL REGIONS OF THE PACKAGE SURFACES.

3. DISSOLVED HALIDE IONS COULD BECOME MORE CONCENTRATED THAN IN THE ORIGINAL GROUNDWATER.

4. THE IMPORTANCE OF CARBOXYLIC ACIDS REMAINS TO BE DETERMINED.

Corrosion Considerations for Nuclear Waste Disposal in a Tuff Geologic Repository — Corrosion Rates and Mechanisms for Container Materials

R. S. GLASS

NUCLEAR WASTE STORAGE IN TUFF

* Austenitic stainless steels are prospective candidates for long–term (300–1000 yrs) high–level waste encapsulation.

1. What are potential long–term degradation mechanisms (pitting, crevice, SCC)?

2. What are effects of gamma radiolysis on corrosion rates/mechanisms?

Results from electrochemical experiments:

1. Accurate and quick in-lab experiments for assessing environmental stabilities of materials under a wide range of conditions — corrosion rates from Tafel extrapolation, linear polarization resistance, ac impedance

2. Anodic polarization curves — characterize response of a system to external perturbation (i - E relationship) — regions of active corrosion, passivity, pitting

3. Occluded cell experiments — crevice corrosion resistance

4. Detail models for corrosion mechanisms — long-term predictability

What is corrosion?

Anodic (corrosion) process, $M \rightarrow M^{+n} + ne^-$

Cathodic (reduction) process, $2H^+ + 2e^- \rightarrow H_2$

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

$i_{meas} = i_{corr} - i_{redn} = 0$ at E_{corr}

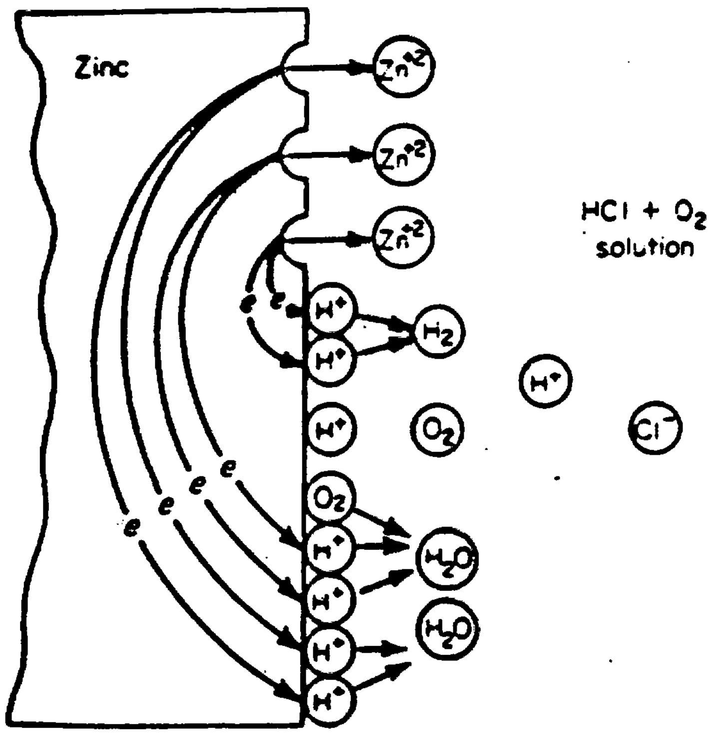


Fig. 2-4. Electrochemical reactions occurring during corrosion of zinc in aerated hydrochloric acid.

Eight forms of corrosion:

1. Uniform
2. Galvanic
3. Crevice corrosion
4. Pitting
5. Intergranular corrosion
6. Selective leaching
7. Erosion corrosion
8. Stress corrosion

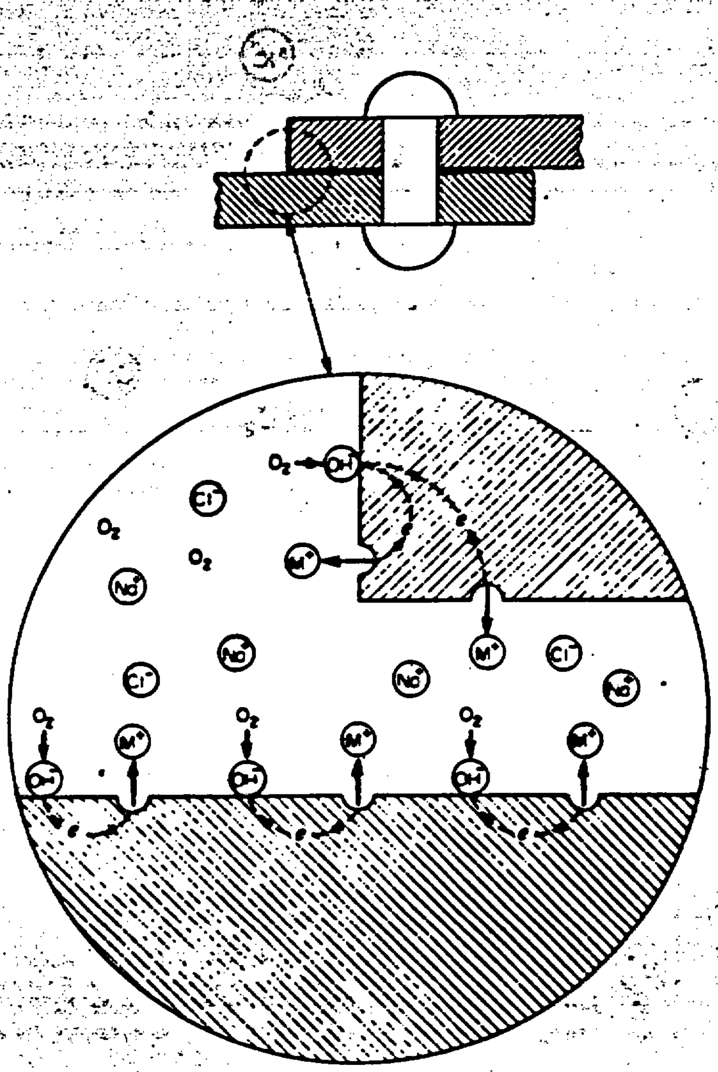


Fig. 3-9. Crevice corrosion—initial stage.

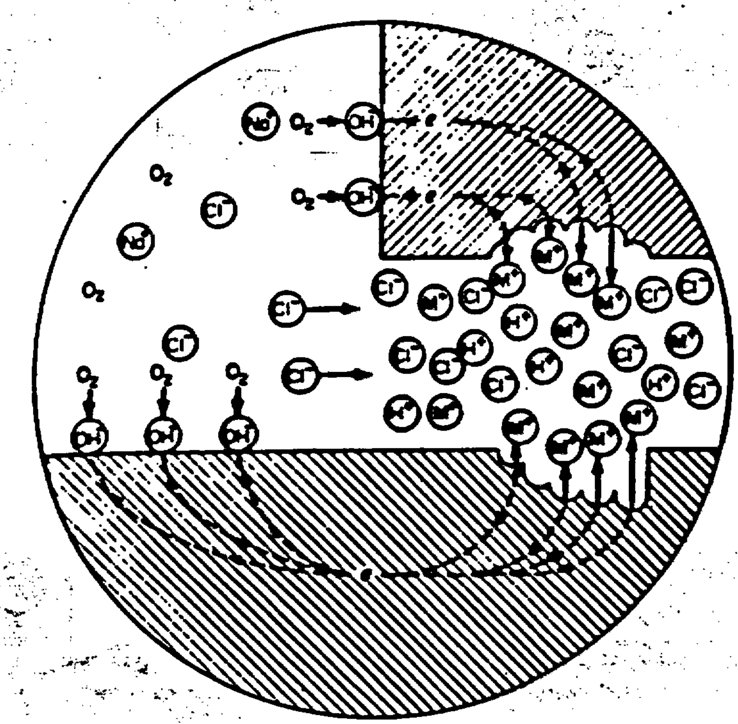


Fig. 3-10. Crevice corrosion—later stage.

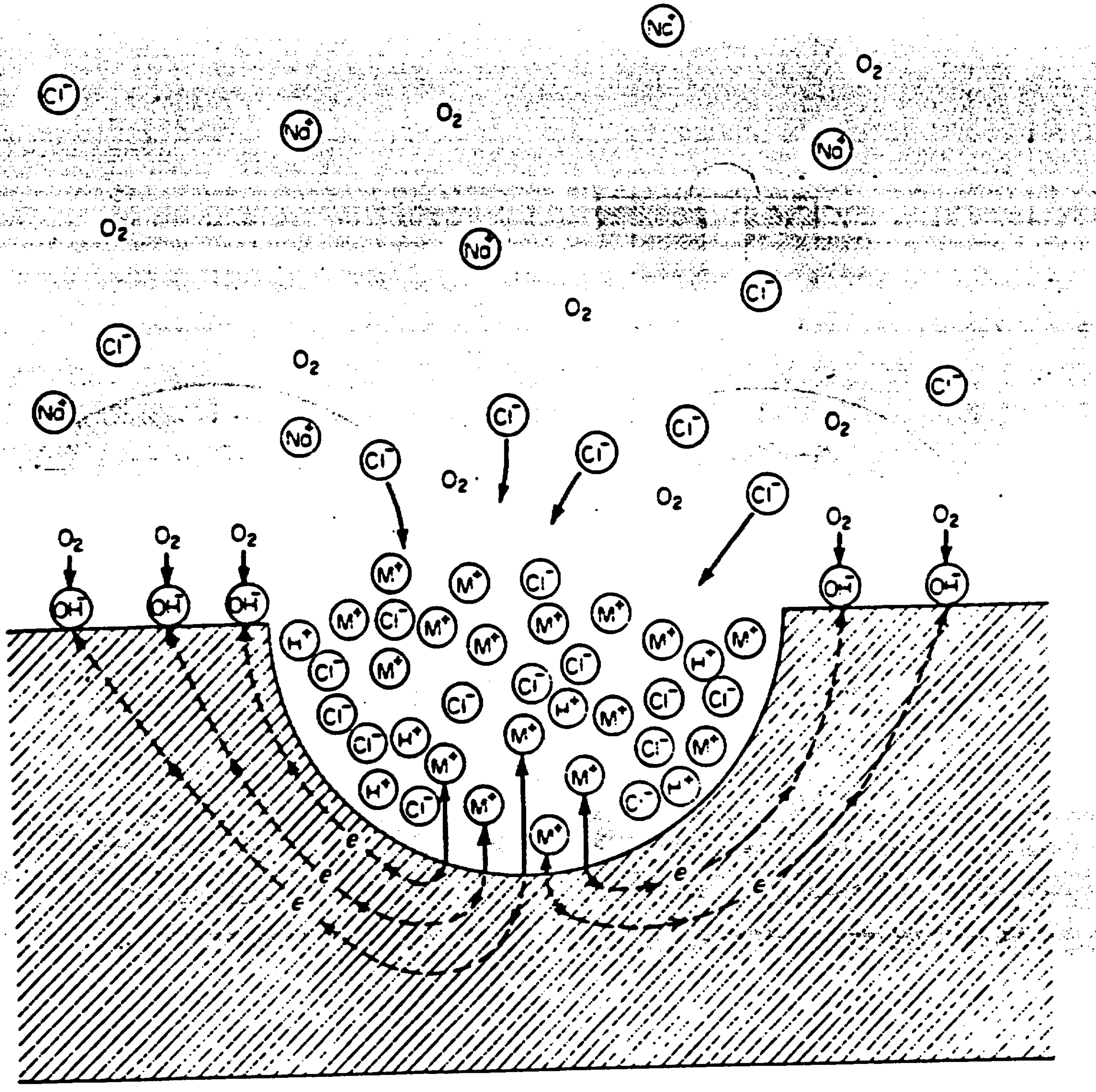


Fig. 3-19. Autocatalytic processes occurring in a corrosion pit.

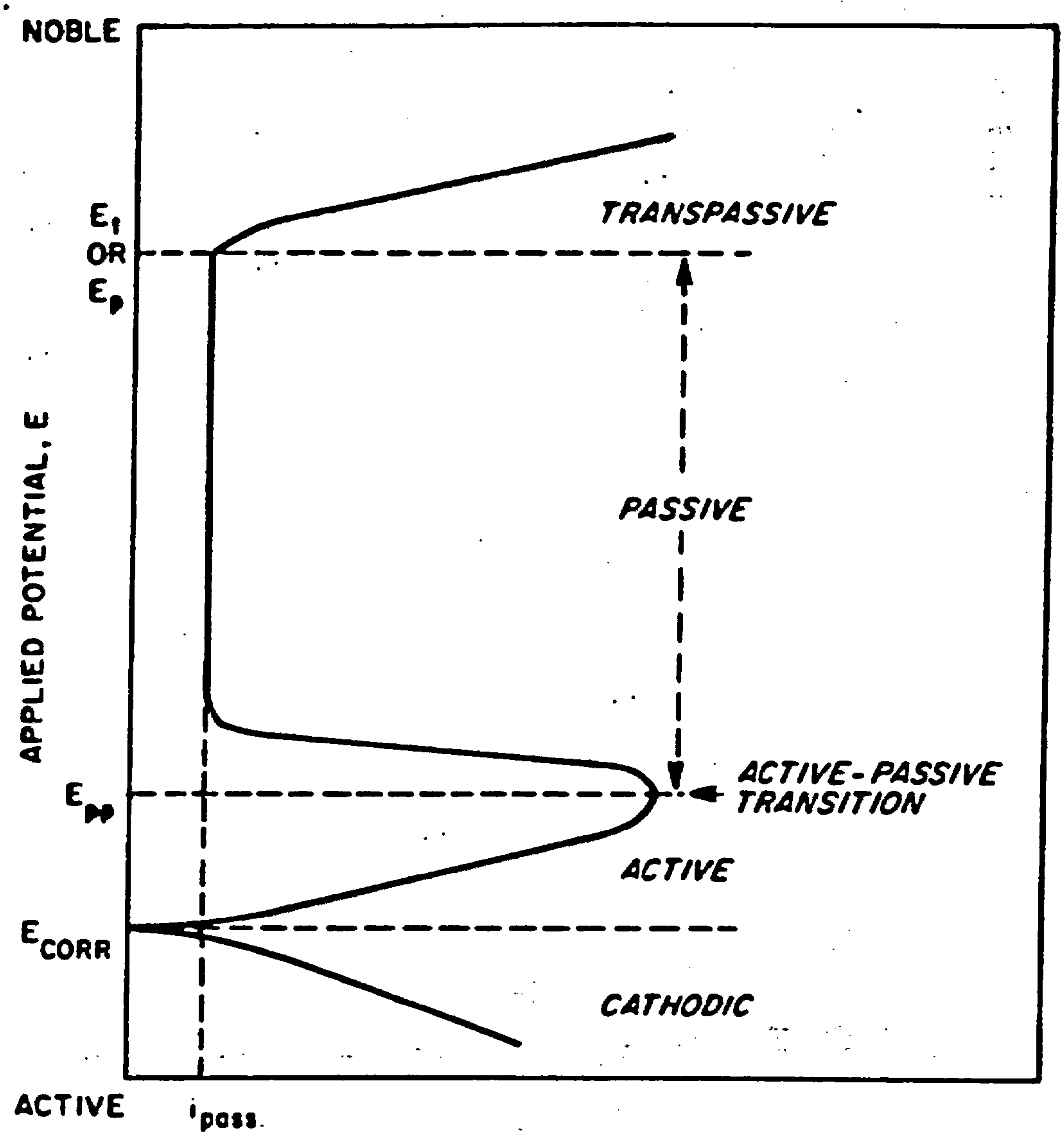


Figure 3-3. A schematic polarization curve for a stainless steel in a sulfuric acid solution.

1. GENERAL ELECTROCHEMICAL BEHAVIOR OF AUSTENITIC STAINLESS STEEL ALLOYS IN J13 AND RELATED ENVIRONMENTS.

2. COMPARATIVE BEHAVIOR OF L AND LN AUSTENITIC STAINLESS STEEL ALLOYS AND EFFECT OF ALLOY "CLEANLINESS."

3. GAMMA RADIATION EFFECTS ON THE ELECTROCHEMISTRY OF AUSTENITIC STAINLESS STEELS IN AQUEOUS MEDIA.

4. ELECTROCHEMISTRY OF COPPER ALLOYS IN J13 AND RELATED ENVIRONMENTS.

5. GAMMA RADIATION EFFECTS ON COPPER ALLOYS IN J13.

Radiation effects on the corrosion process

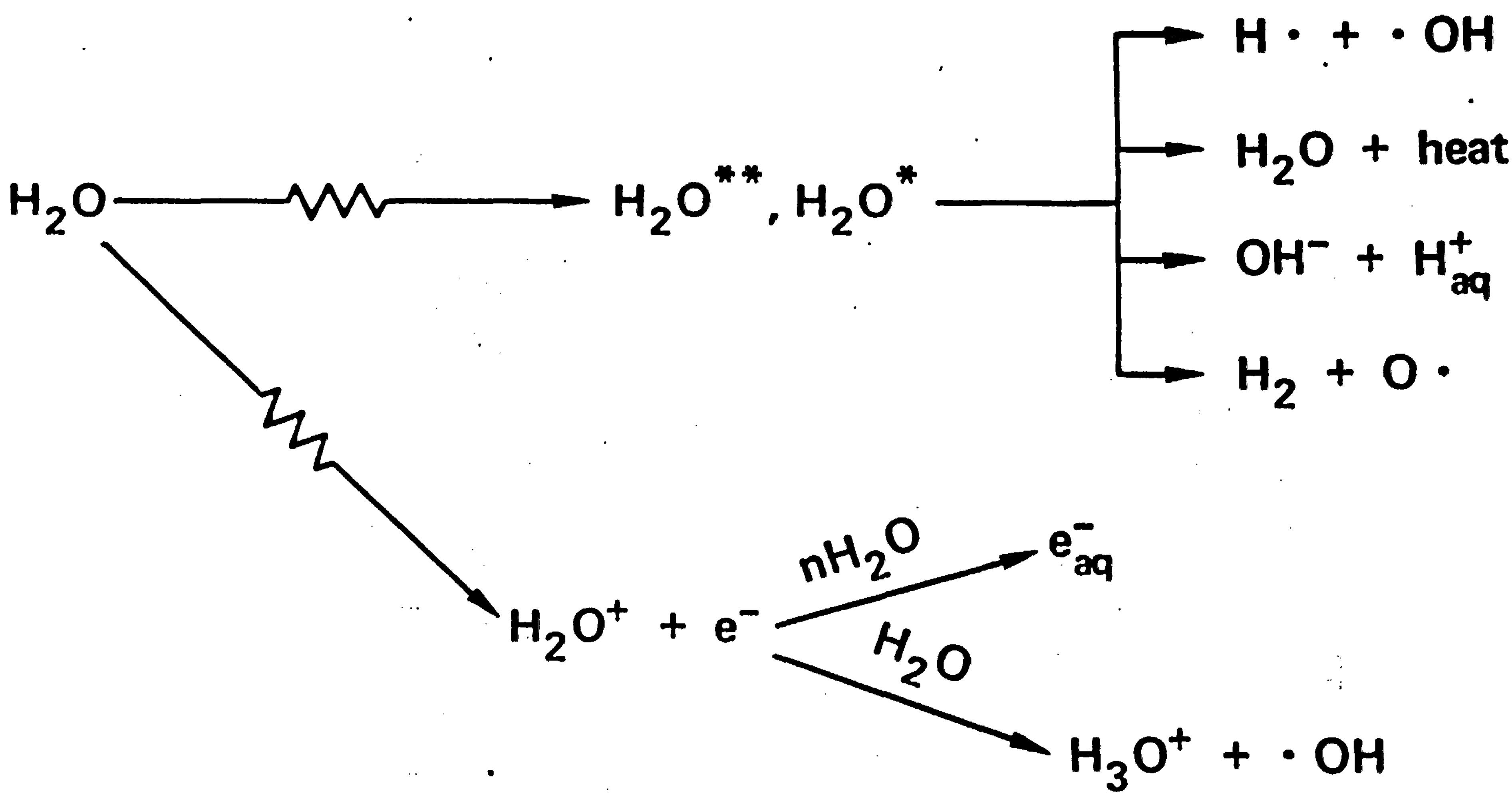
- On the metal itself
- On the protective oxide layer
- On the corrodant itself (the chemical environment)

TABLE 1. Measured Analyses of the Electrode Materials

	Composition (wt%)												
Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	Co	Ti	Cu	Cb	N
304L	.022	1.55	.024	.025	.63	9.26	18.31	.36	.16	.002	.46	.01	.072
316L	.02	1.71	.033	.014	.56	10.29	16.51	2.07	.10	--	.28	--	.054

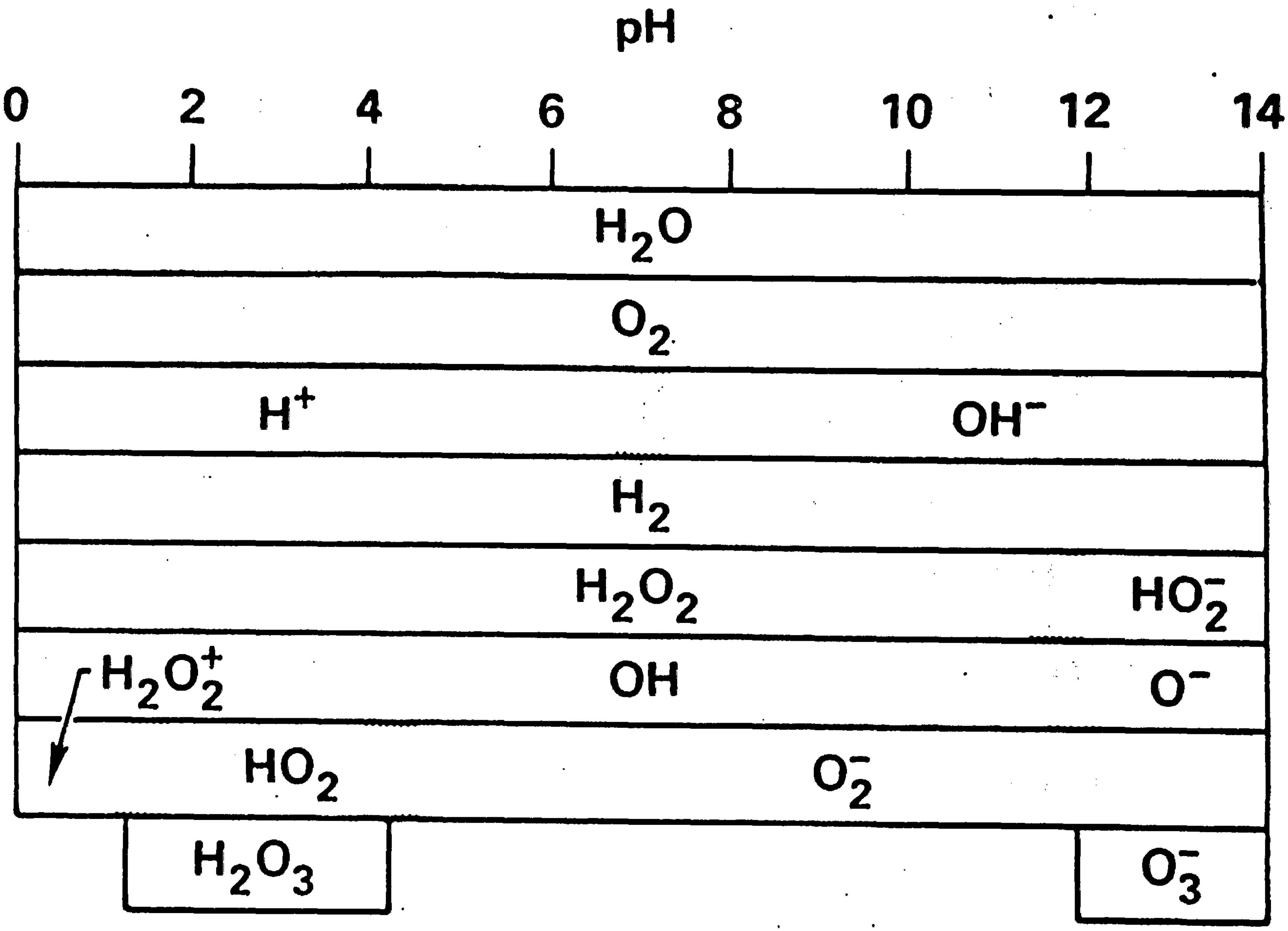
TABLE 2. Composition of J-13 water (average of 6 samples, by OES-ICP and IC), ppm

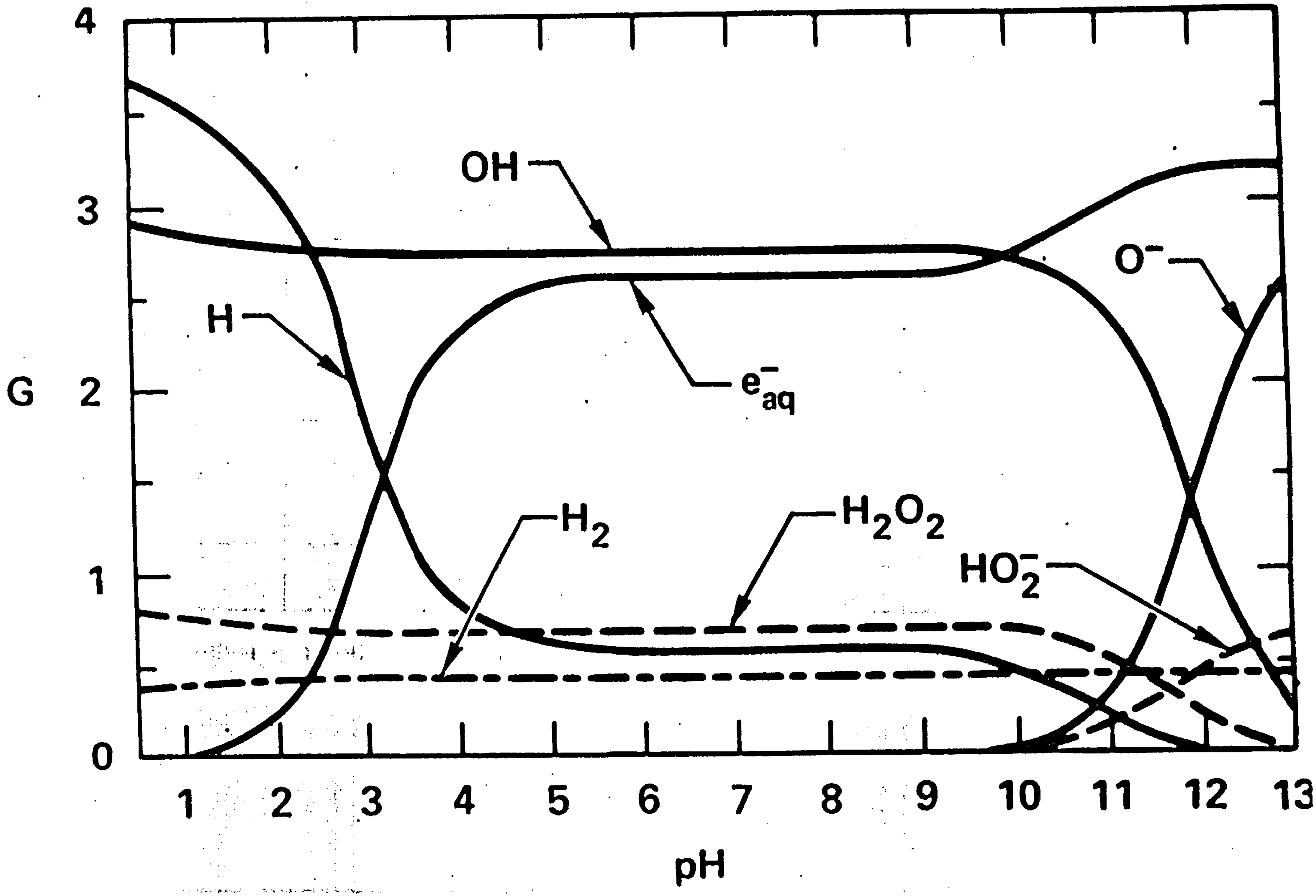
Al	<0.020	Si	27.0 ± 0.1
As	<0.060	Sr	0.054 ± 0.005
B	0.11 ± 0.01	U	<0.084
Be	0.003	V	0.011 ± 0.001
Cd	<0.003	Zn	<0.008
Co	<0.003	Ca	13.0 ± 0.1
Cu	<0.003	K	5.5 ± 0.3
Fe	<0.004	Mg	1.92 ± 0.01
Li	0.044 ± 0.001	Na	43.4 ± 0.3
Mn	<0.0005	Cl^-	7.1 ± 0.3
Mo	0.013 ± 0.002	F^-	2.4 ± 0.1
Ni	<0.008	NO_3^-	9.1 ± 0.2
P	<0.124	$SO_4^{=}$	18.5 ± 0.1
Pb	0.022 ± 0.003	HCO_3^-	132 ± 6
Se	<0.100		



$$H_2O \rightsquigarrow H\cdot\,,\ \cdot OH\,,\ e^-_{aq}\,,\ H_3O^+\,,\ H_2\,,\ H_2O_2\,,\ OH^-\,,\ O_2\,,\ O_2^-$$

Species in water containing dissolved oxygen, 10^{-8} sec after irradiation





4
3
2
1
0
G
OH
H
e^-_{aq}
O^-
H_2
H_2O_2
HO_2^-
1
2
3
4
5
6
7
8
9
10
11
12
13
pH

Radical and molecular product yields in irradiated water and water vapor

Radiation	pH	G_{-H_2O}	G_{H_2}	$G_{H_2O_2}$	$G_{e^-_{aq}}$	G_H	G_{OH}	G_{HO_2}
Water vapor								
x or γ-rays, electrons		8.2	0.5	0	(G_{e^-} = 3.0)	7.2	8.2	
Liquid water								
γ-rays and fast electrons with energies in the range 0.1 to 20 MeV	0.46	4.45	0.40	0.78	0	3.65	2.90	0.008[a]
	3-13	4.08	0.45	0.68	2.63	0.55	2.72	0.026[b]

Estimated steadystate concentrations of species in oxygen-saturated J-13 water irradiated at 3.3×10^6 rad/hr

Species		Estimated concentration (moles/liter)
HCO_3^-	(measured value)	2×10^{-3}
O_2	(air-saturated solution)	3×10^{-4}
H_2O_2	(1/3 of O_2 conc)	1×10^{-4}
OH^-	(assuming pH = 8)	1×10^{-6}
O_2^-	(assumed $\alpha\sqrt{\text{dose rate}}$)	1×10^{-7}
HO_2	$(= [H^+]\,[O_2^-]/10^{-4.88})$	1×10^{-10}
H^+	(assuming pH = 8)	1×10^{-8}
OH	(assumed $\alpha\sqrt{\text{dose rate}}$)	2×10^{-9}
H_2	(assumed $\alpha\sqrt{\text{dose rate}}$)	3×10^{-9}
e^-_{aq}	(assumed $\alpha\sqrt{\text{dose rate}}$)	3×10^{-11}
H	(assumed $\alpha\sqrt{\text{dose rate}}$)	2×10^{-11}
HO_2^-	(assumed $\alpha\sqrt{\text{dose rate}}$)	4×10^{-12}

Reactions producing H_2O_2:

$$\cdot OH + \cdot OH \rightarrow H_2O_2$$

$$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$$

Reactions destroying molecular products:

$$\cdot OH + H_2O_2 \rightarrow H_2O + HO_2$$

$$e^-_{aq} + H_2O_2 \rightarrow OH^- + \cdot OH$$

$$H\cdot + H_2O_2 \rightarrow H_2O + \cdot OH$$

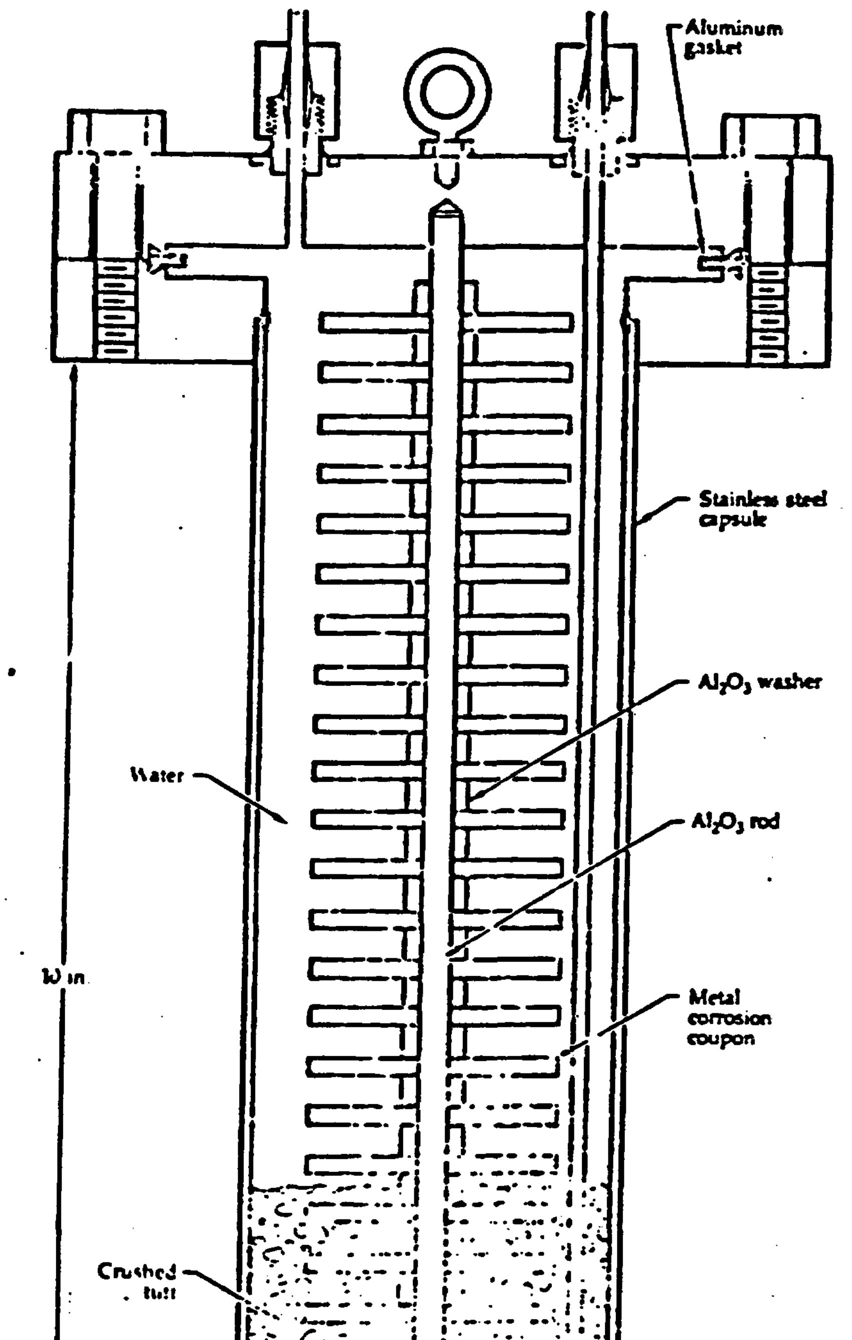
$$H_2 + \cdot OH \rightarrow H_2O + H\cdot$$

$$e^-_{aq} + O_2 \rightarrow O_2^-$$

$$H + O_2 \rightarrow HO_2$$

$$HO_2 \rightleftharpoons H^+ + O_2^-$$

$$2O_2^- + 2H^+ \rightarrow H_2O_2 + O_2$$


Aluminum gasket
Stainless steel capsule
Al_2O_3 washer
Water
Al_2O_3 rod
Metal corrosion coupon
Crushed tuff

Corrosion Test Results for Room Temperature Irradiated and Non-Irradiated 304L Coupons (8760 Hrs Exposure)

304L Stainless Steel Material Condition	J-13 Water Environment (28°C)	Corrosion Rates (μm/yr) Vessel A (Irradiated)	Corrosion Rates (μm/yr) Vessel B (Non-Irradiated)
Solution Annealed	Rock + Water	Average: 0.0811*	0.242**
		Range: 0.0690-0.0951	0.215-0.272
		St'd Deviation: 0.00959	0.0201
Solution Annealed	Water	Average: 0.151	0.285
		Range: 0.0817-0.299	0.138-0.451
		St'd Deviation: 0.0734	0.118
Sensitized***	Rock + Water	Average: 0.123	0.249
		Range: 0.111-0.142	0.165-0.322
		St'd Deviation: 0.0114	0.0522
Sensitized	Water	Average: 0.116	0.283
		Range: 0.092-0.142	0.203-0.452
		St'd Deviation: 0.0470	0.0980

* Averages of 6 coupons in each set.

** Maximum localized penetration measured = 0.010 μm in 8760 hours (appx. 1 year).

*** "Sensitizing" heat treatment: 1 hour at 650°C.

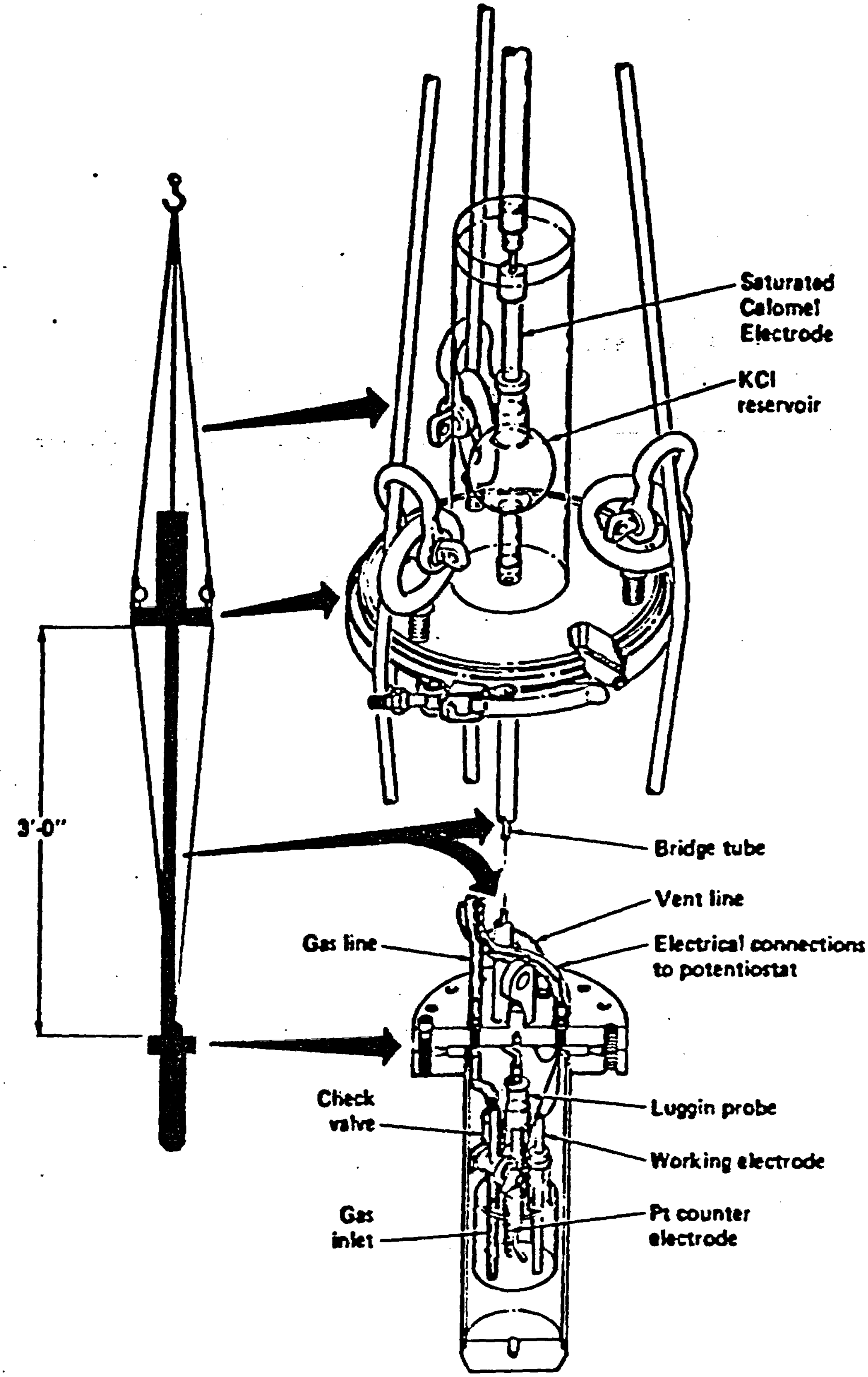


Figure 1: Schematic of the electrochemical cell used in this work. Details are provided in the text.

Figure 2: Corrosion potential behavior for 316L stainless steel in 10X concentrated J-13 well water under gamma irradiation. The solution was not exposed to irradiation prior to initiation of the first "on/off" irradiation cycle.

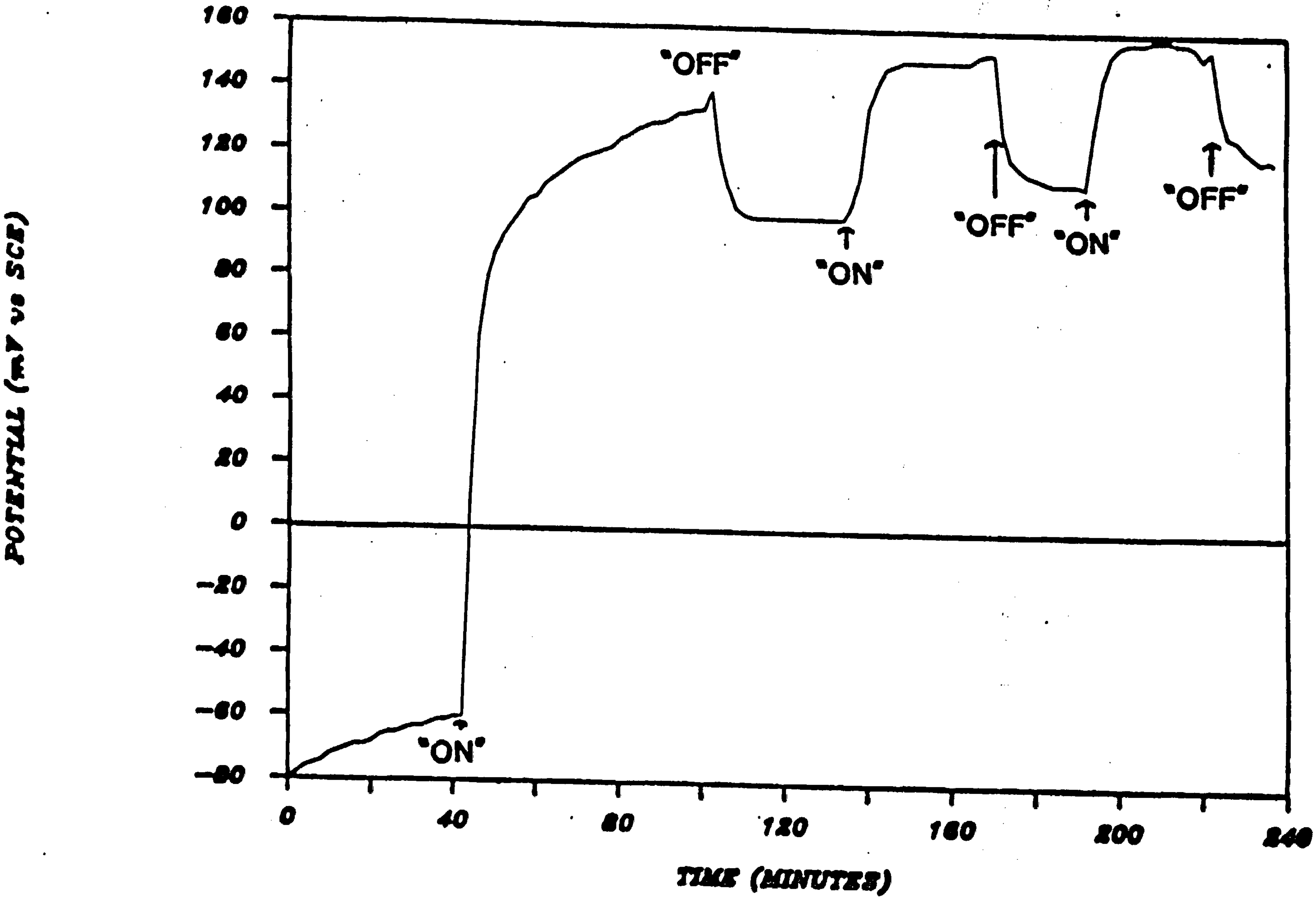


TABLE 3. Possible Redox Reactions in Gamma-Irradiated Solutions

$H_2O + e^- \rightleftharpoons e^-_{aq}$	$H_2O_2^- + H^+ + e^- \rightleftharpoons H_2O + OH$
$H^+ + e^- \rightleftharpoons H\ (aq)$	$HO_2^- + H_2O + 2e^- \rightleftharpoons 3OH^-$
$OH\ (ads) + e^- \rightleftharpoons OH^-$	$HO_2^- + H_2O + e^- \rightleftharpoons 2OH^- + OH$
$OH + H^+ + e^- \rightleftharpoons H_2O$	$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$
$HO_2 + H^+ + e^- \rightleftharpoons H_2O_2$	$O_2 + 2H_2O + 2e^- \rightleftharpoons H_2O_2 + 2OH^-$
$OH + e^- \rightleftharpoons OH^-$	$O_2 + H_2O + 2e^- \rightleftharpoons HO_2^- + OH^-$
$HO_2 + 2H^+ + 2e^- \rightleftharpoons H_2O + OH$	$2H^+ + 2e^- \rightleftharpoons H_2$
$O_2^- + H_2O + e^- \rightleftharpoons HO_2^- + OH^-$	$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$
$O_2 + H^+ + e^- \rightleftharpoons HO_2$	$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$
$O_2 + e^- \rightleftharpoons O_2^-$	$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	

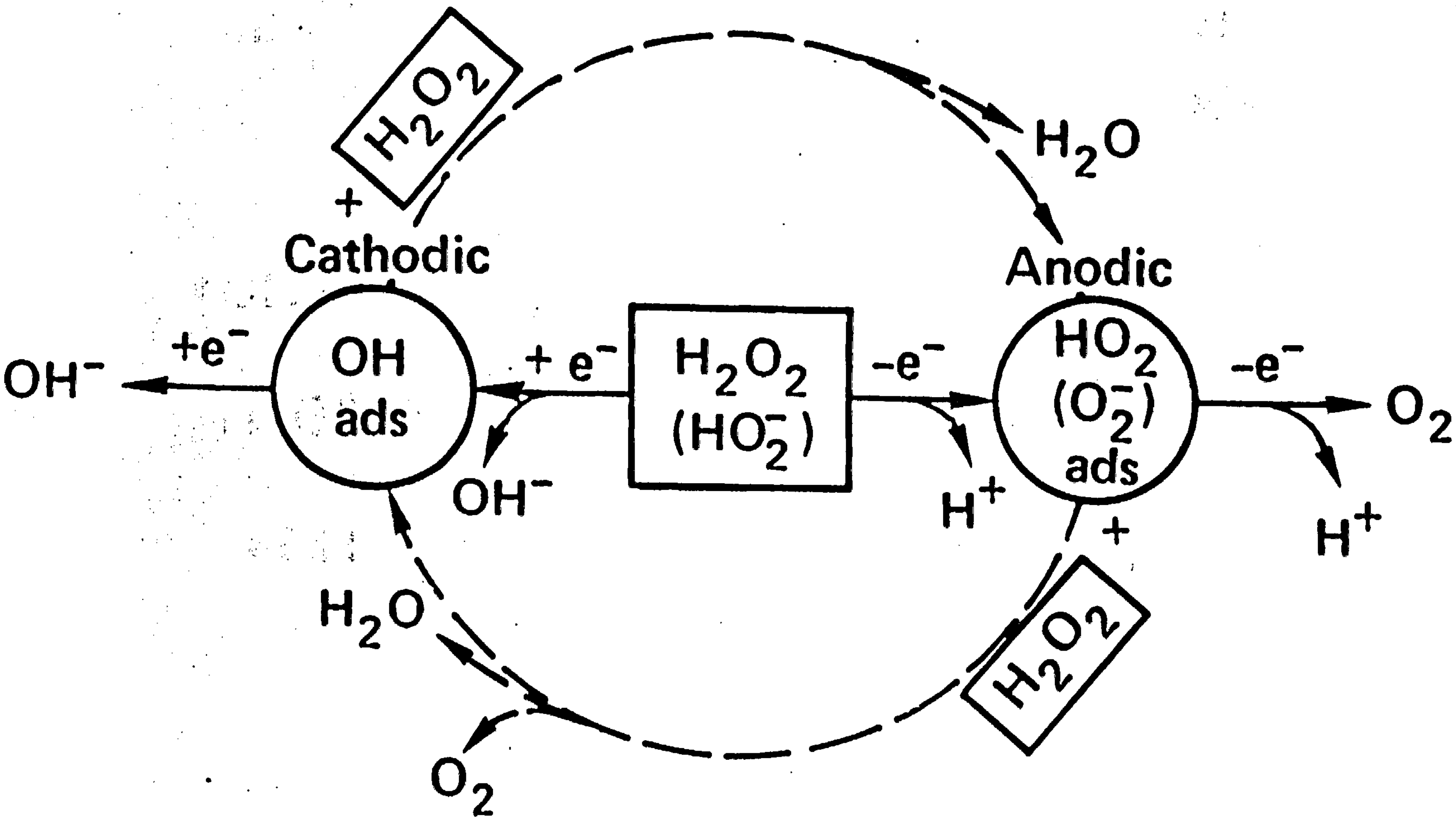
$$\bullet OH\ (aq) \rightarrow \bullet OH_{ads}$$

$$H_2O_2\ (aq) \leftrightarrows 2OH_{ads}$$

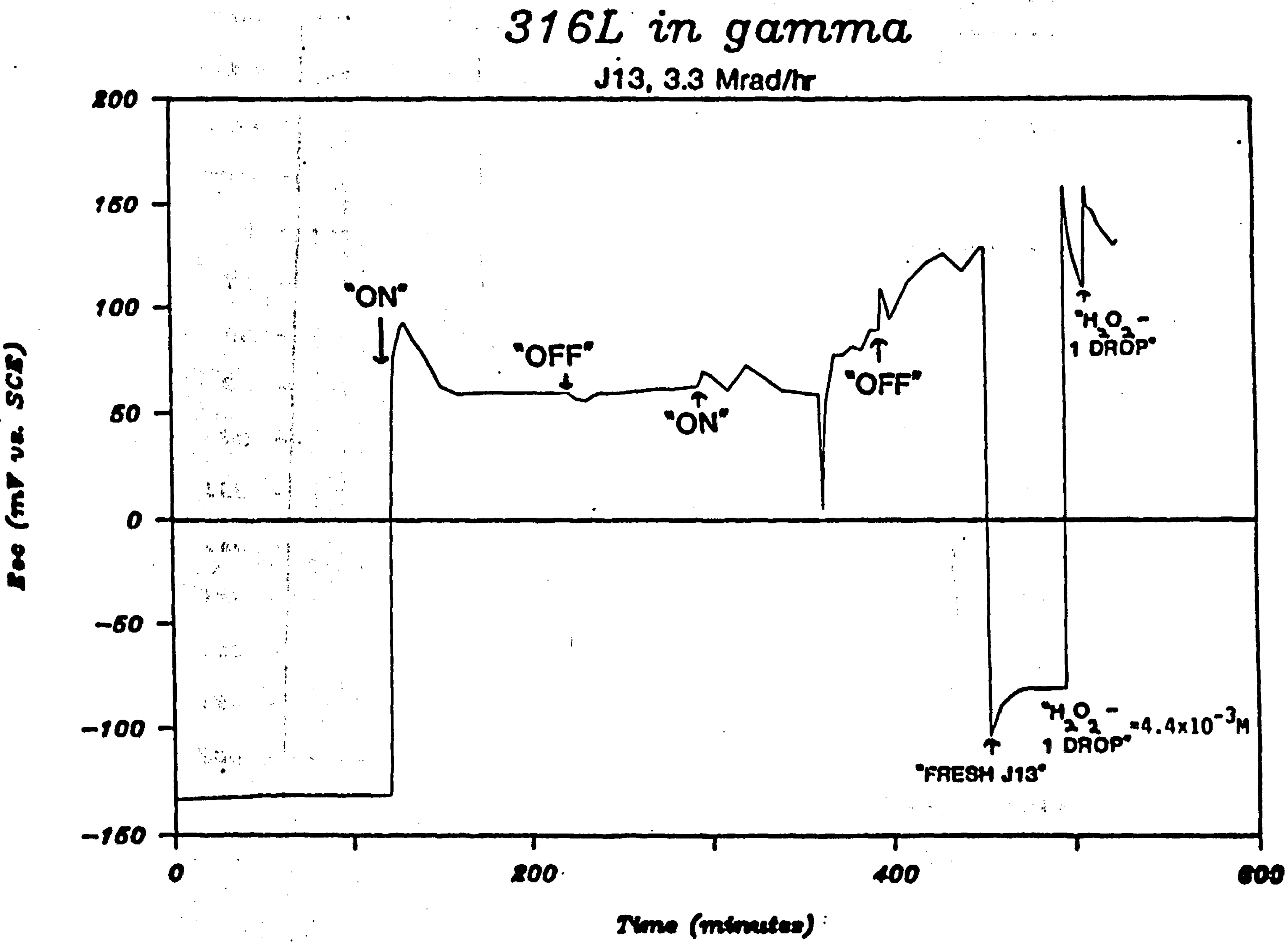
$$\bullet OH_{ads} + e \rightleftharpoons OH^-$$

$E_{oc,Pt} = 0.594 - 0.059\ pH$, volts vs SCE at 25°C, independent of $[H_2O_2]$ to 10^{-6} M

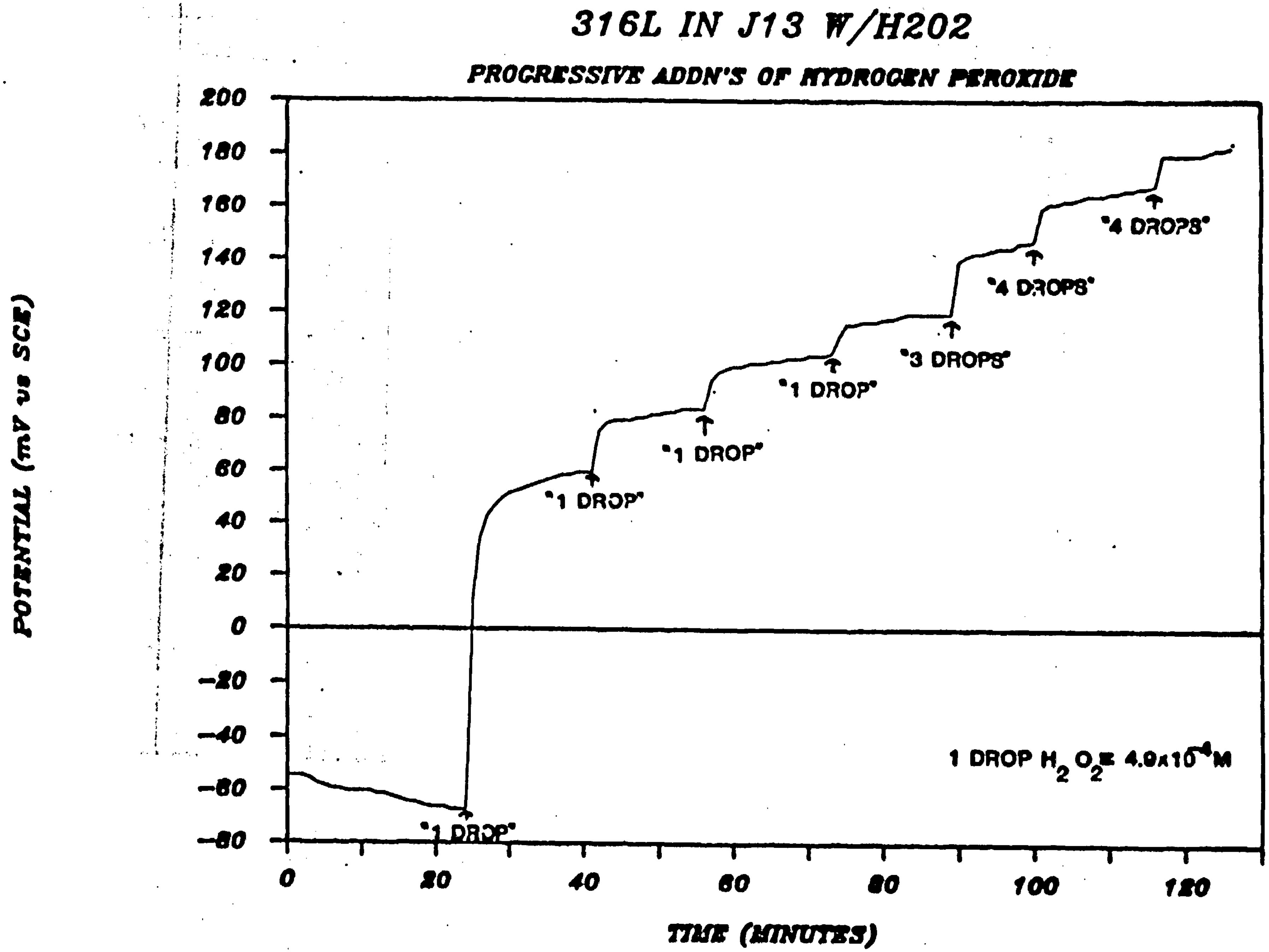
at pH = 7, E = 0.181V at $(a_{OH})_{sat}$



H2O2
+
Cathodic
OH ads
+e⁻
OH⁻
+ e⁻
OH⁻
H2O2 (HO2⁻)
-e⁻
H⁺
Anodic
HO2 (O2⁻) ads
-e⁻
O2
H⁺
H2O
+
H2O2
H2O
O2



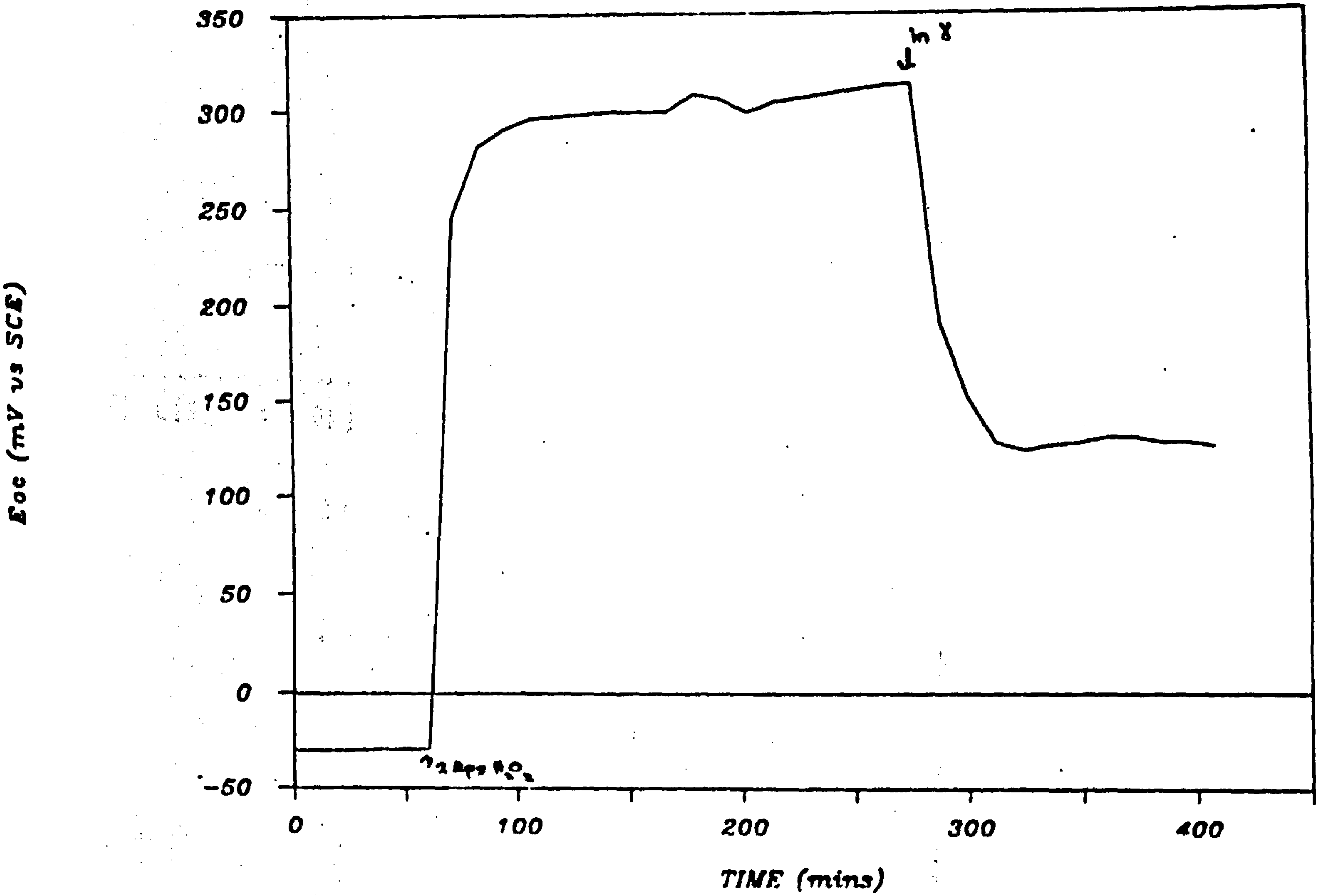
316L in gamma
J13, 3.3 Mrad/hr
200
150
100
50
0
-50
-100
-150
Eoc (mV vs. SCE)
0
200
400
600
Time (minutes)
"ON"
"OFF"
"ON"
"OFF"
"FRESH J13"
"H2O2 - 1 DROP"
=4.4x10-3M
"H2O2 - 1 DROP"



316L IN J13 W/H202
PROGRESSIVE ADDN'S OF HYDROGEN PEROXIDE
POTENTIAL (mV vs SCE)
TIME (MINUTES)
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0
20
40
60
80
100
120
"1 DROP"
"1 DROP"
"1 DROP"
"1 DROP"
"3 DROPS"
"4 DROPS"
"4 DROPS"
1 DROP H_2O_2 = 4.9x10^-4 M

316L IN J13 w/ADDN'S OF H202

3.3Mrad/hr gamma



Cathodic reactions (neutral to basic):

$$OH\ (ads) + e^- \rightleftharpoons OH^-$$

$$O_2 + 2H_2O + 4\,e^- \rightleftharpoons 4OH^-$$

small, $$O_2^- + H_2O + e^- \rightleftharpoons HO_2^- + OH^-$$

very small, $$HO_2^- + H_2O + 2\,e^- \rightleftharpoons 3OH^-$$

Anodic reactions:

$$Fe \rightleftharpoons Fe^{+2} + 2\,e^-$$

$$Cr \rightleftharpoons Cr^{+3} + 3\,e^-$$

$$Ni \rightleftharpoons Ni^{+2} + 2\,e^-$$

Small, higher pH
$$OH^- + H_2O_2 \rightleftharpoons O_2 + 2H_2O + 2\,e^-$$
$$HO_2^- + OH^- \rightleftharpoons O_2 + H_2O + 2\,e^-$$

Oxidations of Fe^{+2} by radiolysis products:

$$\bullet OH + Fe^{2+} \rightarrow Fe^{3+} + OH^-$$

$$HO_2 + Fe^{2+} \rightarrow Fe^{3+} + HO_2^-$$

$$H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + \bullet OH$$

$$H\bullet + Fe^{2+} \rightarrow Fe^{3+}H^-$$

$$Fe^{3+}H^- + H^+ \rightarrow Fe^{3+} + H_2$$

$$2Fe(OH)_2 + H_2O_2 \rightarrow 2FeOOH + 2H_2O$$

$$xMe + yOH \longrightarrow Me_x(OH)_y$$

$$xMe + yHO_2 \longrightarrow Me_xO_{1.5y}\ 0.5\,y\,H_2O$$

316L IN J13 W/H202 & H2

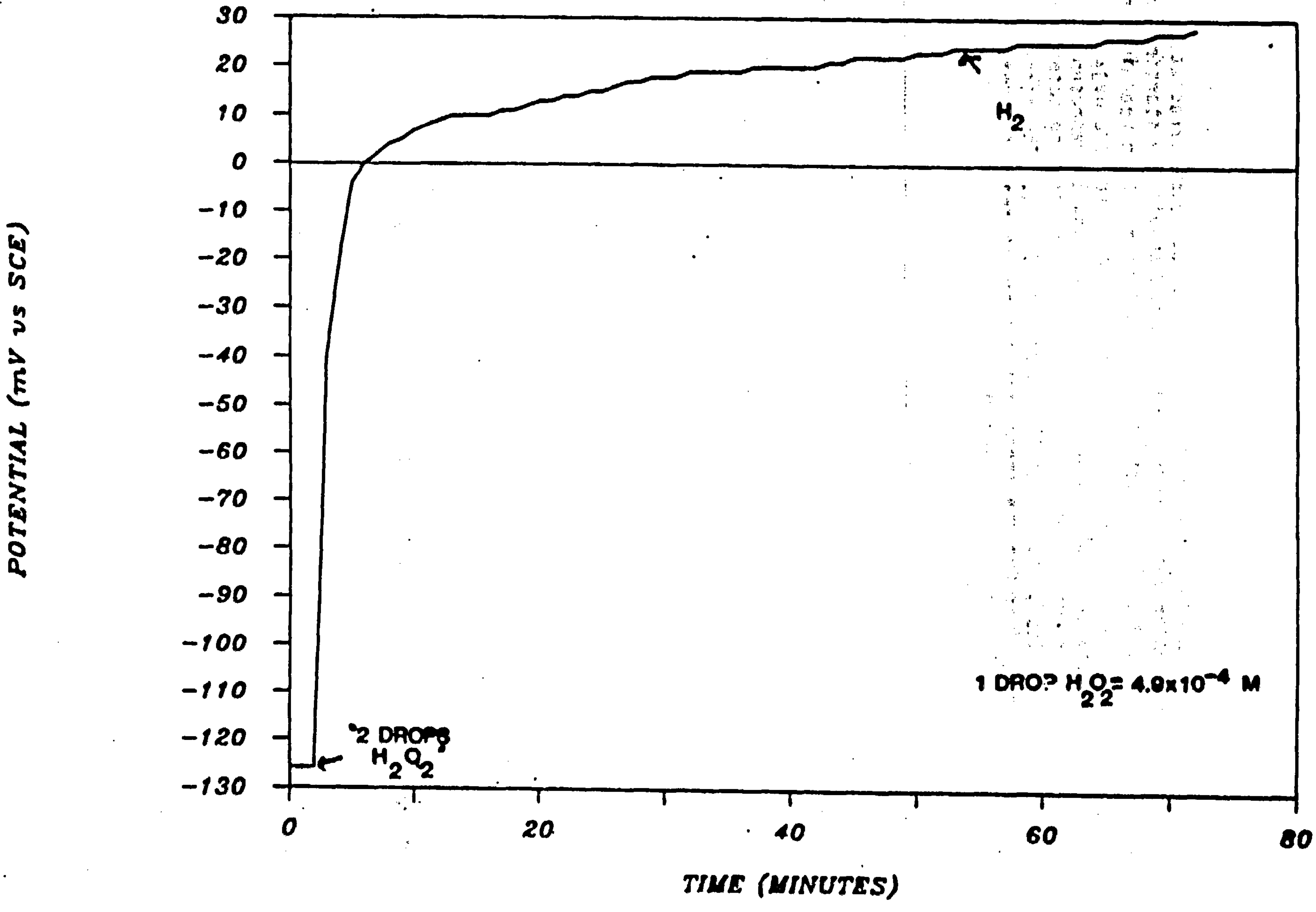
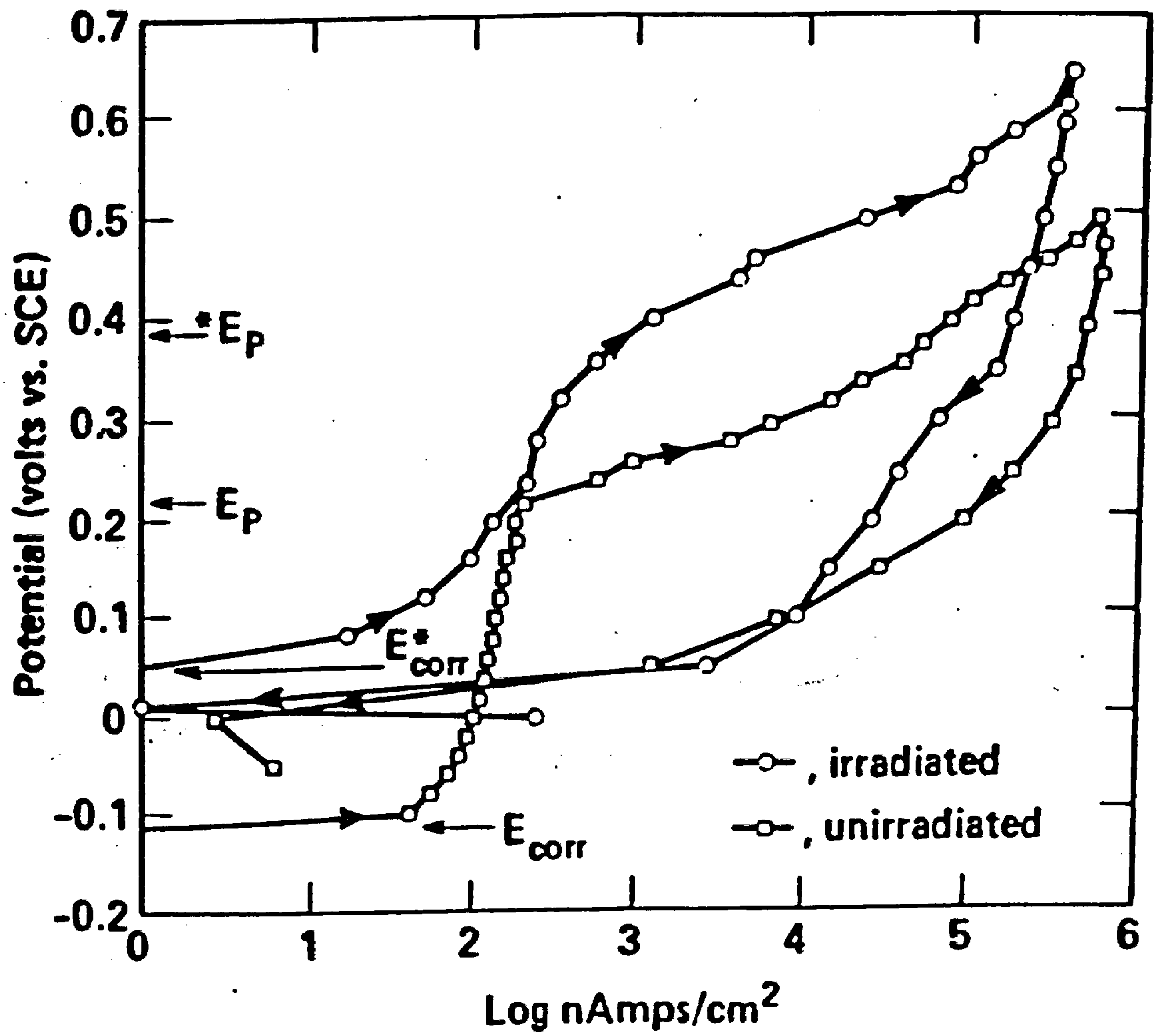


Figure 11: Comparison of the potentiostatic anodic polarization behavior for 316L stainless steel in 650 ppm Cl^- solution in deionized water with and without gamma irradiation. The polarization curves were scanned anodically starting from the corrosion potential in each case. Upon reaching the anodic limit, the scans were reversed to more negative potentials. In this figure, E_{corr} and E_p represent values of the corrosion potential and pitting potential, respectively, for the unirradiated case. The corresponding values for the irradiated experiment are indicated on the figure as $*E_{corr}$ and $*E_p$.



CONCLUSIONS:

1. Gamma radiation increases the oxidizing nature of the environment (H2O2); preliminary evidence suggests the oxide film changes are negligible.

2. OH(ads) + e– = OH– may be an important equilibrium (analogy to Pt); situation complex.

3. Positive potential shifts appear generic to austenitic steels and electrolytes related to J13.

4. Equilibrium processes responsible for for Ecorr shifts occur in near–surface solution layers.

5. Ecorr of stainless steels is more sensitive to H2O2 than bulk H2.

6. Preliminary results suggest radiation does not increase pitting susceptibility.

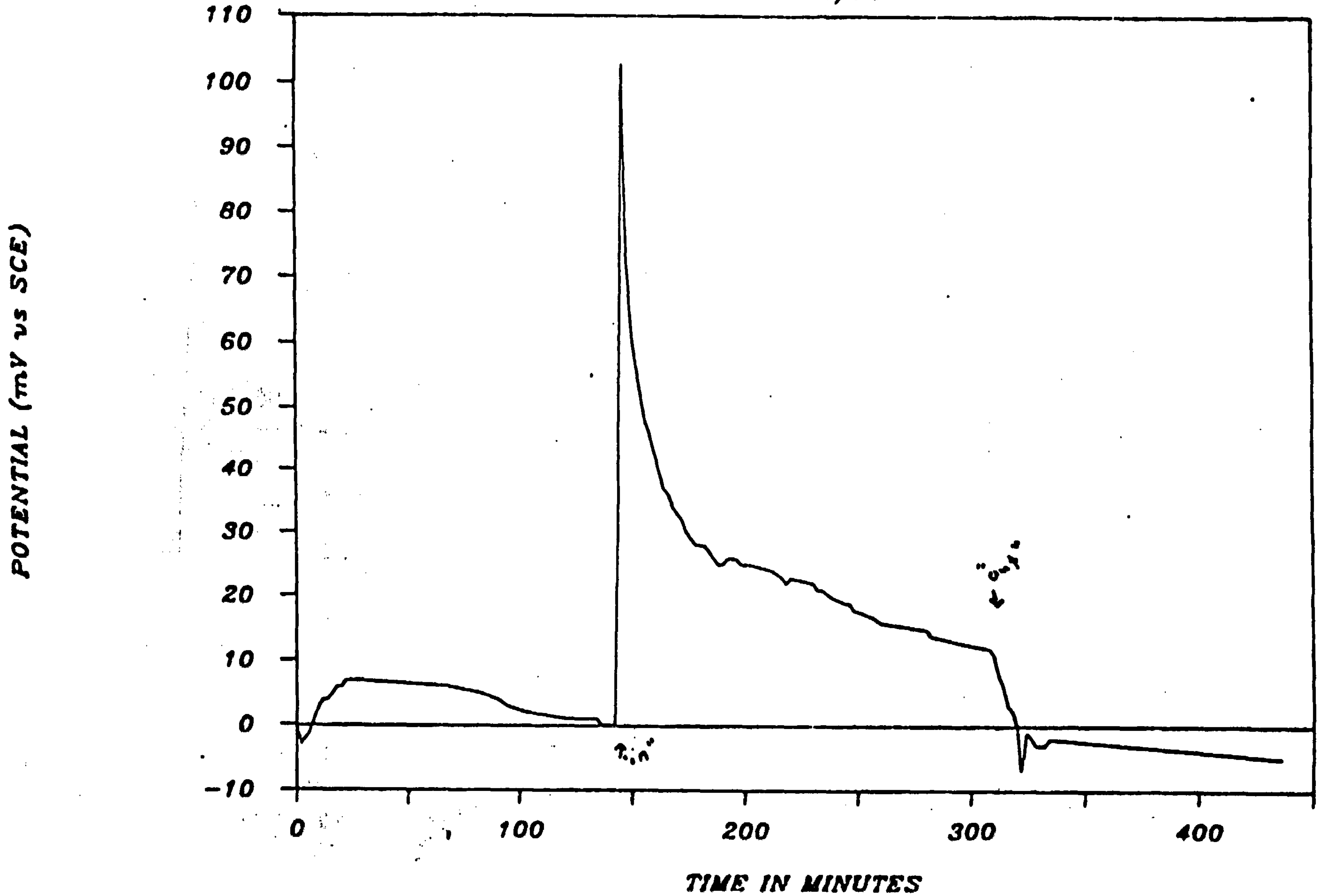
5. GAMMA RADIATION EFFECTS ON COPPER ALLOYS IN J13.

Measured analyses of copper alloys

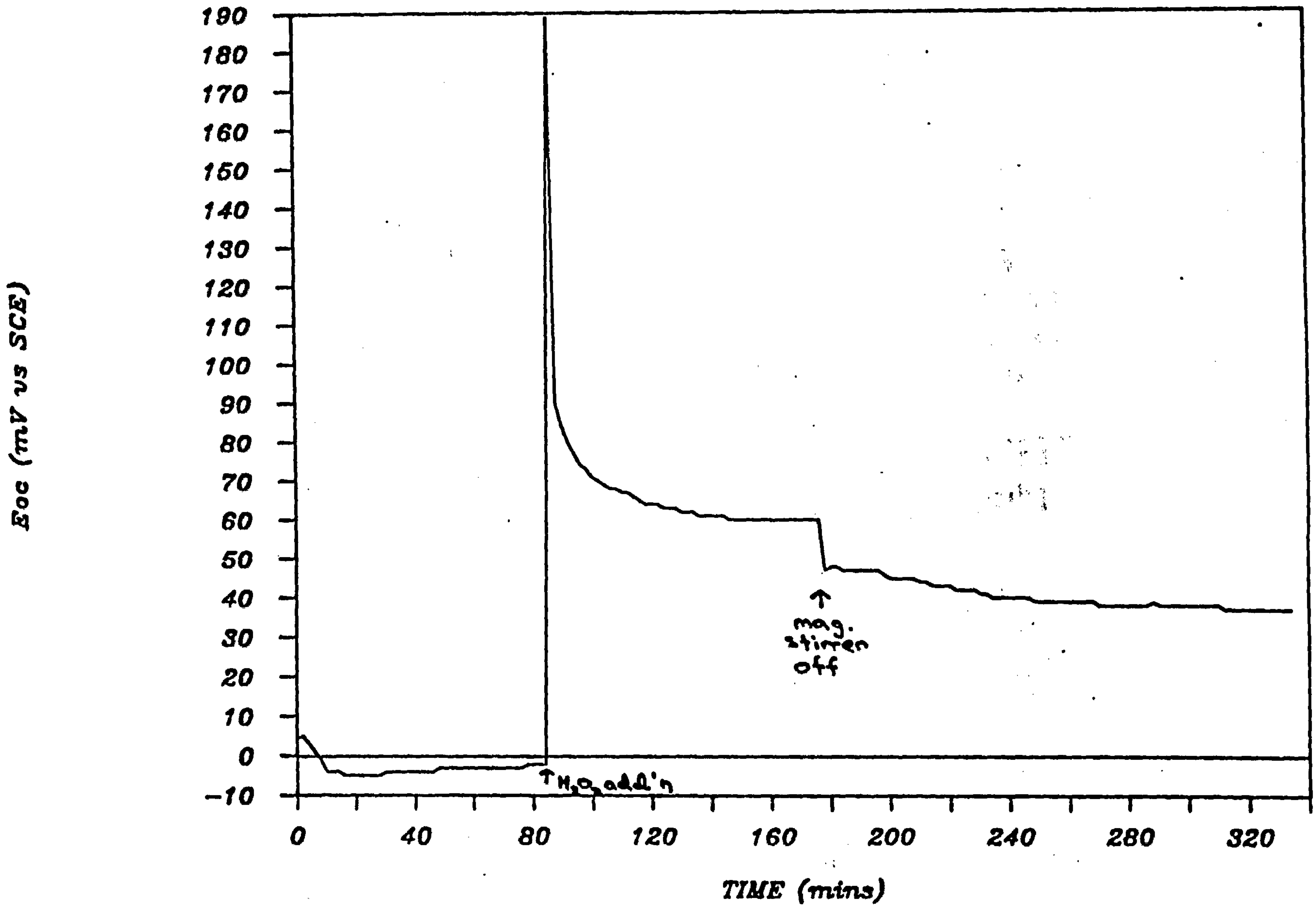
Alloy	Elemental composition (wt %)							
	Cu	Ni	Al	Mn	Sn	Fe	Zn	Other
CDA 102	99.95	–	–	–	–	–	< 0.001	Pb < 0.001; Cd < 0.001 S < 0.0018; Hg < 0.0001 P < 0.003
CDA 613/614	90.82	0.05	6.75	0.16	0.20	2.46	0.01	Pb < 0.01; Co < 0.01
CDA 715	69.18	29.60	–	0.51	–	0.53	0.07	Pb - 0.01; P - 0.002; C - 0.04; S - 0.01

CDA102 IN J13

3.3MRADS/HR



CDA102 W/H202 IN J13



Sample	Exp. duration (h)	Date	Soln. vol.(ml)	Sample area	$[H_2O_2]$, µM
Blank	2.20	8/17/84	~100	N/A	139.00
CDA102	355.00	3/8/85	25	30.91	6.00
316L	"	"	27	30.70	135.00
Blank	"	"	25	N/A	139.00
CDA102	164.00	4/15/85	25	30.95	37.00
316L	"	"	27	30.60	187.00
Blank	"	"	25	N/A	132.00

CATALYTIC AUTODISSOLUTION OF COPPER:

$$Cu \rightleftharpoons Cu^{+} + e^{-}$$

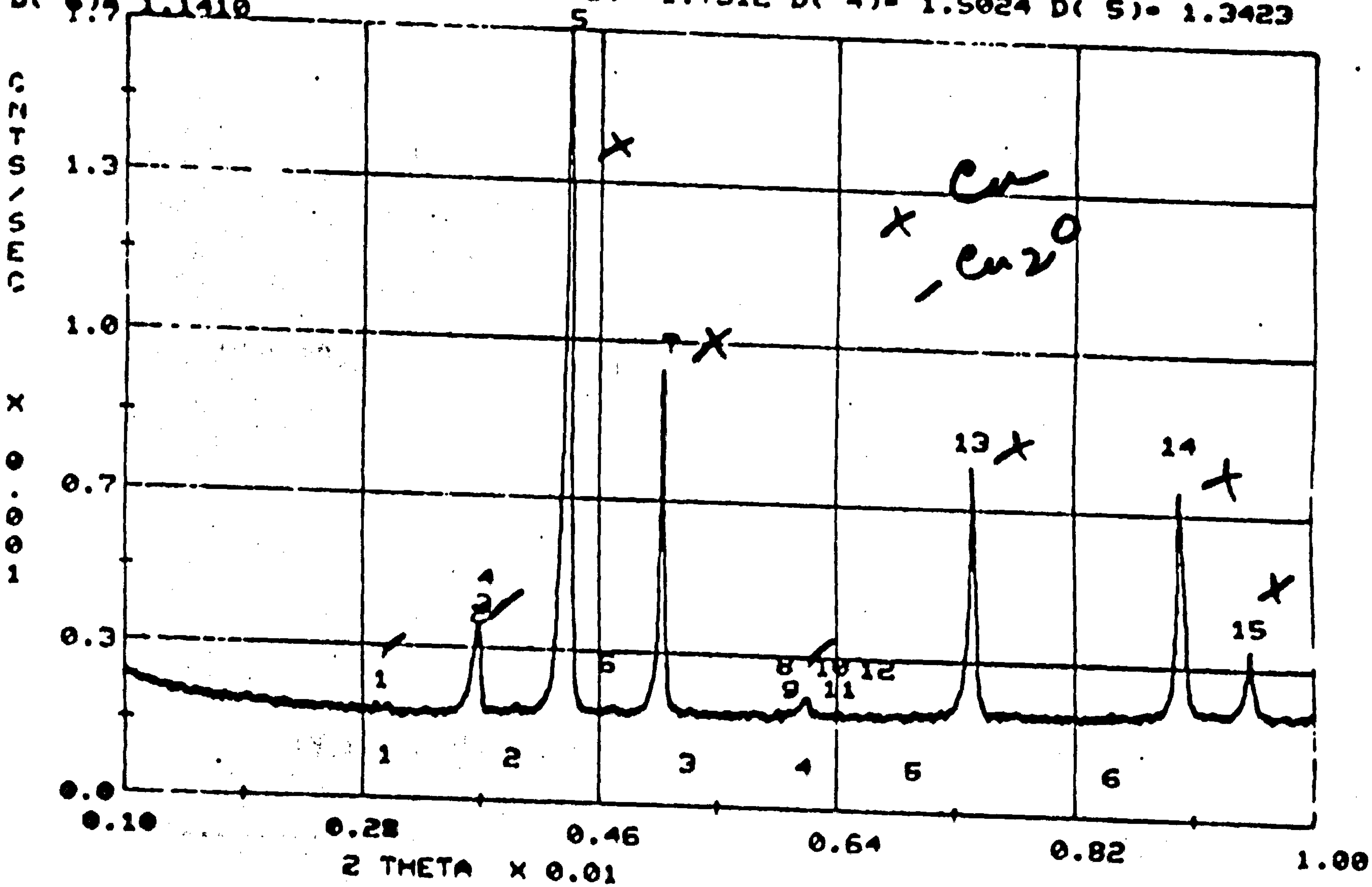
$$Cu^{+2} + e^{-} \rightarrow Cu^{+}$$

WITH Cu^{+2}, ACTING AS AN OXIDANT BEING GENERATED FROM:

$$Cu^{+} + H_2O_2 \rightarrow Cu^{+2} + OH + OH^{-}$$

$$Cu^{+} + OH \rightarrow Cu^{+2} + OH^{-}$$

4921 4-17-85 DIFF CAR CDA 102 CU ROD J13 WELL H20 162 HRS
INITIAL 2THETA= 10.000 DELTA 2THETA= 0.040 TIME INTERVAL= 4.00SEC
ISM= 7 IBKG= 0 0 TGKA2= TGDSP=CU ND2= 7 SENS= 2.0 NUM= 1 IPF=5
D(1)= 2.9847 D(2)= 2.2759 D(3)= 1.7312 D(4)= 1.5024 D(5)= 1.3423
D(6)= 1.1410



$$H_2O + N_2 + 2.5O_2 \rightarrow HNO_3$$

LONG-TERM TEST CONDITIONS:

1. 150°C air/steam, 1×10^5 R/hr
2. 95°C liquid/vapor, 1×10^5 R/hr

1, 3, 6, 9, 12 .. month exposures — wt. loss, crevice and "tear drop" specimens for all copper materials

U-MICHAN:

1.0 Electrochemistry of Copper in Aqueous Solutions
- 1.1 Kinetics studies in bulk electrolyte to identify reactions and processes (impedance and rotating disk experiments)
- 1.2 Modeling of impedance under thin films
- 1.3 Modeling of electrodissolution and corrosion under thin films of electrolyte

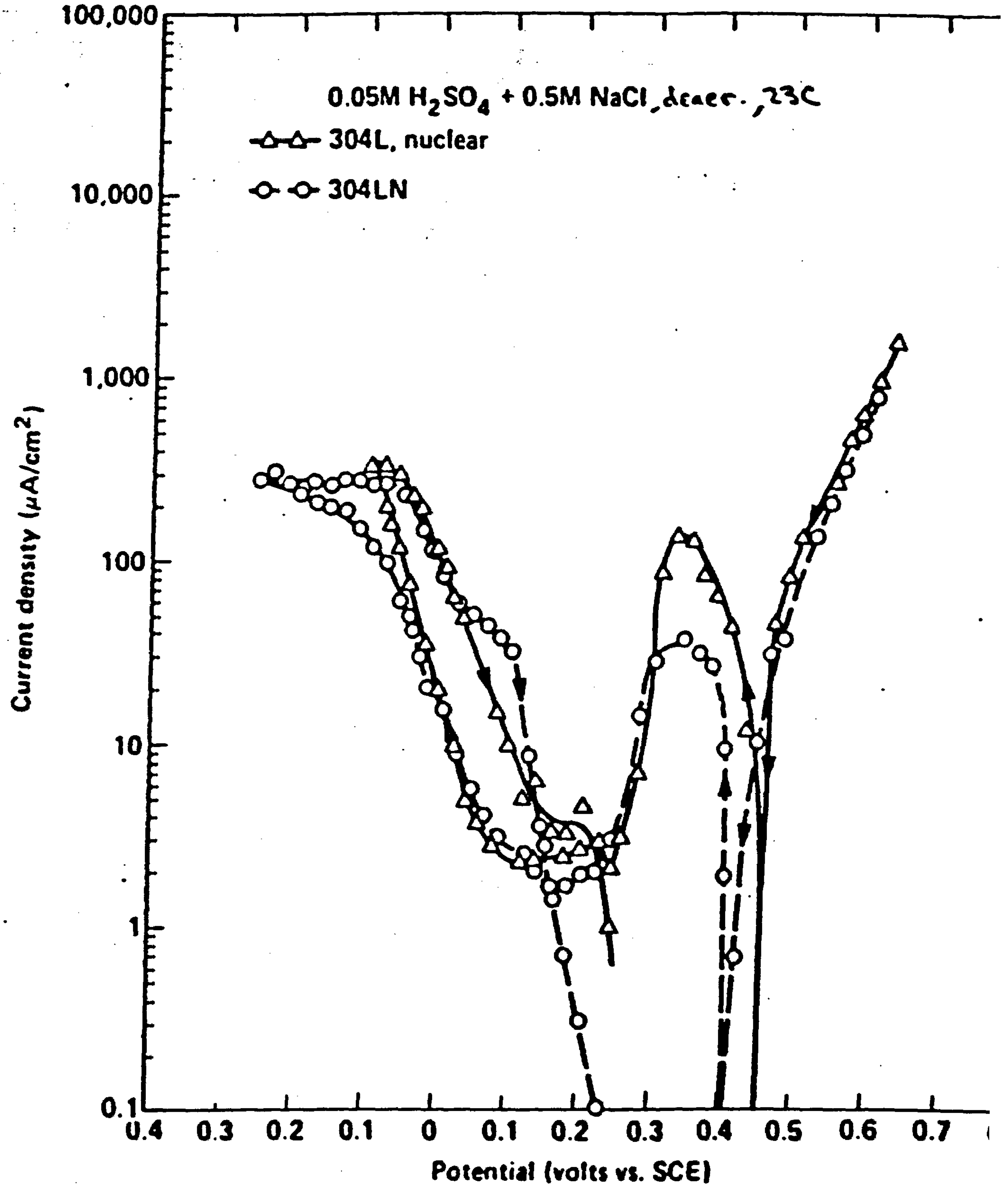
2.0 Electrochemistry of Copper in Irradiated Environments
- 2.1 Cathodic process investigation, in gamma field and in simulated irradiated environments
- 2.2 Modeling of radiolysis products build up in moisture films (electrolyte films)

3.0 Photoelectrochemical Measurements on Copper Alloy Surfaces
- 3.1 Imaging of oxide layers on copper alloy surfaces
- 3.2 Imaging of oxide layers under thin electrolyte films

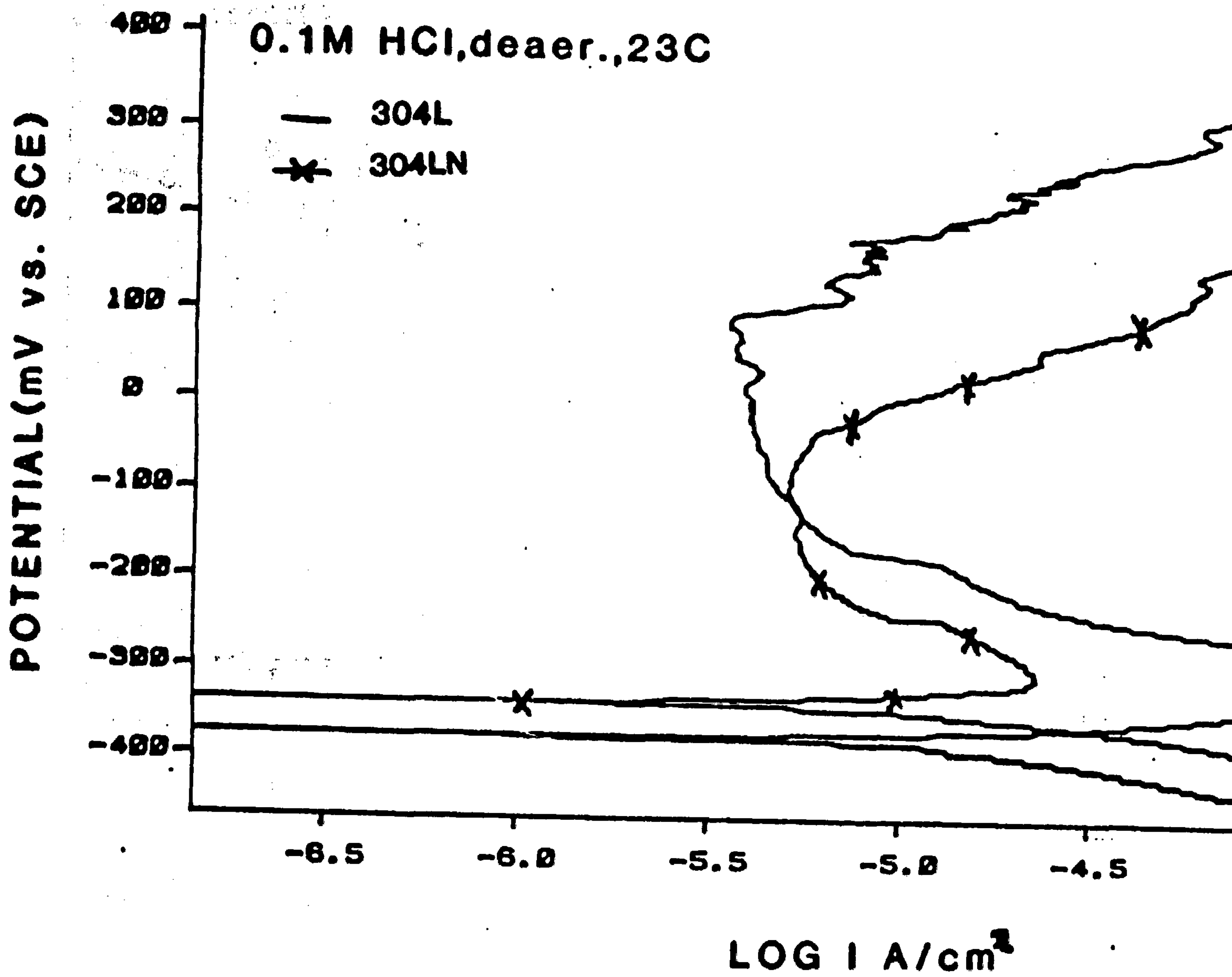
2. COMPARATIVE BEHAVIOR OF L AND LN AUSTENITIC STAINLESS STEEL ALLOYS AND EFFECT OF ALLOY "CLEANLINESS."

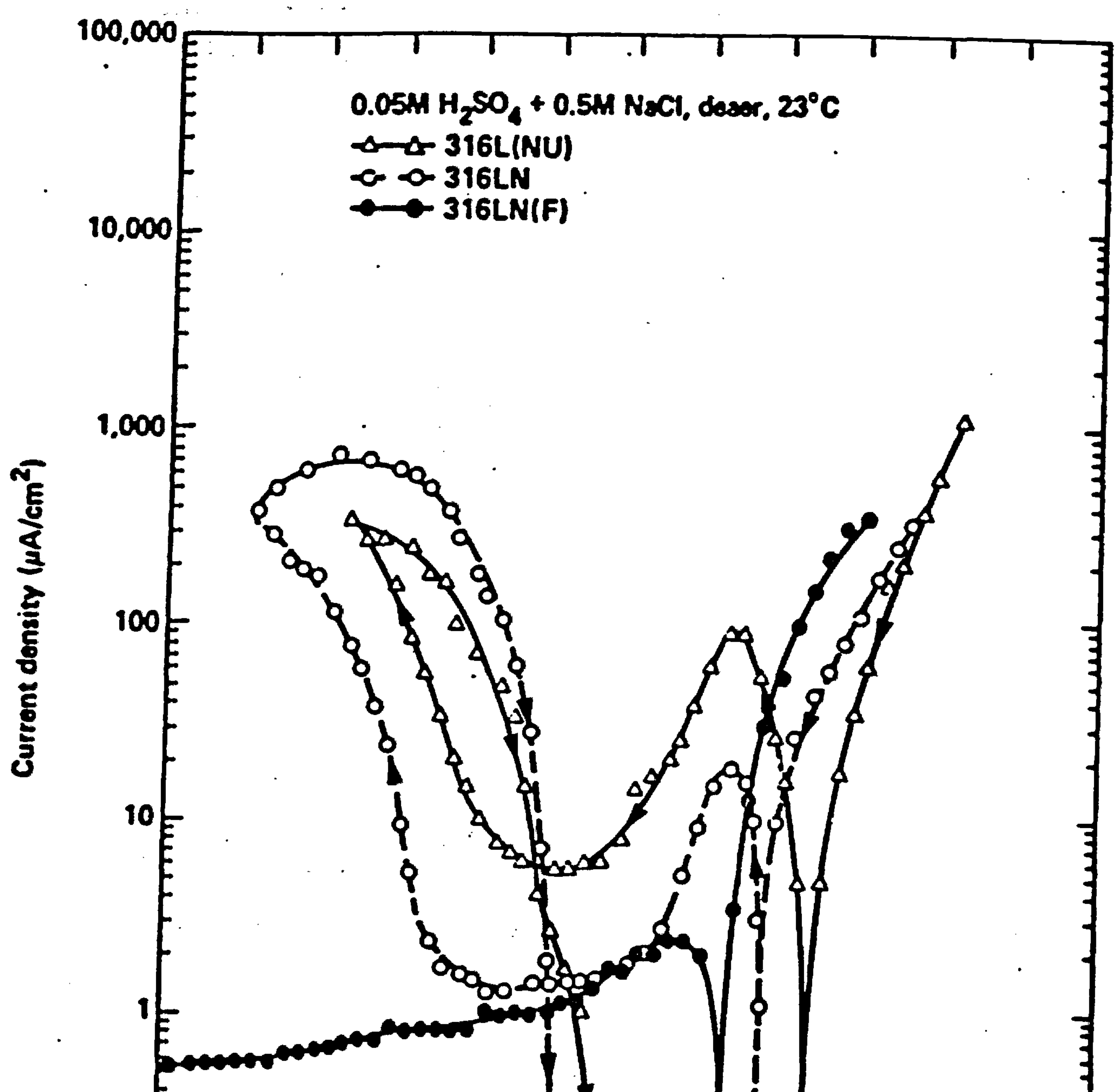
TABLE 1. Analyses of Alloys Used

Alloy	Elements											
	C	Mn	P	S	Si	Co	Cu	Ni	Cr	Mo	N	OTHER
304L	0.017	1.39	0.025	0.015	0.48	0.08	0.43	9.51	18.29	0.23	0.04	bal-Fe
304L (NU)	0.011	1.73	0.031	0.004	0.34	0.12	0.20	9.01	18.38	0.41	0.08	bal-Fe
304LN	0.025	1.10	0.016	0.007	0.45	0.19	0.14	9.28	18.36	0.24	0.16	bal-Fe
316L (NU)	0.020	1.71	0.033	0.014	0.56	0.10	0.28	10.29	16.51	2.07	0.05	bal-Fe
316LN	0.015	1.66	0.030	0.006	0.55	0.19	0.29	10.60	16.70	2.15	0.11	bal-Fe
316LN (F)	0.017	1.61	0.028	0.003	0.50	-------	0.24	11.40	17.60	2.80	0.11	bal-Fe

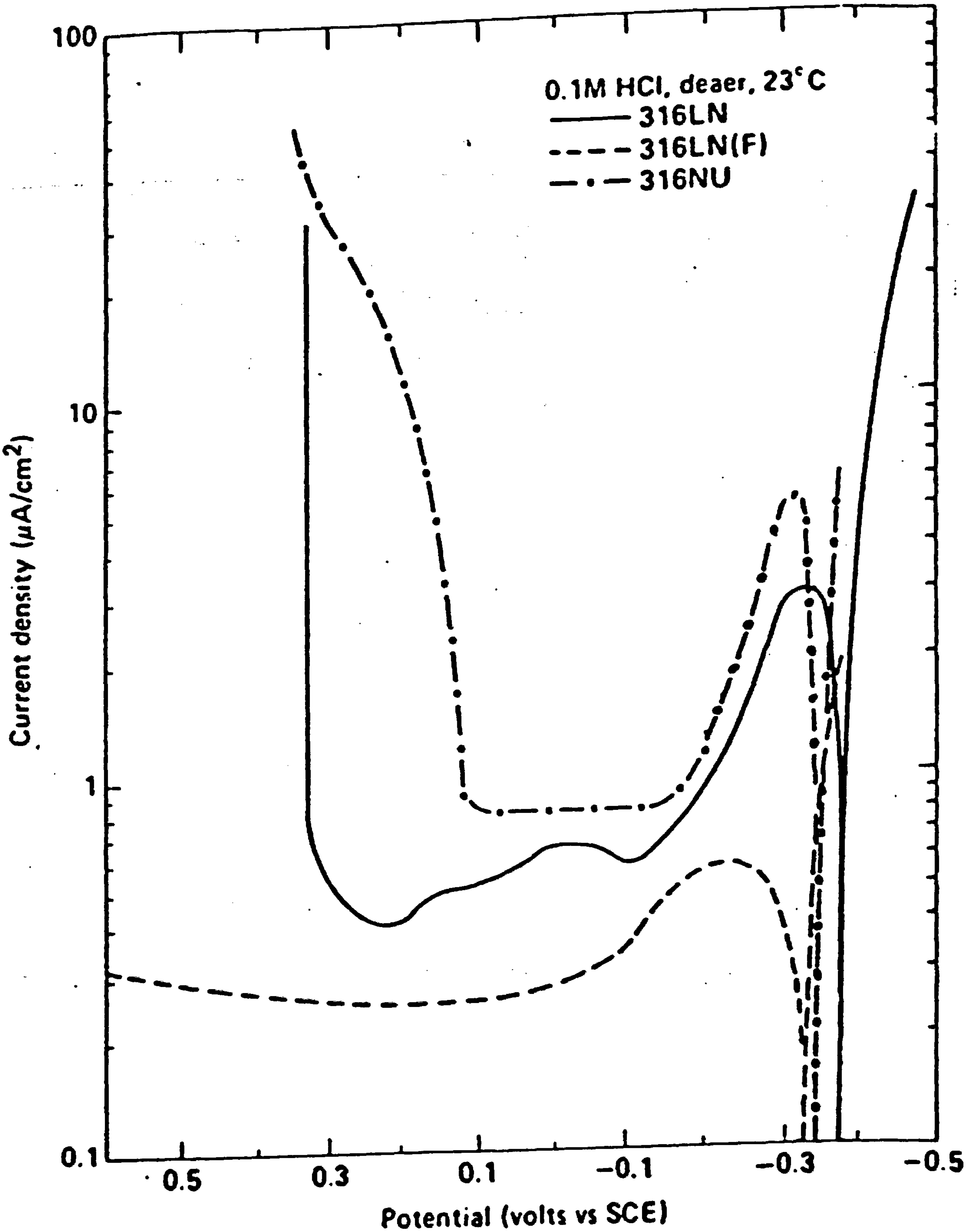


0.05M H_2SO_4 + 0.5M NaCl, deaer., 23C
304L, nuclear
304LN
Current density ($\mu A/cm^2$)
100,000
10,000
1,000
100
10
1
0.1
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Potential (volts vs. SCE)

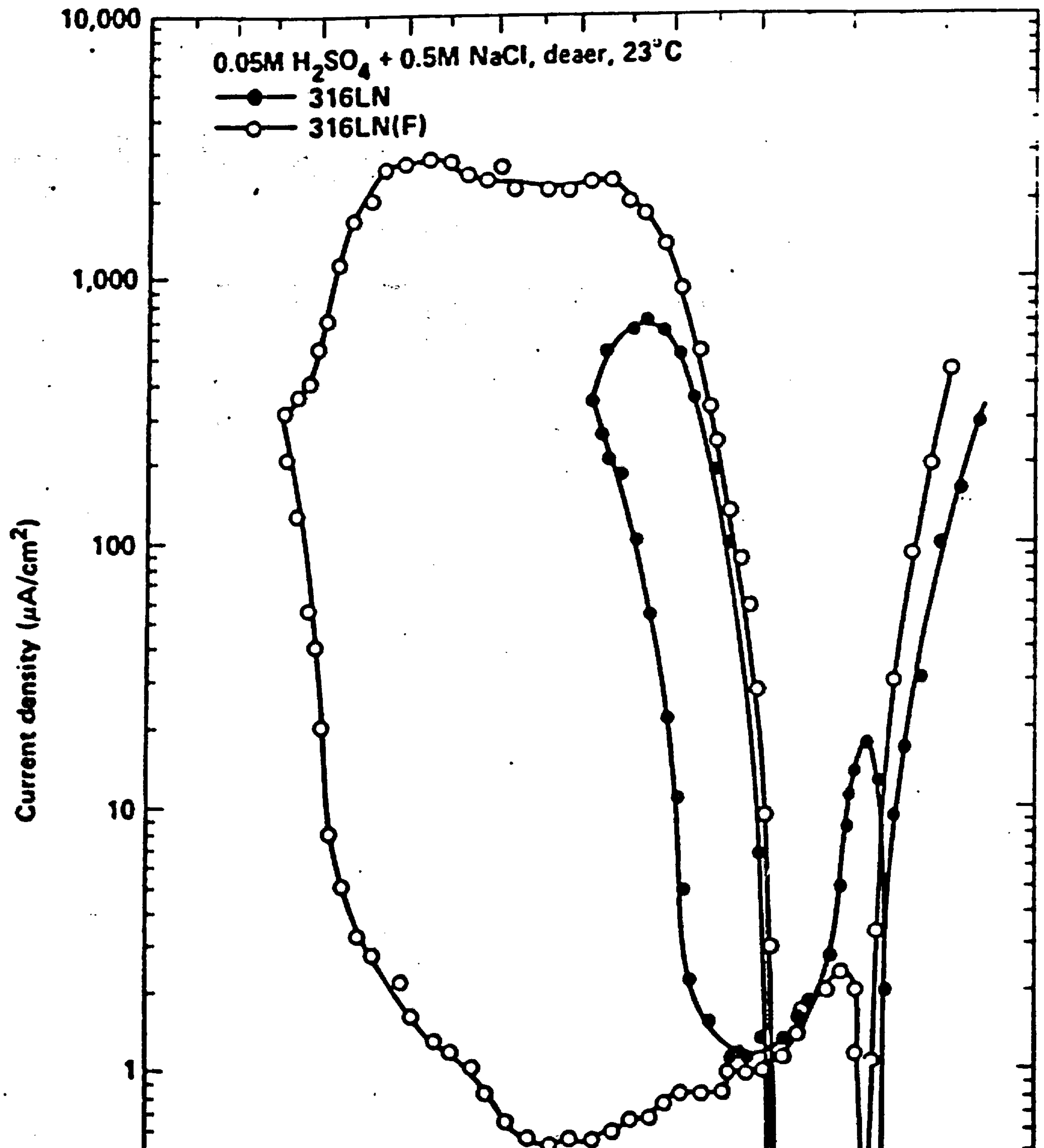

0.1M HCl,deaer.,23C
304L
304LN
POTENTIAL(mV vs. SCE)
400
300
200
100
0
-100
-200
-300
-400
-6.5
-6.0
-5.5
-5.0
-4.5
LOG I A/cm²



100,000
10,000
1,000
100
10
1
Current density (μA/cm²)
0.05M H₂SO₄ + 0.5M NaCl, deaer, 23°C
316L(NU)
316LN
316LN(F)



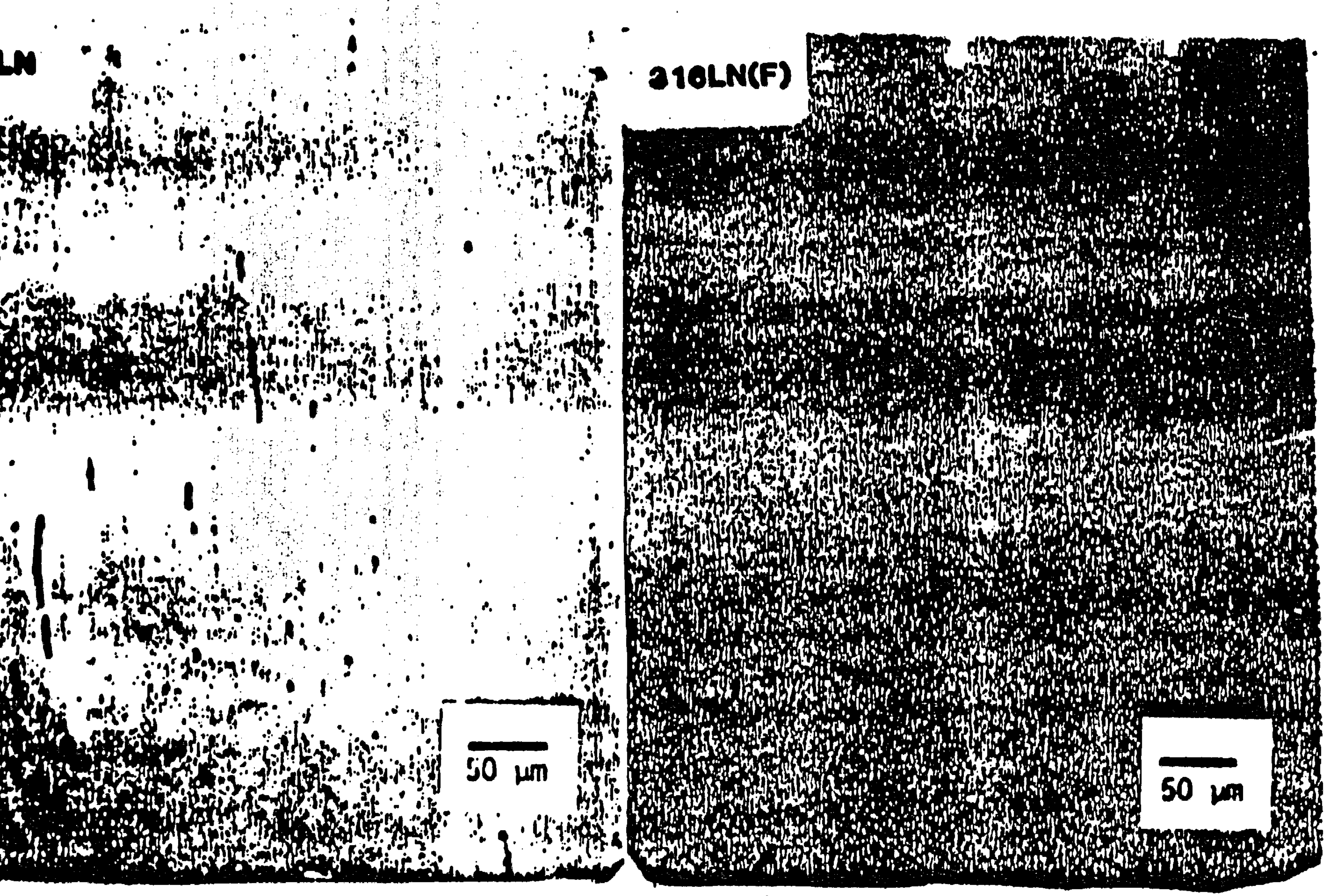
0.1M HCl, deaer, 23°C
316LN
316LN(F)
316NU
100
10
1
0.1
Current density (μA/cm²)
0.5
0.3
0.1
−0.1
−0.3
−0.5
Potential (volts vs SCE)

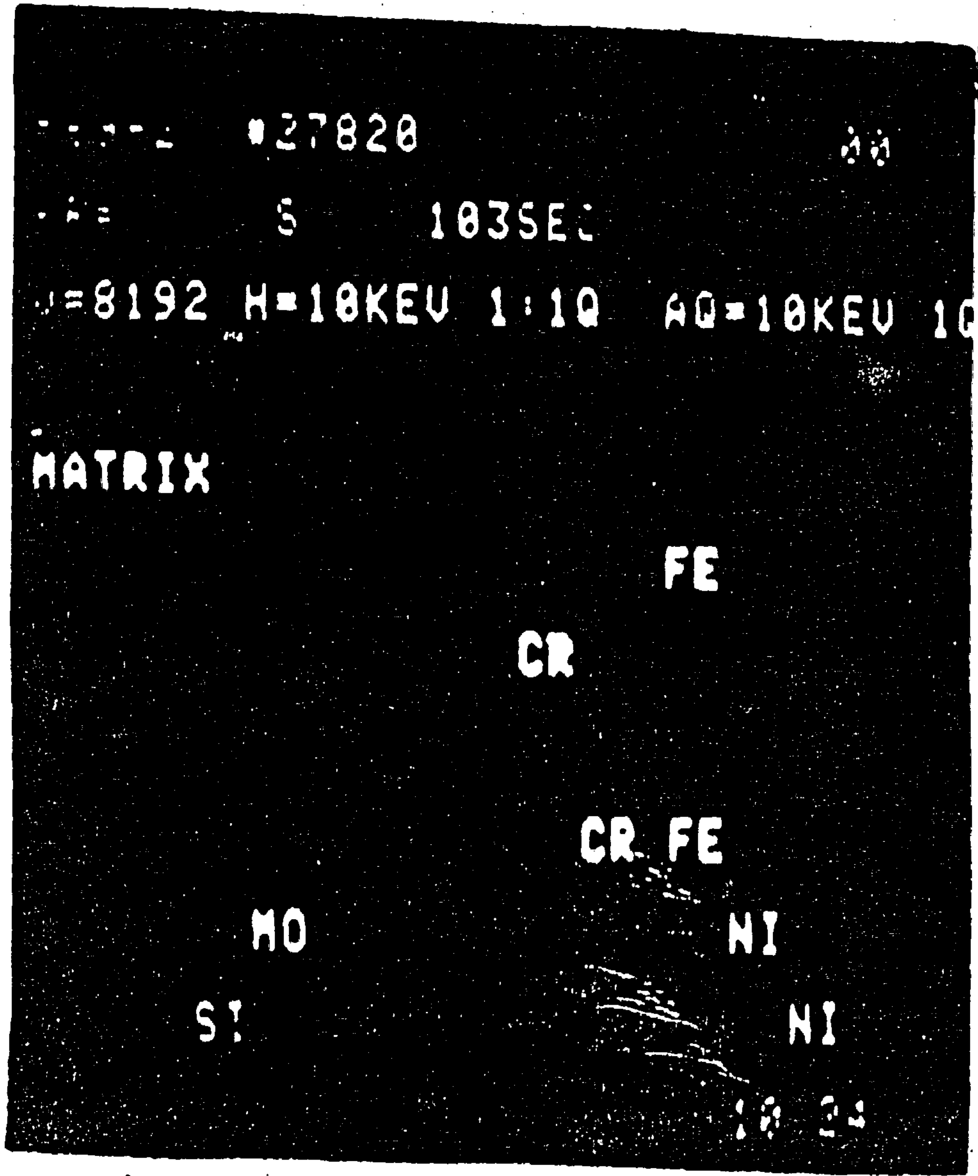


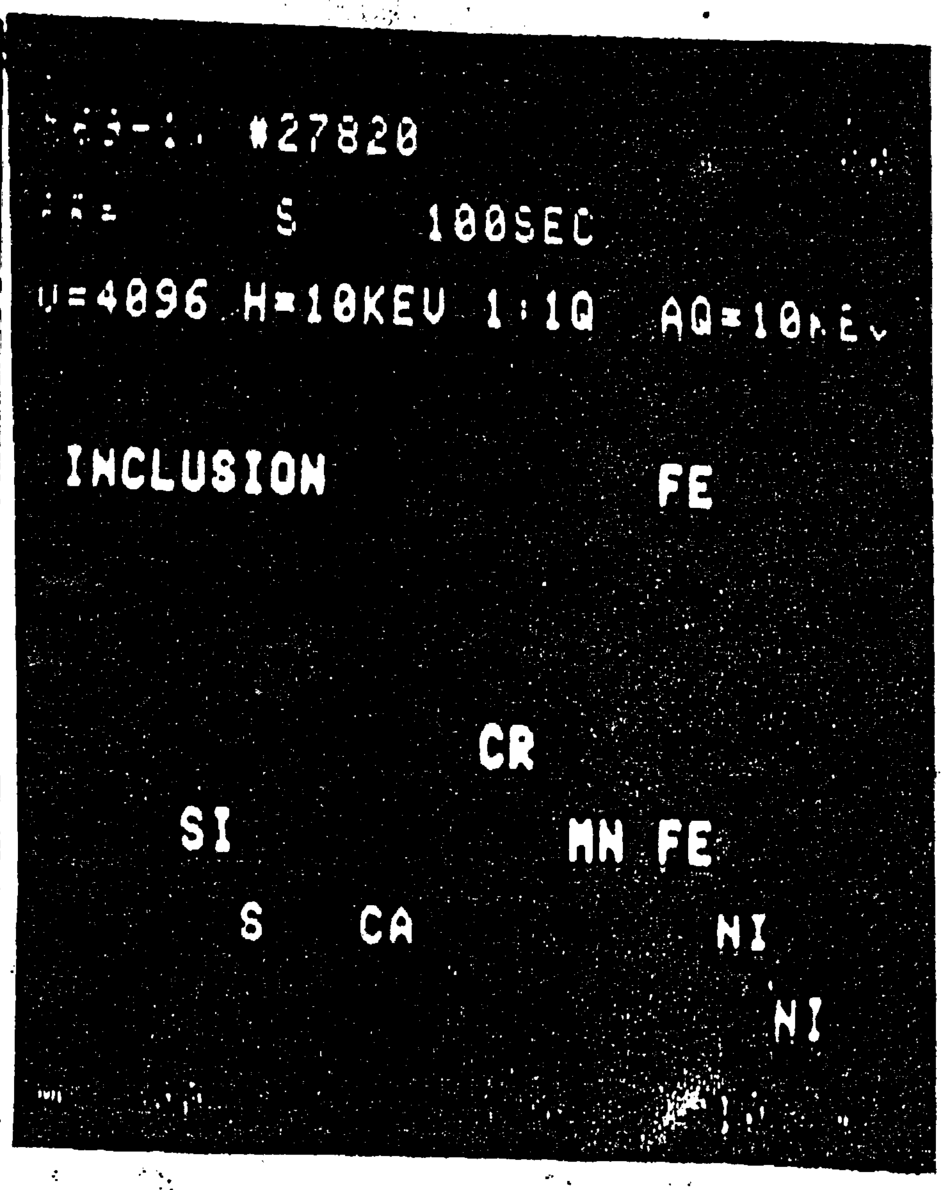
10,000
1,000
100
10
1
Current density (μA/cm²)
0.05M H₂SO₄ + 0.5M NaCl, deaer, 23°C
316LN
316LN(F)

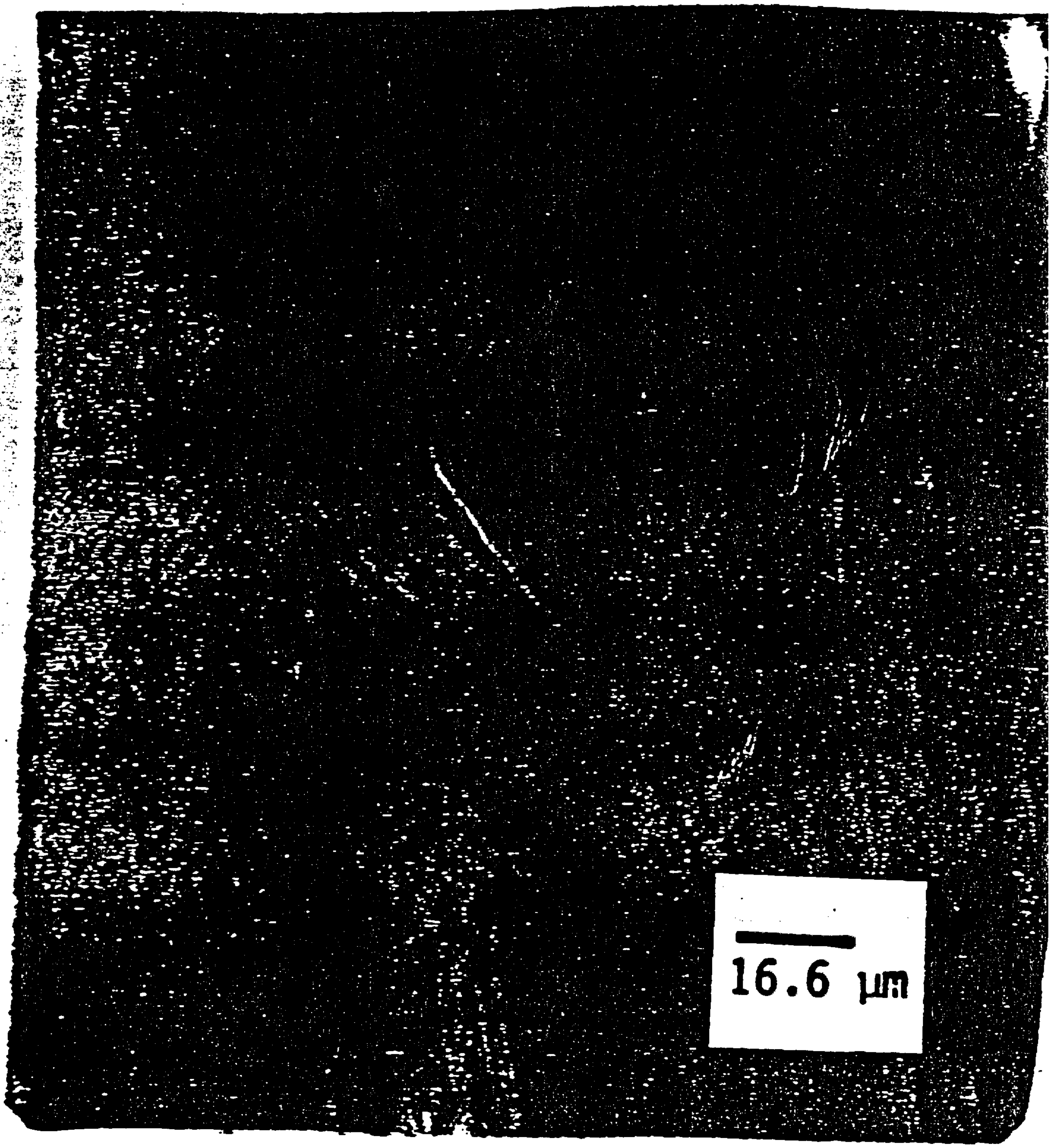
TABLE 1. Analyses of Alloys Used

	Elements											
Alloy	C	Mn	P	S	Si	Co	Cu	Ni	Cr	Mo	N	OTHER
316L (NU)	0.02	1.71	0.033	0.014	0.56	0.10	0.28	10.29	16.51	2.07	0.05	bal-Fe
316LN	0.02	1.66	0.030	0.006	0.55	0.19	0.29	10.60	16.70	2.15	0.11	bal-Fe
316LN (F)	0.02	1.61	0.028	0.003	0.50	-------	0.24	11.40	17.60	2.80	0.11	bal-Fe

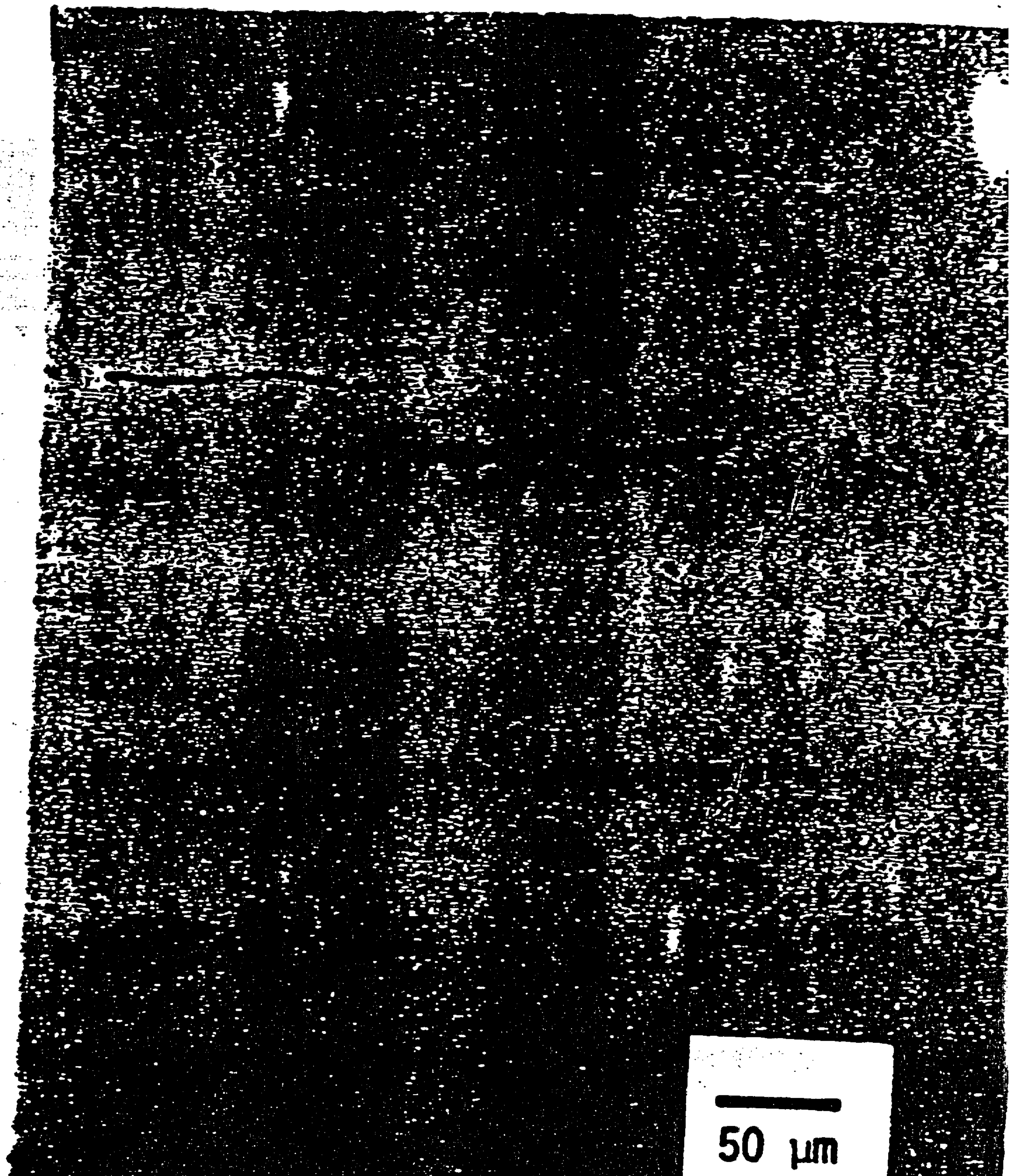

LN
316LN(F)
50 µm
50 µm


#27820
S 103SEC
V=8192 H=10KEV 1:1Q AQ=10KEV 10
MATRIX
FE
CR
CR FE
MO
NI
SI
NI


#27820
S 100SEC
V=4096 H=10KEV 1:1Q AQ=10
INCLUSION
FE
CR
SI
MN FE
S
CA
NI
NI



316LN-INCLUSION PITTING

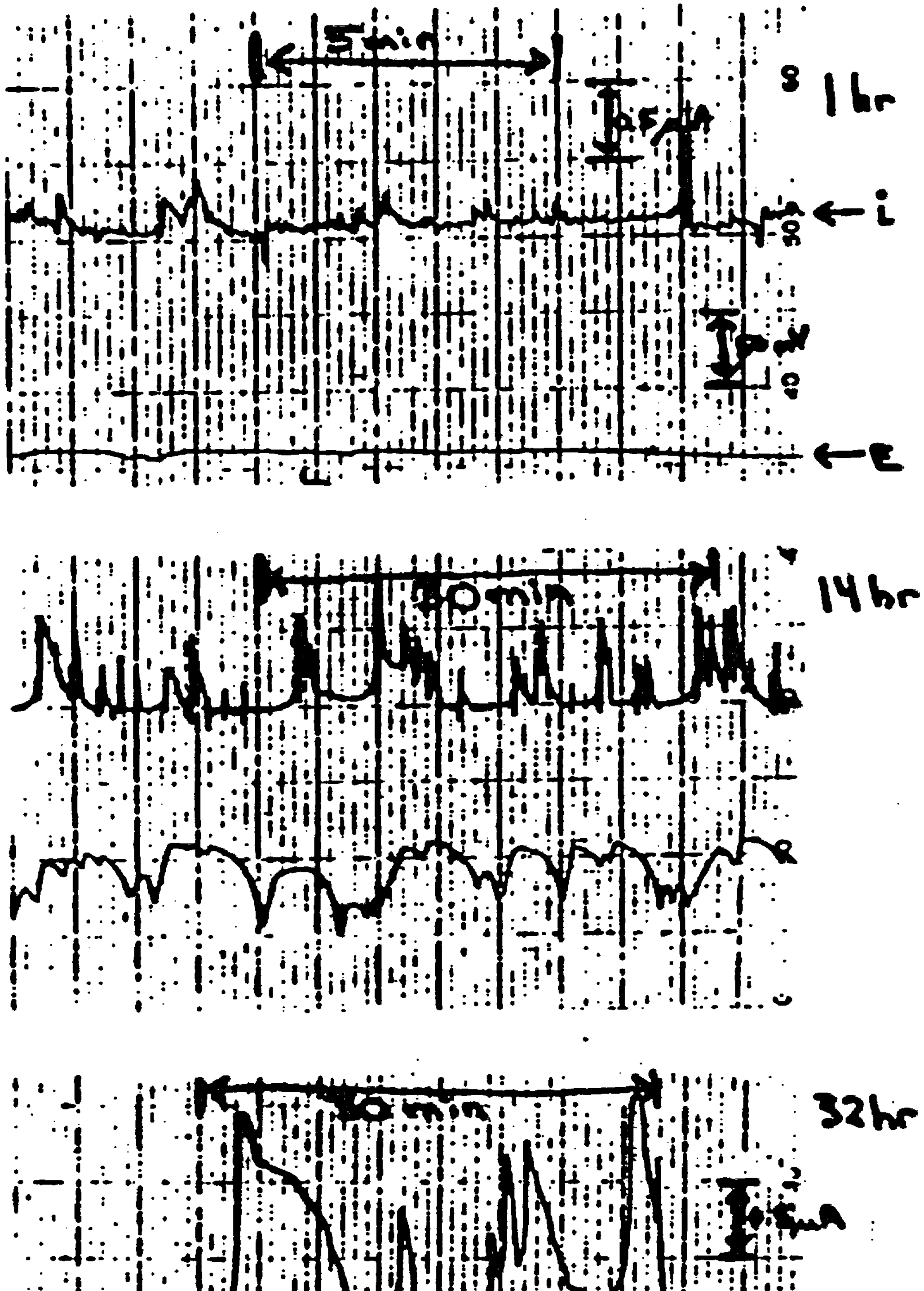


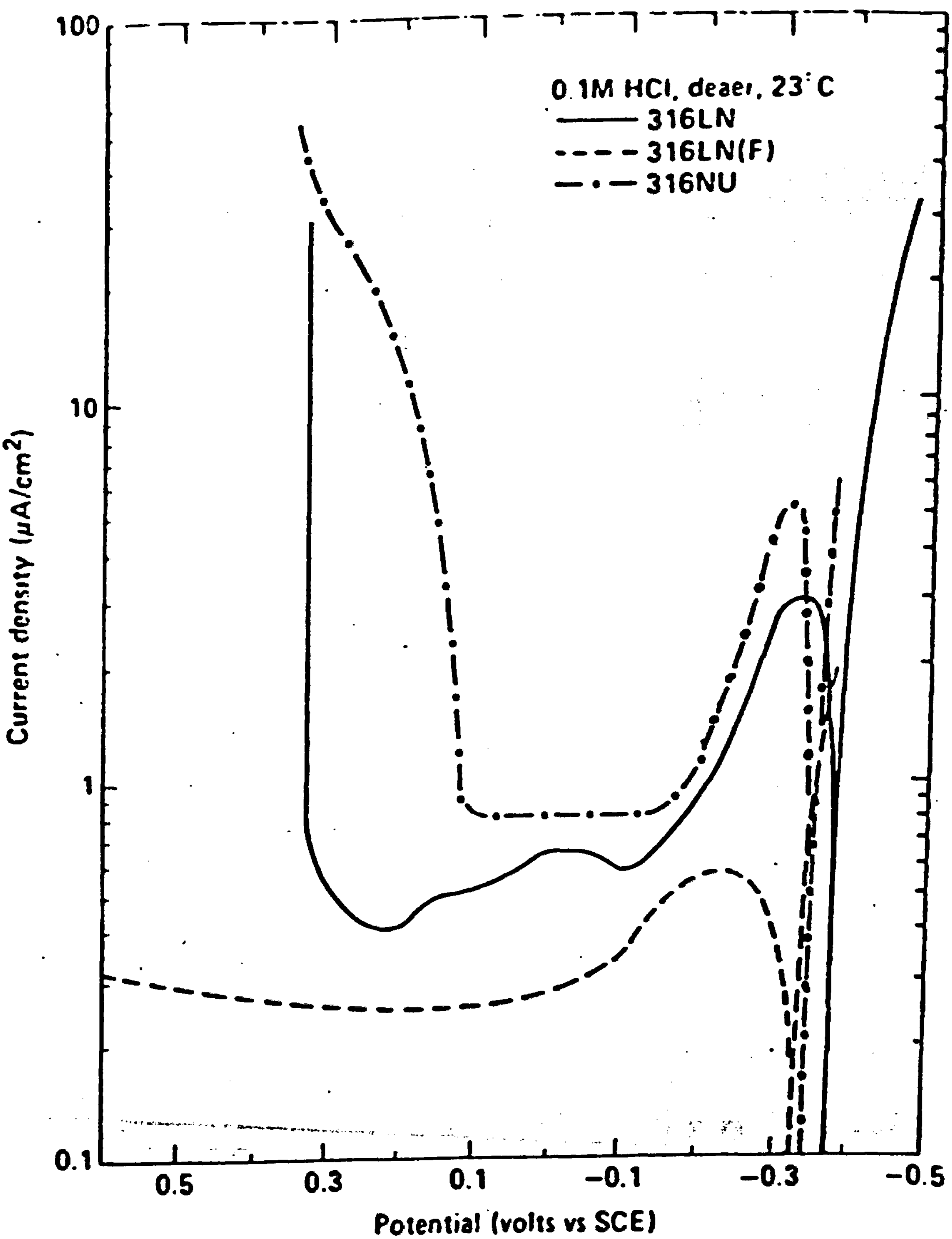
316LN(F)-FERRITE ETCH

Bolted Coupon (Teflon Spacer) Crevice

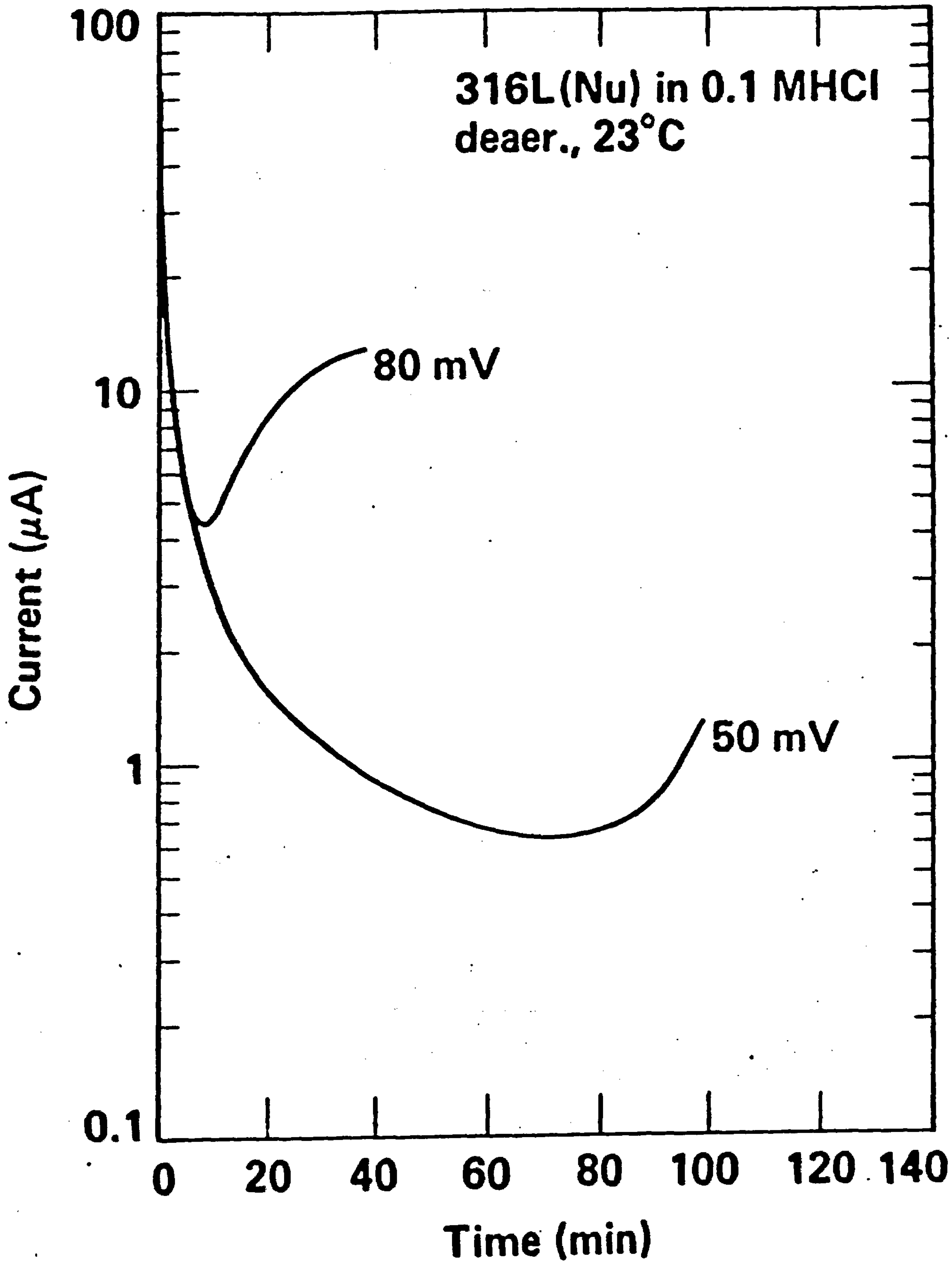
Corrosion Tests in 10,000 mg/l Cl^- at 35°C, 54 days

Alloy	Sample	% rel. wt. loss	% area attacked
304L	1	0.0157	7.4
	2	0.0137	7.2
	3	0.0131	8.6
	ave.	0.0142	7.7
304LN	1	0.0047	2.1
	2	0.0078	5.1
	3	0.0054	3.5
	ave.	0.0059	3.5
316L	1	0.0076	1.2
	2	0.0060	2.1
	3	0.0041	0.6
	ave.	0.0059	1.3
316LN	1	0.0105	2.5
	2	0.0098	3.5
	3	0.0103	4.7
	ave.	0.0102	3.6

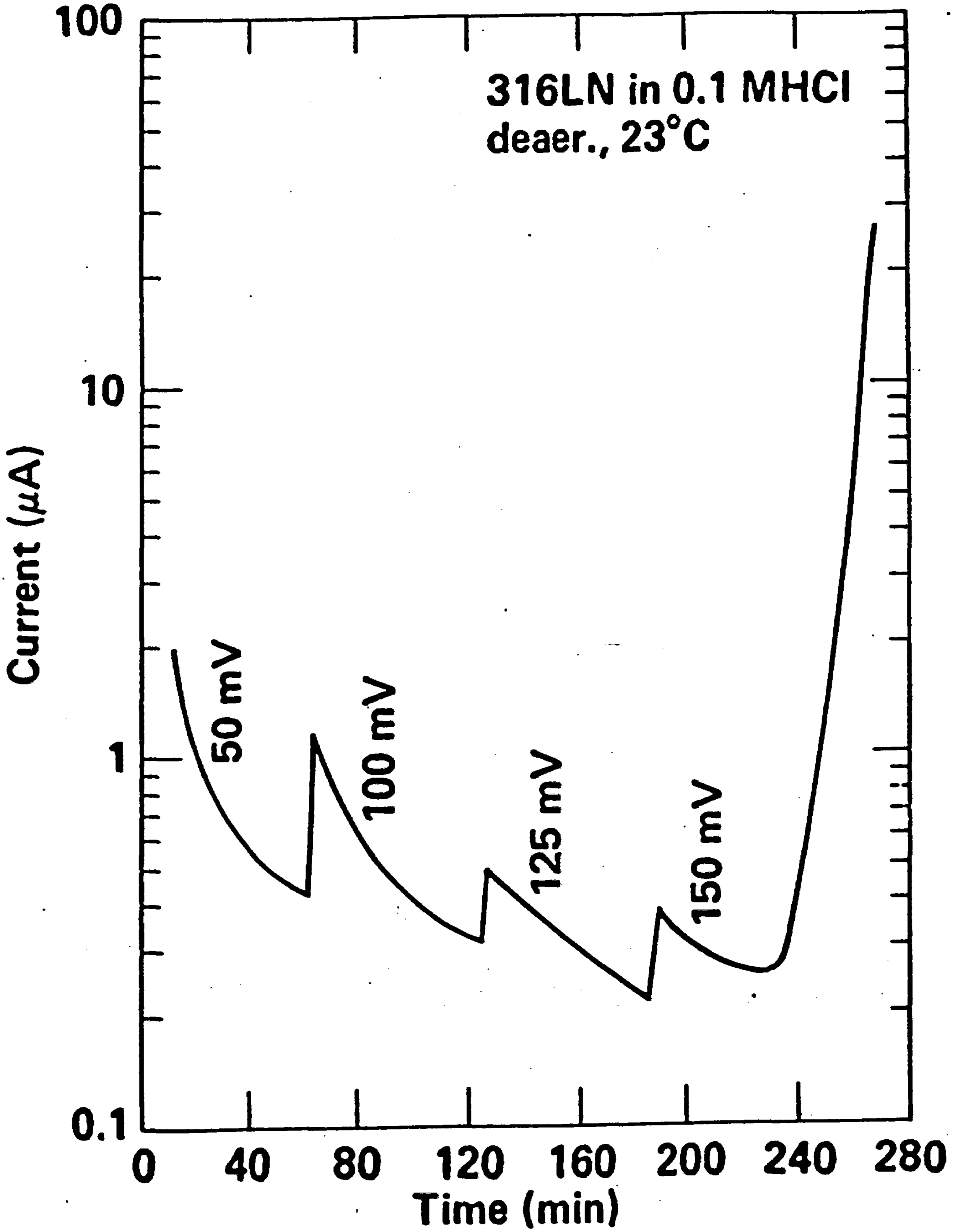

5 min
1 hr
← i
← E
14 hr
30 min
32 hr



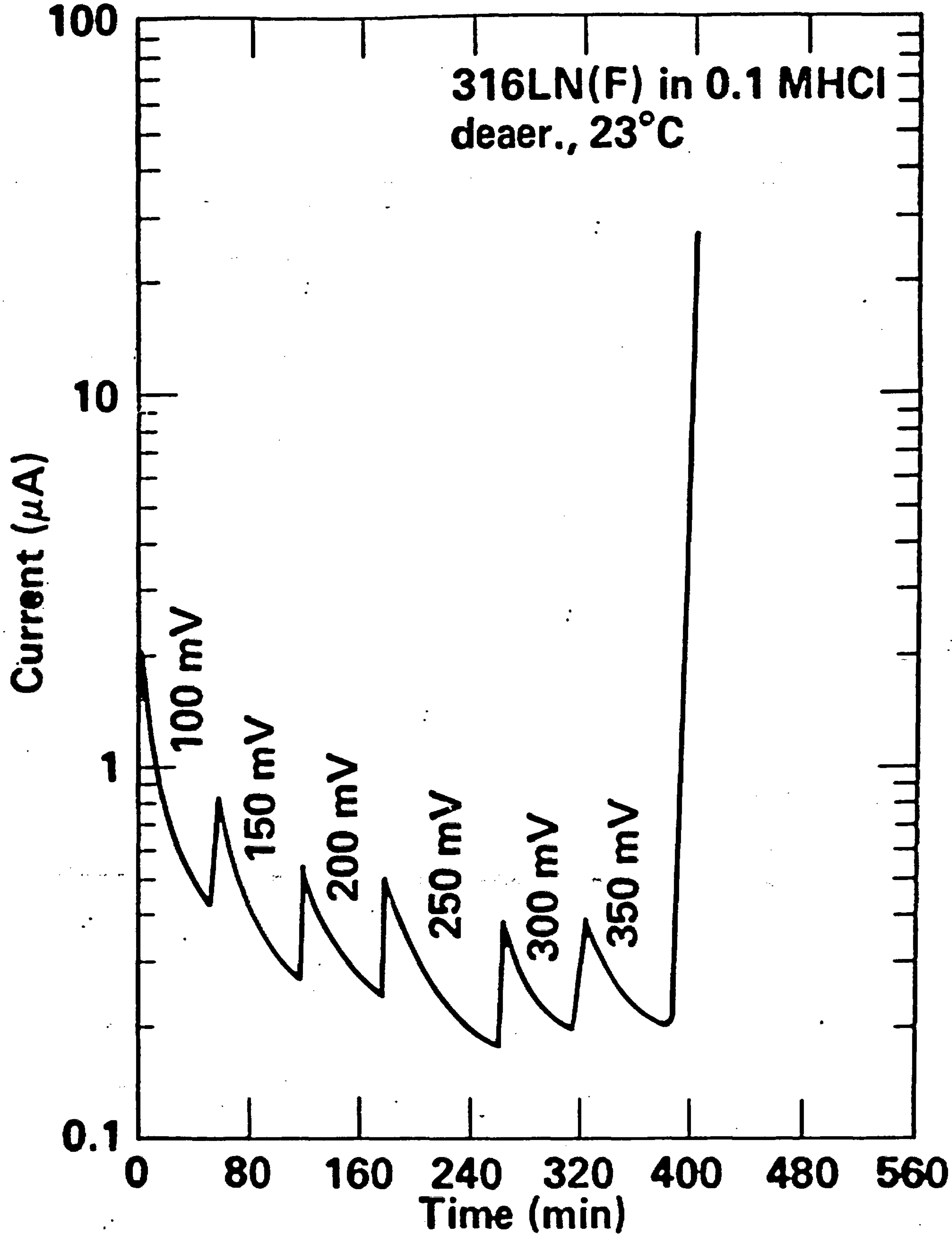
0.1M HCl, deaer, 23°C
316LN
316LN(F)
316NU
100
10
1
0.1
Current density (μA/cm²)
0.5
0.3
0.1
−0.1
−0.3
−0.5
Potential (volts vs SCE)



316L(Nu) in 0.1 MHCl
deaer., 23°C
80 mV
50 mV
100
10
1
0.1
Current (μA)
0
20
40
60
80
100
120
140
Time (min)



316LN in 0.1 MHCl
deaer., 23°C
Current (μA)
100
10
1
0.1
50 mV
100 mV
125 mV
150 mV
0
40
80
120
160
200
240
280
Time (min)

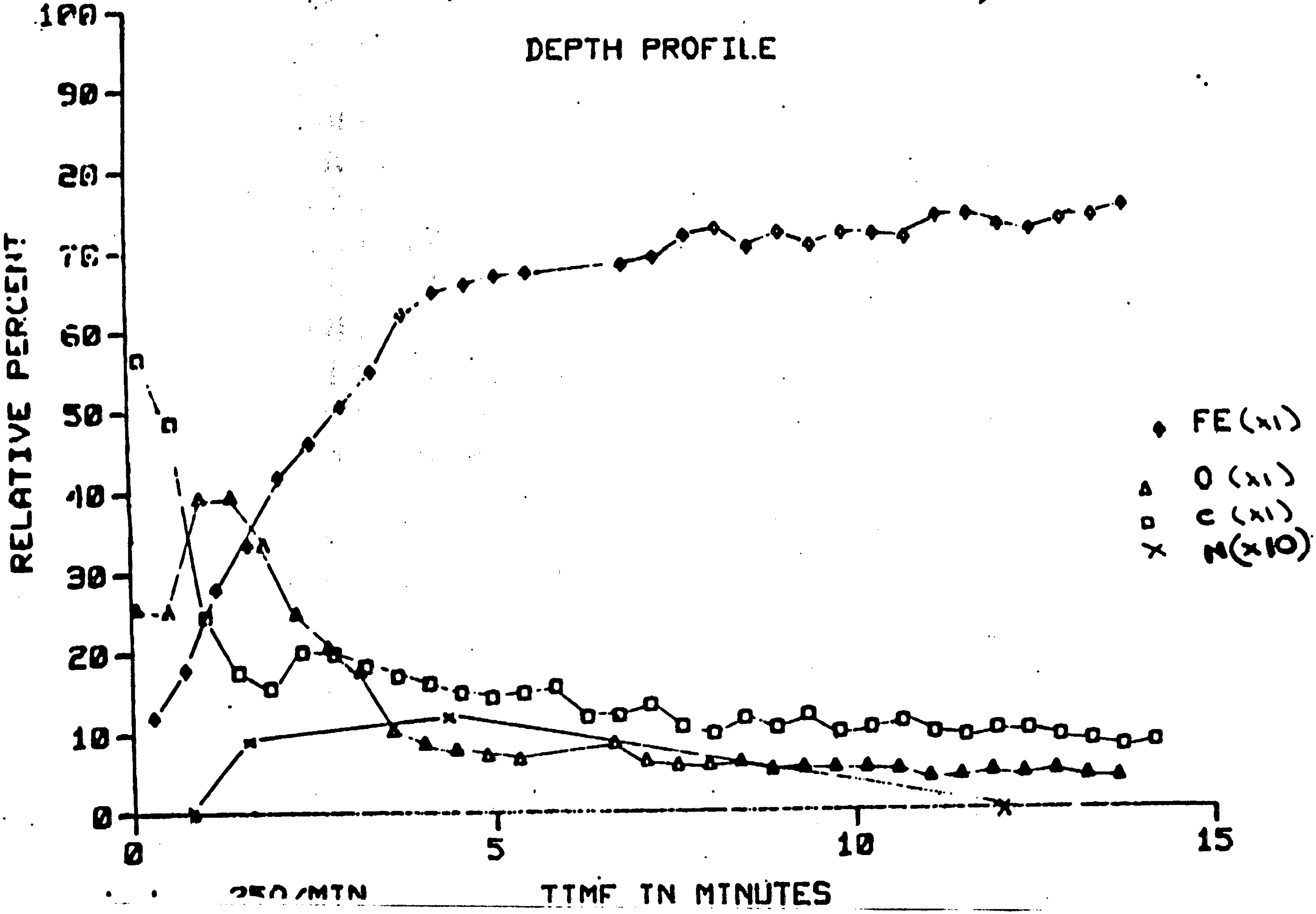

316LN(F) in 0.1 MHCl
deaer., 23°C
Current (μA)
100
10
1
0.1
100 mV
150 mV
200 mV
250 mV
300 mV
350 mV
0
80
160
240
320
400
480
560
Time (min)

Critical Potentials for Crevice Corrosion in 0.1M HC

Alloy	E_{crit} (mV vs. SCE)
304L	-20 to 0
304LN	20 to 40
316L(NU)	50 to 80
316LN	125 to 150
316LN(F)	300 to 350

316LN SS PASSIVATED IN H2SO4-NACL, 0.15V

DEPTH PROFILE



Conclusions:

1. Differences in localized corrosion resistance exist between L and LN steels

   Generally, 316LN(F) > 316LN > 316L > 304LN $\gtrless$ 304L
   a. Increased nitrogen
   b. Small variations in other alloying constituents
   c. "Cleanliness"

2. With regard to the enhancement of corrosion resistance, 316LN appears to show a more marked improvement with respect to 316L than (relatively) 304LN does with respect to 304L. Synergism between Mo and N?

3. Not all commercial 316LN stainless steels are created equal. "Small" increase in N, Ni, Mo and Cr coupled with fewer inclusions leads to dramatic improvement.

Future Work

1. Continue γ radiation studies -

   a. Higher temperature electrochem
   b. Crevice effects
   c. Ex-situ modeling-stressed samples with impressed potential; SRI
   d. Long-term exposure testing - LLNL, HEDL, Univ. Minn.

2. Localized corrosion - both copper and alloys, and stainless steels - effect of minor variations in alloying constituents; "cleanliness"

3. AC impedance studies in thin films - LLNL, Univ. Minn.

N.N.W.S.I.

"SCC and other metallurgical concerns with austenitic stainless steels"

Mary C. Juhas

June 1985

WHAT ABOUT PHASE STABILITY?

- o LOW TEMPERATURE SENSITIZATION (LTS)
- o SIGMA PHASE
- o EFFECTS OF COLD WORK

WHAT CAUSES THESE MICROSTRUCTURAL CHANGES?

WE MUST SEPARATE MICROSTRUCTURAL CHANGES INTO...

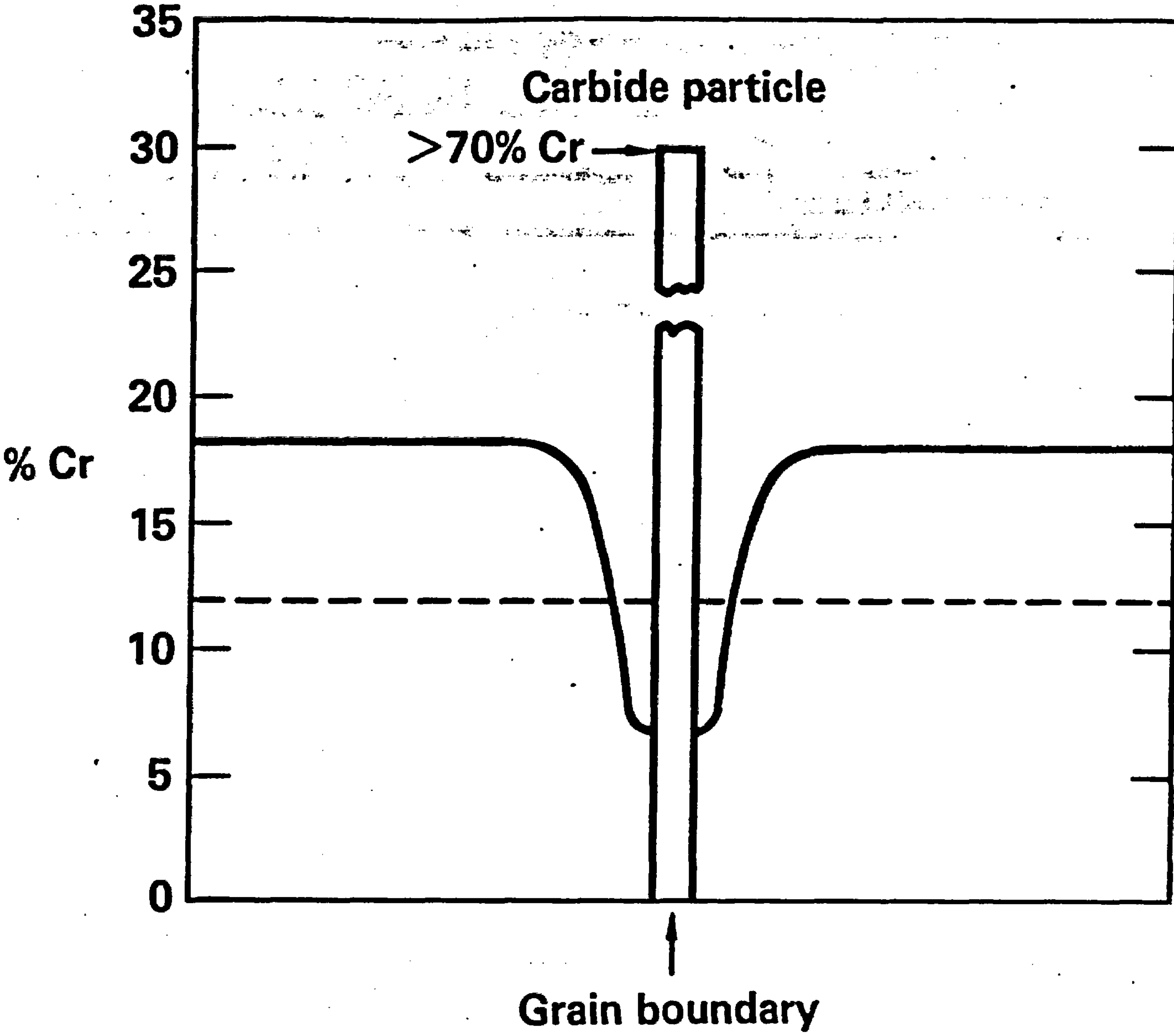
- o LONGTERM
- o SHORTERM

...AND ADDRESS THE QUESTIONS,

HOW DO WE TEST FOR THESE CHANGES IN THE LABORATORY?

CAN SOME PROCESSES BE ACCELERATED?

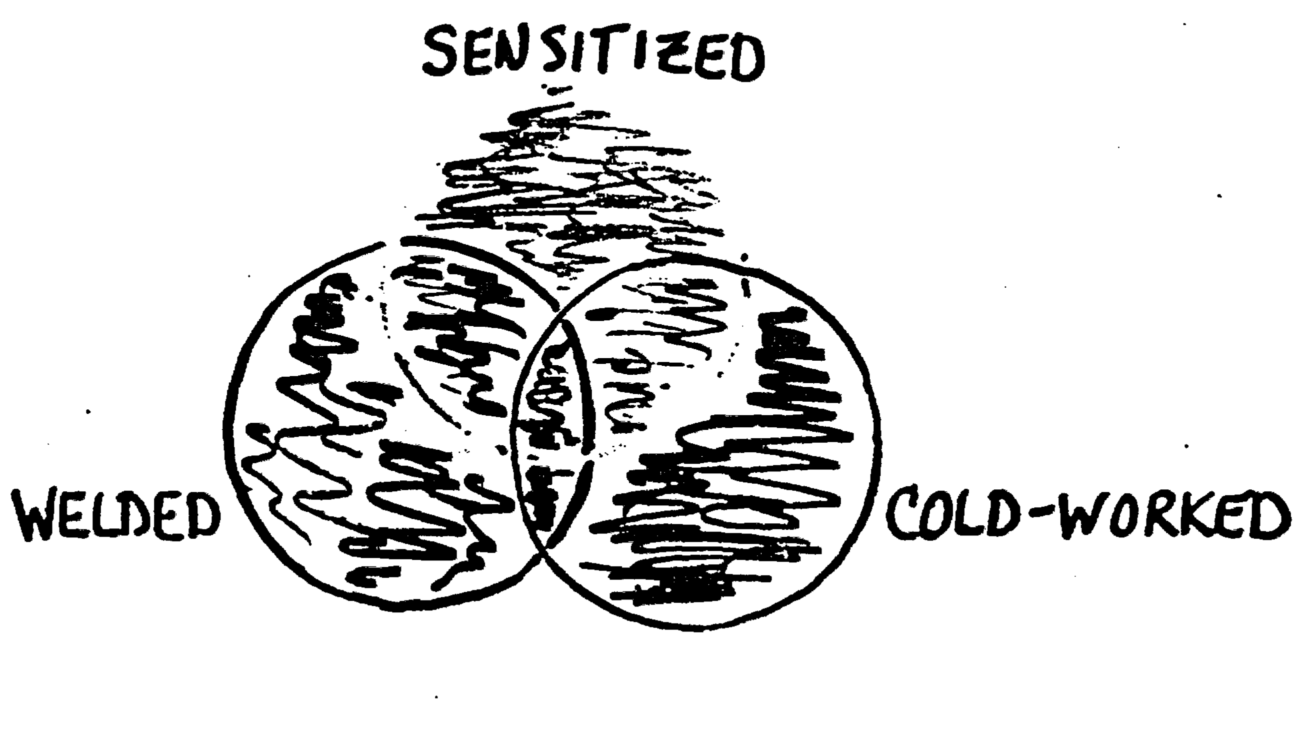
WHAT IS THE SMALLEST DETECTABLE MICROSTRUCTURAL FEATURE THAT WOULD ALERT US OF THE ONSET OF SCC?



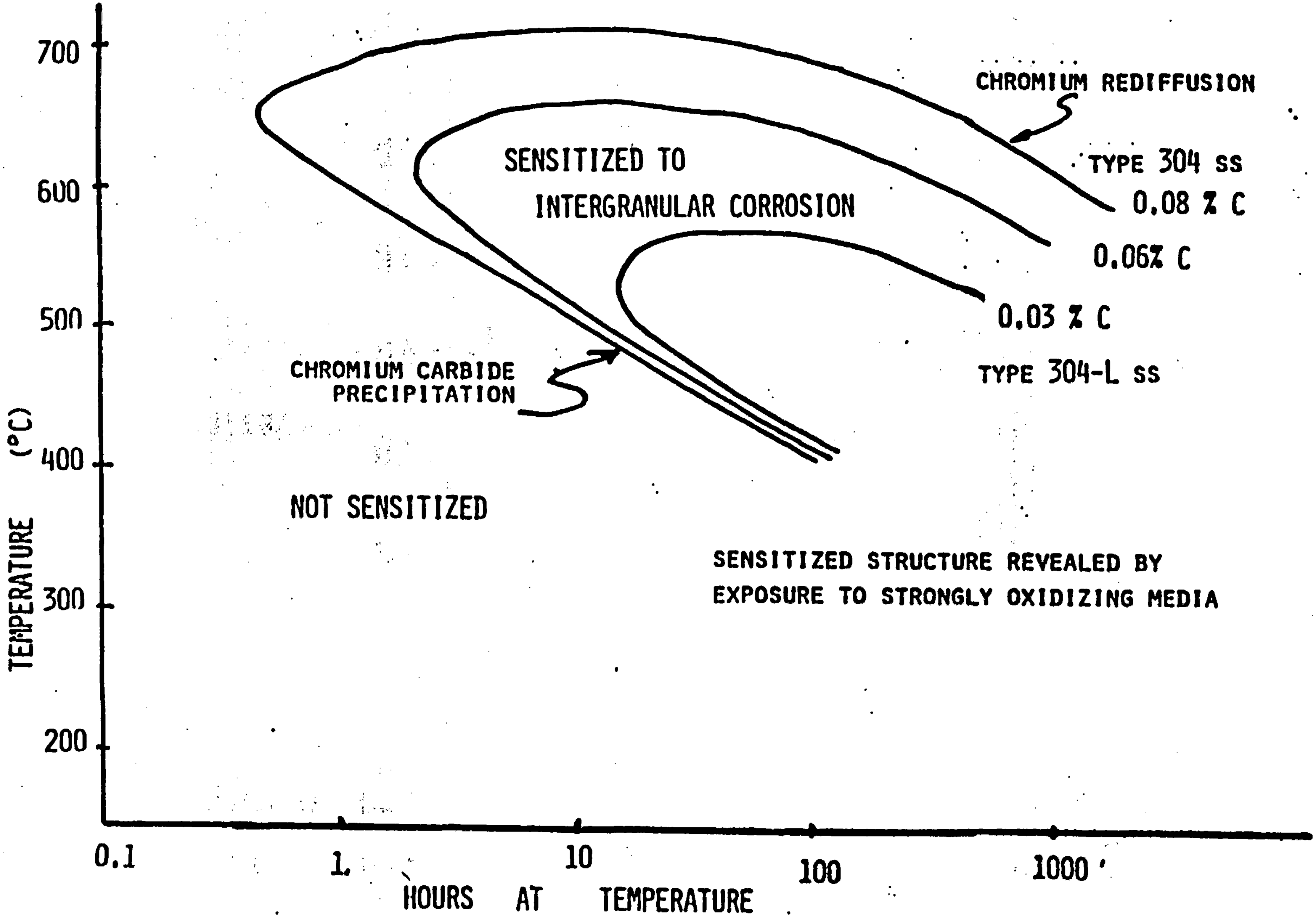
Schematic section through the boundary of two austenite grains of an 18-8 stainless steel. A carbide particle $(CrFe)_{23}C_6$ is precipitated at the boundary.

SEVERE ENVIRONMENTAL CONDITIONS AND A HIGHLY SUSCEPTIBLE MICROSTRUCTURE ARE IMPOSED INITIALLY TO ASSESS MATERIAL RESPONSE.

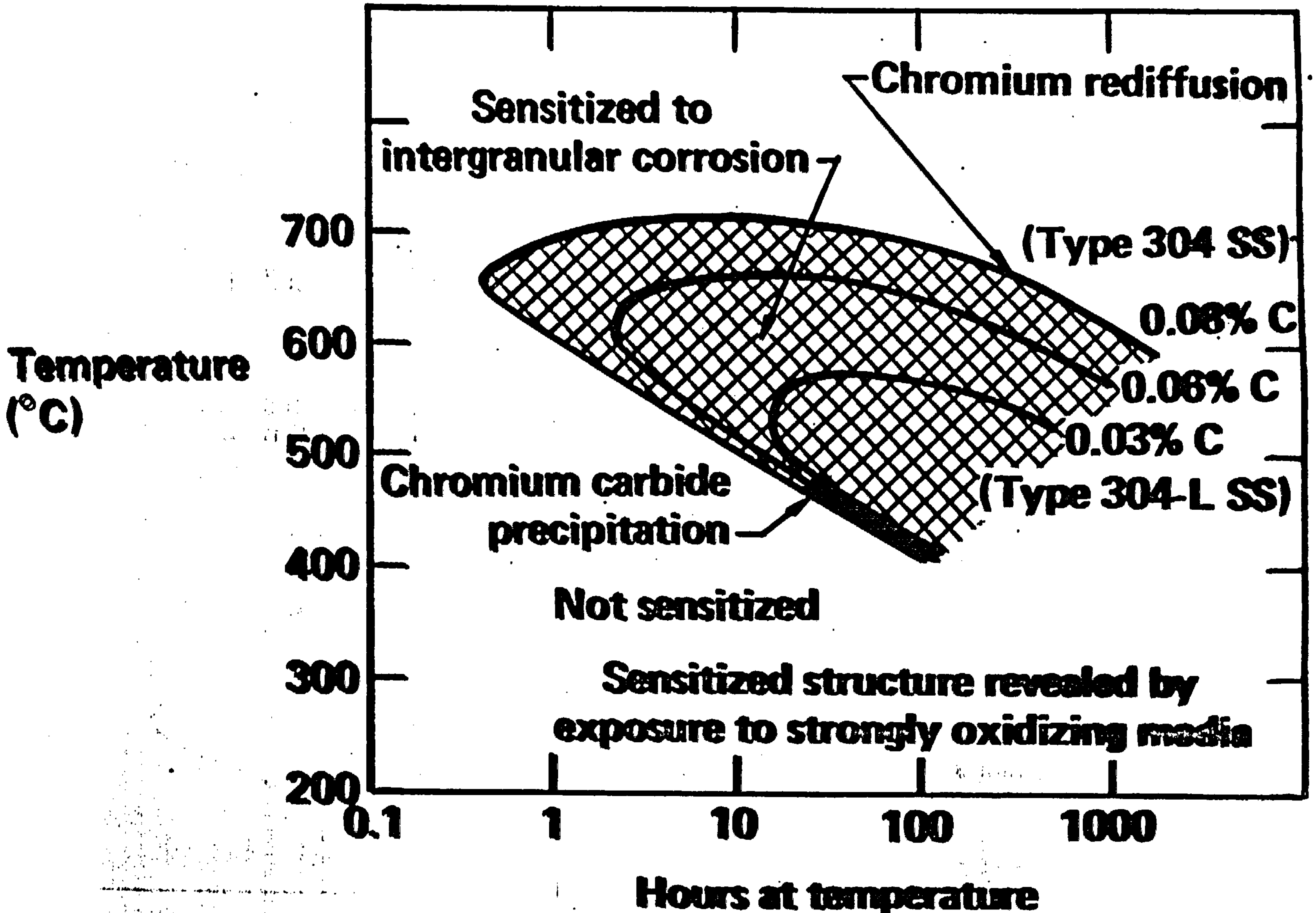
J-13 WATER/STEAM
CRUSHED TUFF
GAMMA RADIATION

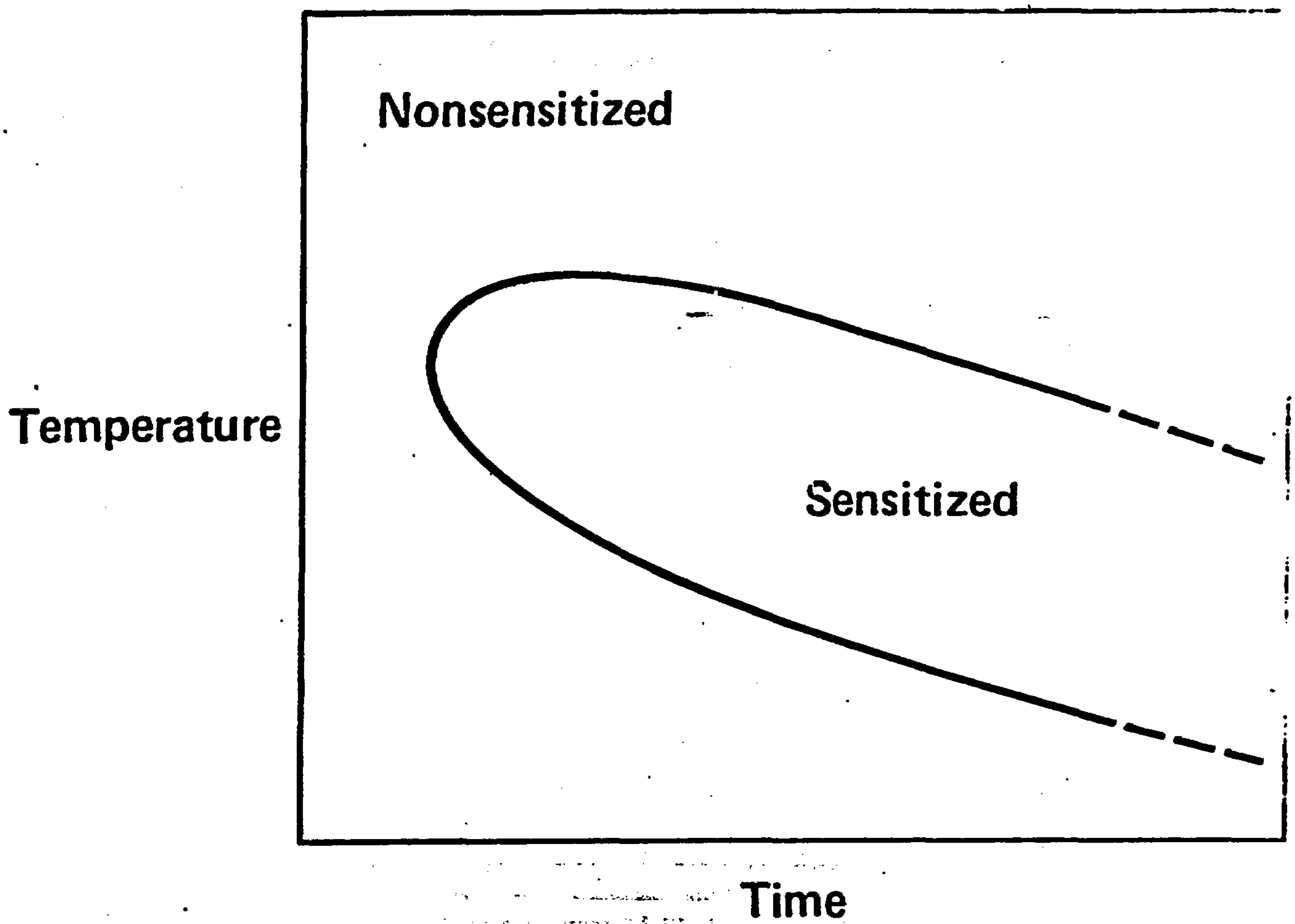


TIME - TEMPERATURE - SENSITIZATION CURVES INDICATE CHROMIUM CARBIDE FORMATION

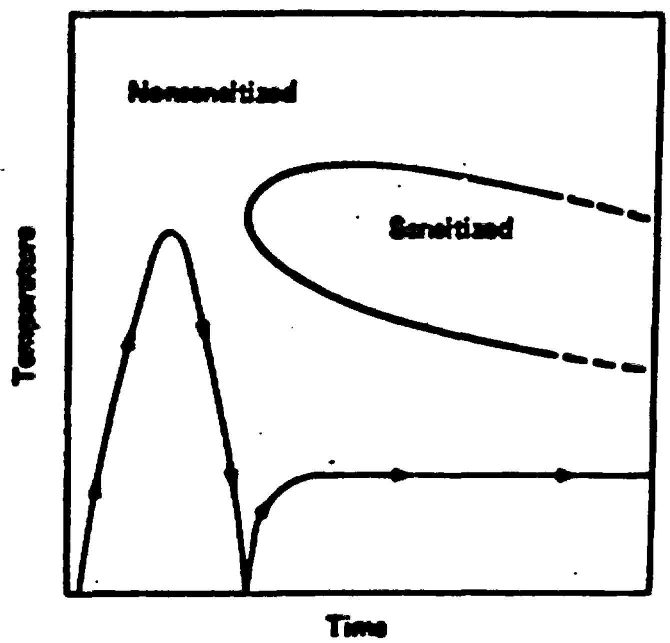


Time—temperature—sensitization curves indicate chromium carbide formation



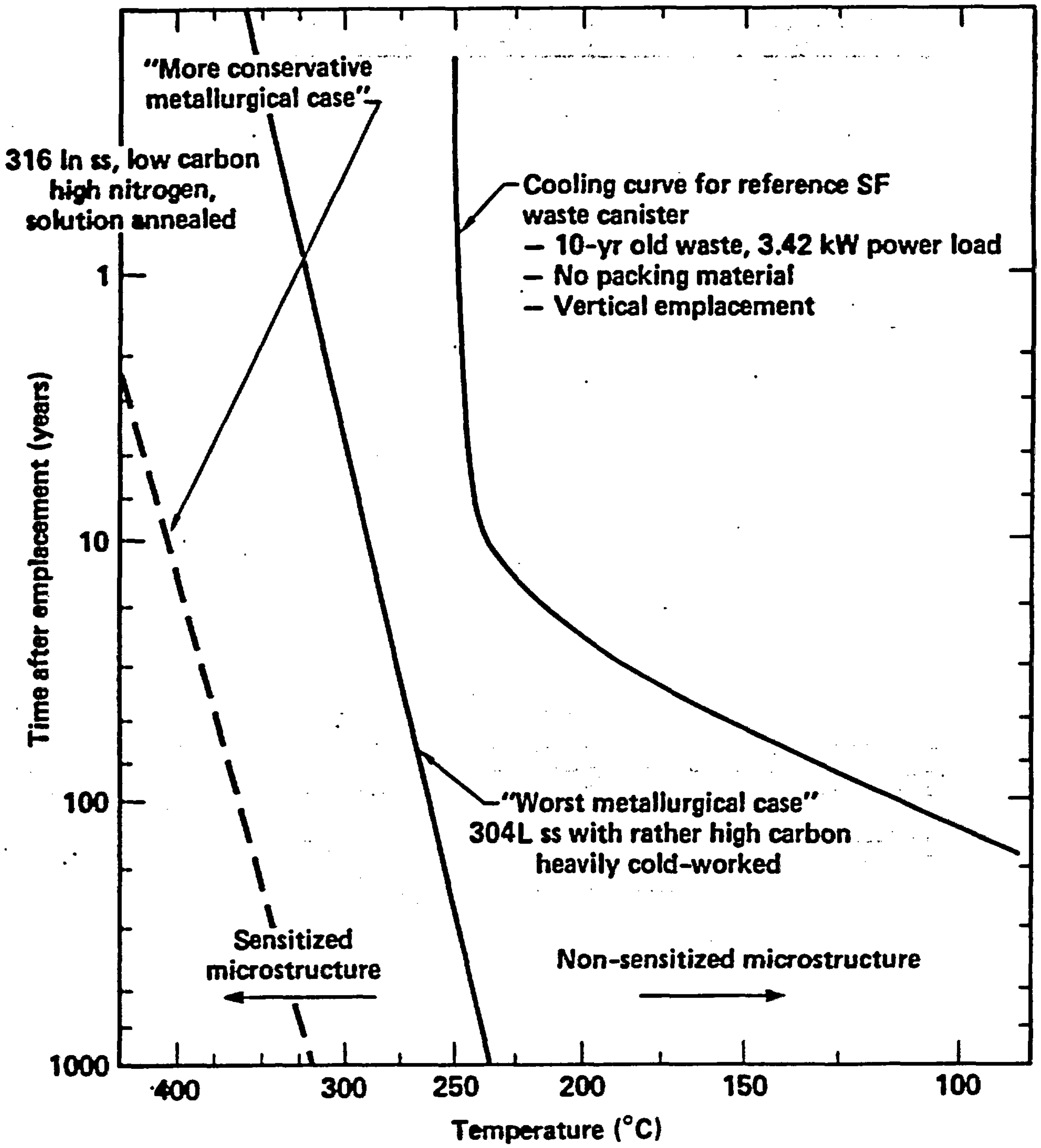


Schematic time, temperature,
sensitization (TTS) diagram



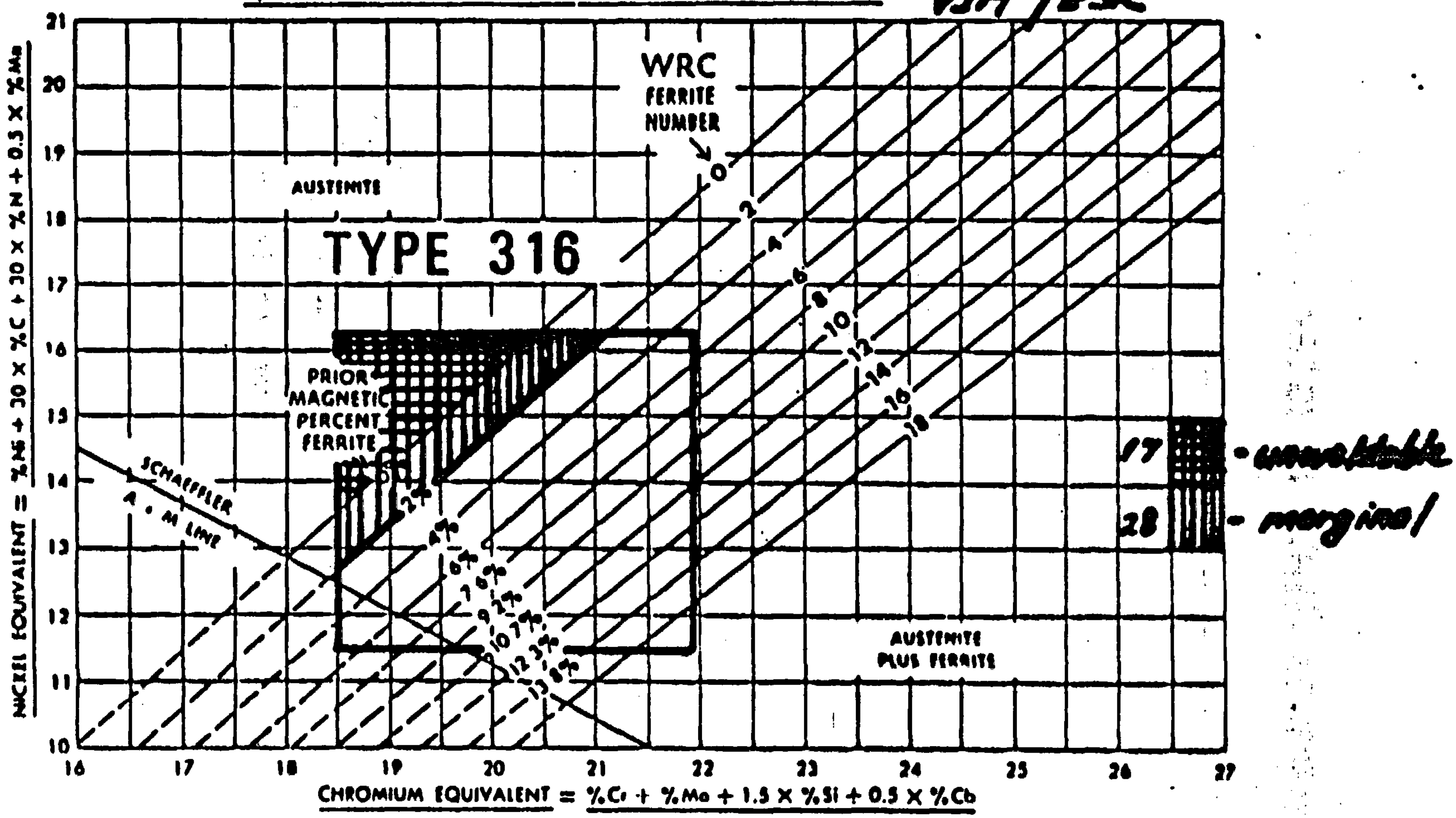
Low temperature sensitization (LTS) occurs when carbides are nucleated by a brief high temperature exposure followed by holding at temperatures below the TTS curve

Analysis of canister thermal history and long-term sensitization in stainless steel indicates that canister will not sensitize



CONSTITUTION DIAGRAM FOR STAINLESS STEEL WELD METAL

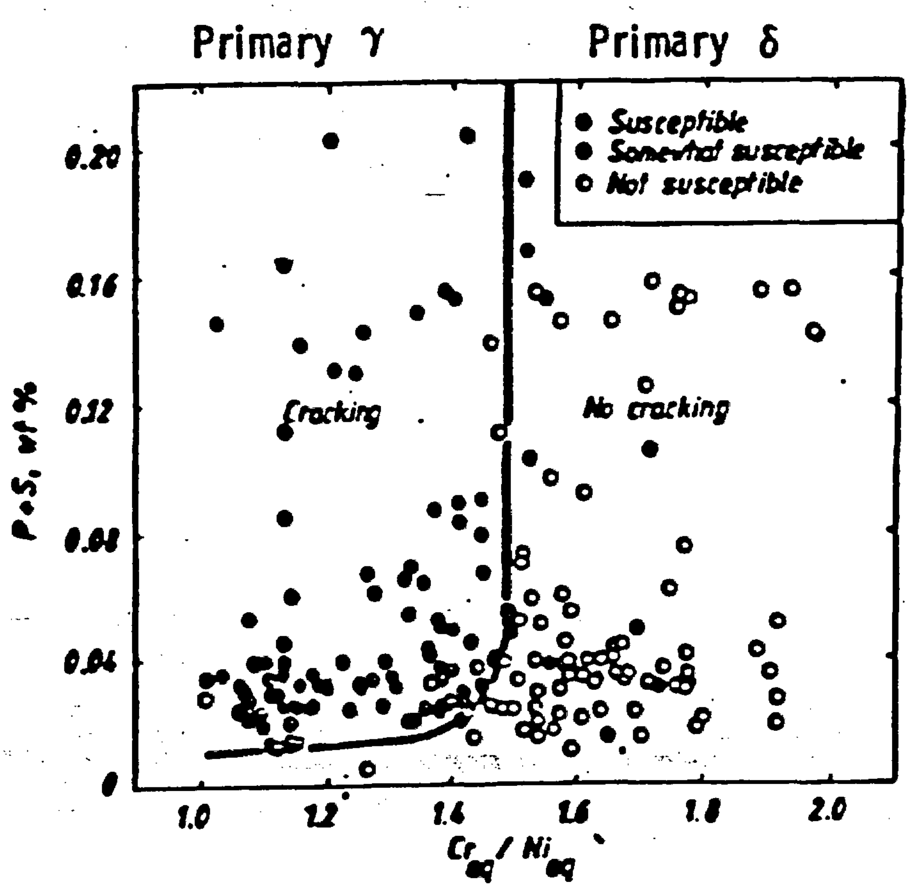
VJM / ESR



Cr	Ni	Mo	Mn	Si	N	C	P
16.0-18.0	10.0-14.0	2.0-3.0	1.5-2.0	0.3-0.7	0.010 max	0.015-.030	.025 max

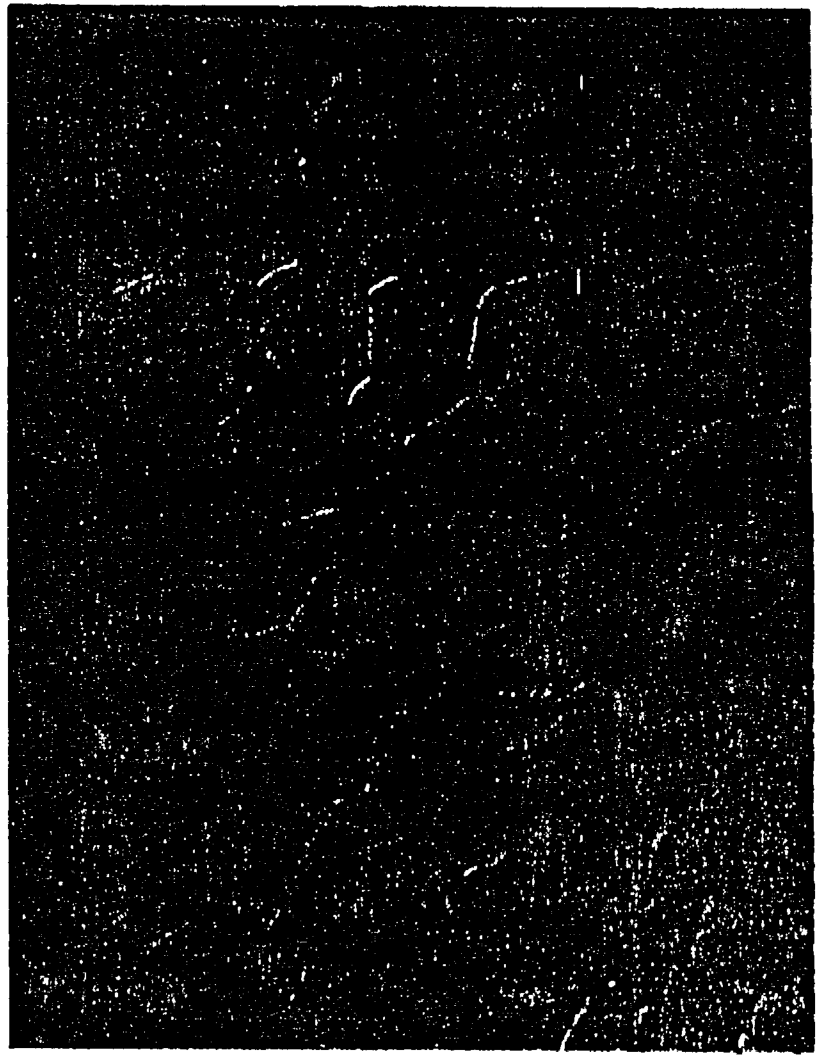
S
.006 max

Cracking Susceptibility of Austenitic Stainless Steels



E316L-15 WITH CONTROLLED FERRITE

20 μ



10 μ

Note δ-ferrite at cell boundaries

SCC tests now underway:

- BOIL DOWN

  Periodic wet/dry environment to concentrate ionic species on specimen surface.

- BENT BEAM

  Used as a screening device to detect relative susceptibility to SCC.

- SSR - SLOW STRAIN RATE

  Determines amount of environmental degradation induced by the testing conditions.

- U-BEND

  Used to augment the effects of localized deformation and stress on a sensitized microstructure.

- SLOW CRACK GROWTH

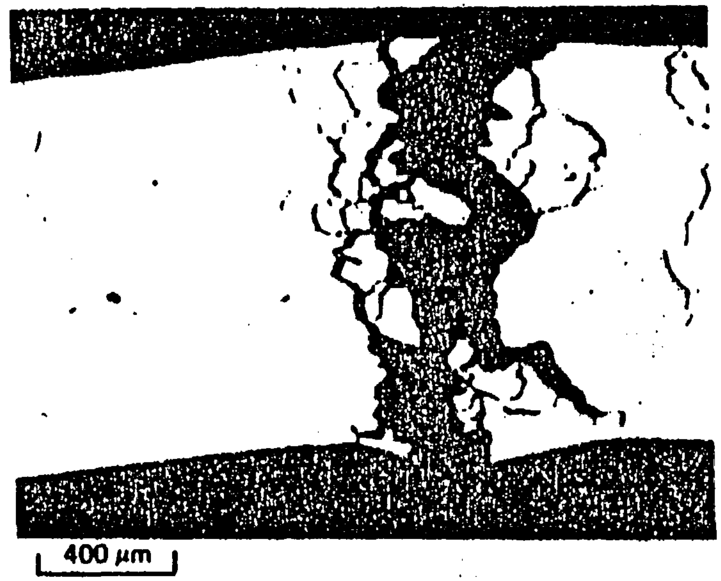
  Predicts crack growth rate at fixed stress levels.

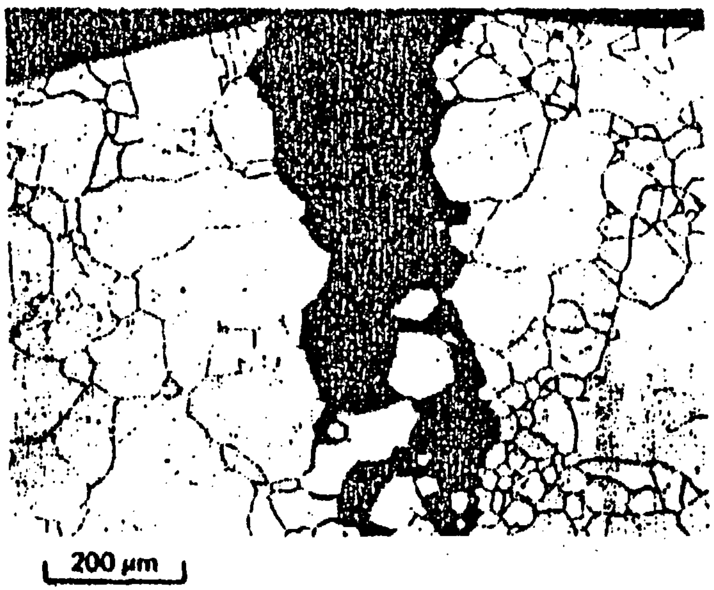
Stress Corrosion Cracking Test Results from U-Bend Specimens Exposed to Irradiated J-13 Water, Crushed Tuff Rock, and Water Vapor.

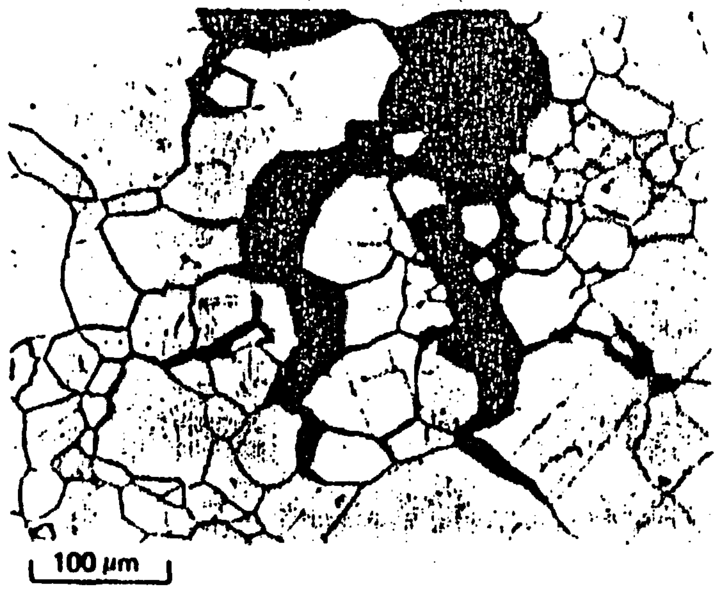
No. of Specimens Cracked/No. of Specimens Tested

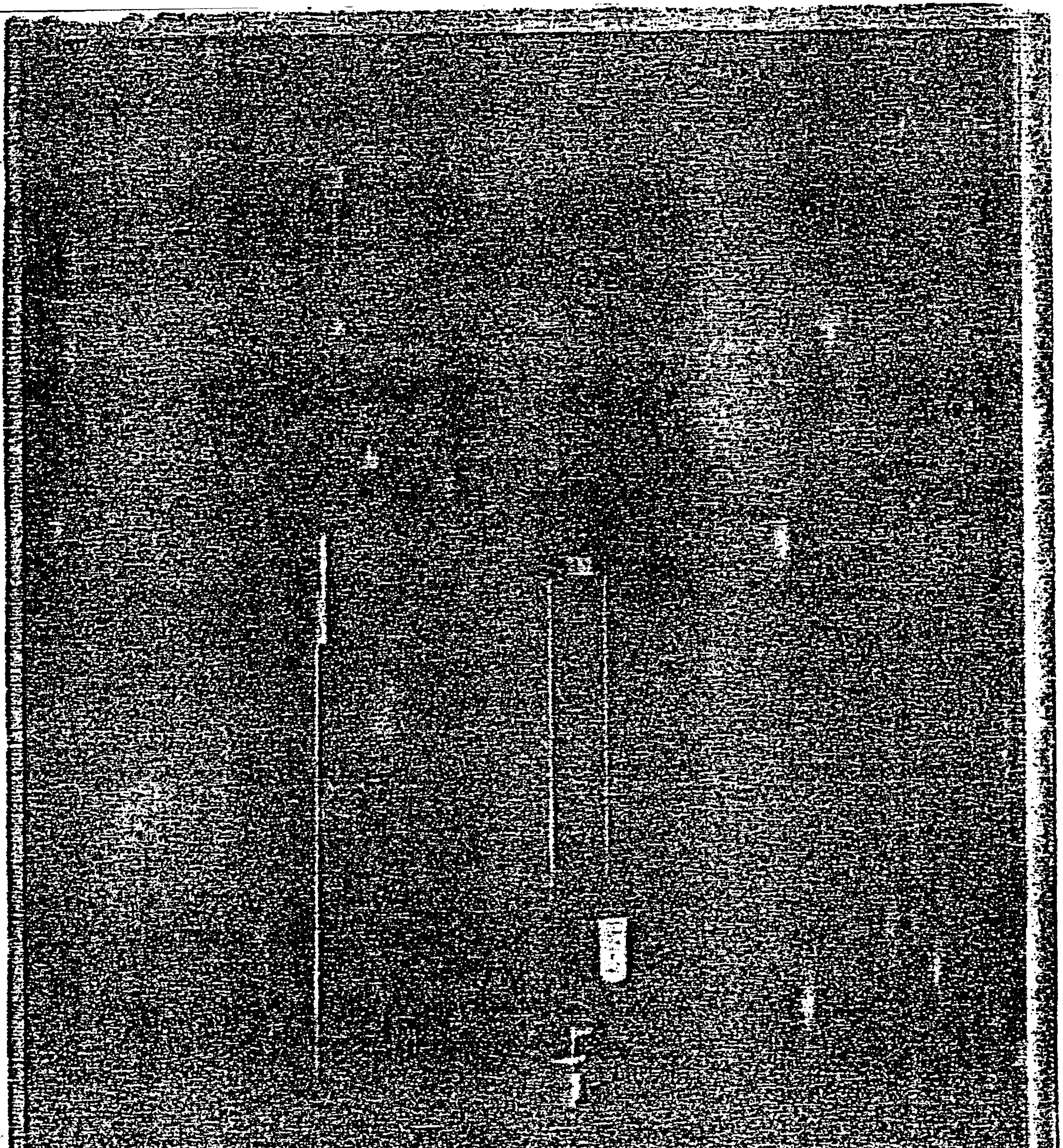
Material	Environment					
	50°C (6×10^5 rads/hr)			90°C (3×10^5 rads/hr)		
	Rock + Water	Rock + Vapor	Vapor	Rock + Water	Rock + Vapor	Vapor
304	0/4	0/4	2/4	0/4	3/4	1/4
304L	0/4	0/4	0/4	0/4	0/4	0/4

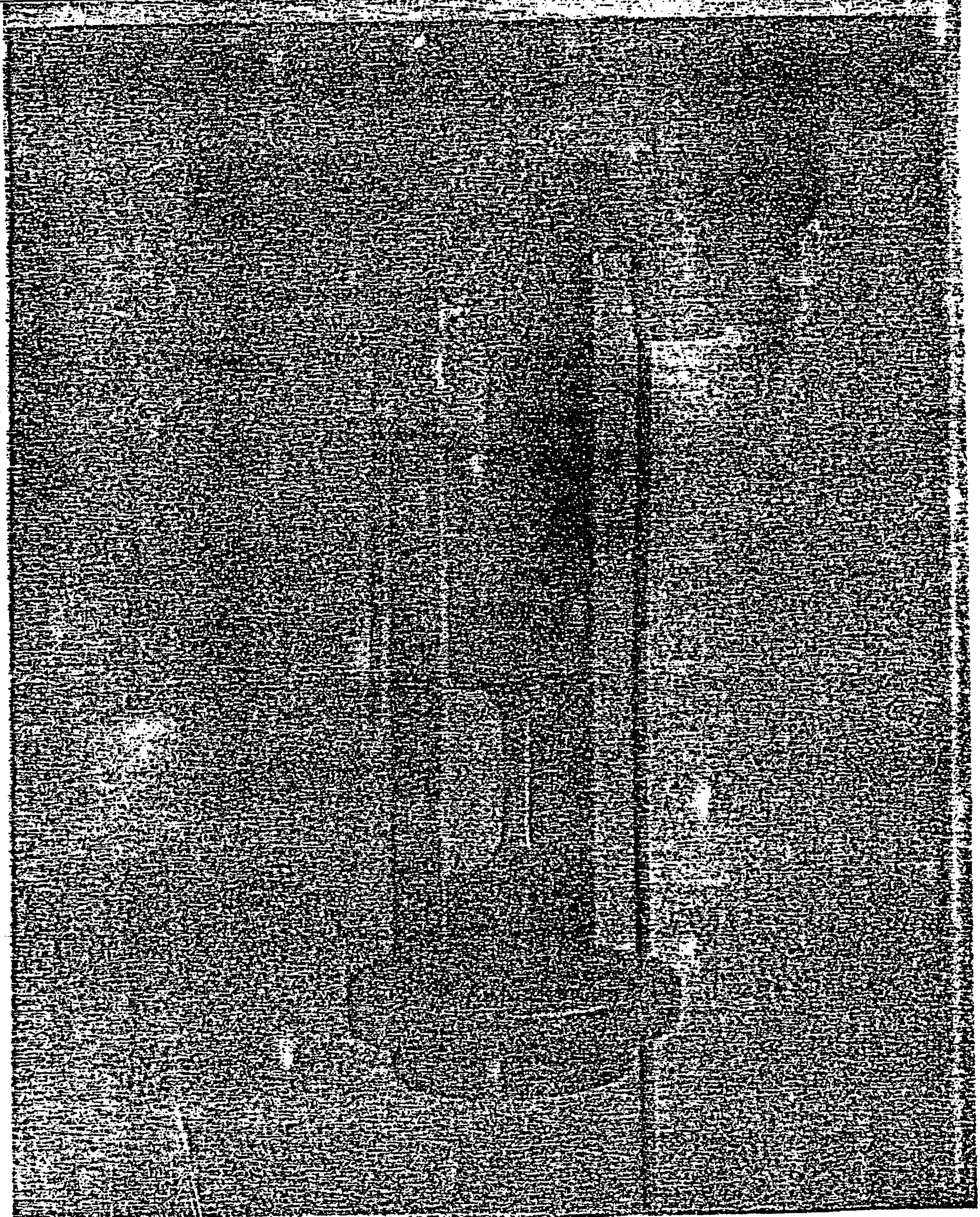
304 U-BEND [illegible]NS
SOL'N ANNEALED (15 MIN. @ 1050°C)
AND SENSITIZED (24 HRS @ 600°C)
TESTED IN J-13 WATER AND CRUSHED
TOPOPAH SPRING TUFF ROCK AT
50°C, 6 x 10^5 RAD/HR.











Results of Slow Strain Rate Tests of 304 Stainless Steel at 150°C

Mill Annealed Specimens

Environment	Strain Rate	Reduction of Area, Percent	Elongation Percent	Yield Strength, ksi	Ultimate Strength, ksi	FAILURE MODE
Air	10^{-4}/s	80.2	48.0	37.4	74.4	ductile
Air	2×10^{-7}/s	76.5	45.0	35.9	76.6	↓
J-13[1]	10^{-4}/s	77.9	47.0	36.1	75.3	↓
J-13	10^{-4}/s	79.6	46.0	36.3	74.9	↓
J-13	2×10^{-7}/s	75.7	50.0	33.5	77.5	↓
J-13	2×10^{-7}/s	76.4	47.0	35.1	77.0	↓

Solution Annealed and Sensitized Specimens

Environment	Strain Rate	Reduction of Area, Percent	Elongation Percent	Yield Strength, ksi	Ultimate Strength, ksi	
Air	10^{-4}/s	72.2	50.6	21.9	68.0	ductile
Air	10^{-4}/s	66.5	51.5	26.0	68.8	"
J-13	10^{-4}/s	75.5	53.5	23.5	68.8	"
J-13	10^{-4}/s	74.9	51.0	23.5	69.0	"
J-13	2×10^{-7}/s	50.9	-[2]	22.0	70.1	I.G.
J-13	2×10^{-7}/s	26.4	-[3]	20.7	64.5	I.G.

1 Air-sparged J-13 well water.
2 Not determined.
3 Broke at gage mark.

TABLE 3. Compositions of Steel Plate Used in SSR Tests

304 STAINLESS STEEL

Alloy Element, percent

N	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Co
0.0480	0.054	1.44	0.019	0.009	0.39	18.07	8.20	--	--	--

YS: 47.3 ksi (326 MPa)
TS: 89.4 ksi (617 MPa)
El: 57.3%

304L STAINLESS STEEL

Alloy Element, percent

N	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Co
--	0.024	1.65	0.031	0.012	0.42	18.12	9.52	--	--	--

YS: 42.4 ksi (292 MPa)
TS: 81.1 ksi (559 MPa)
El: 58.9%

Results of Slow Strain Rate Tests of 304L Stainless Steel at 150°C

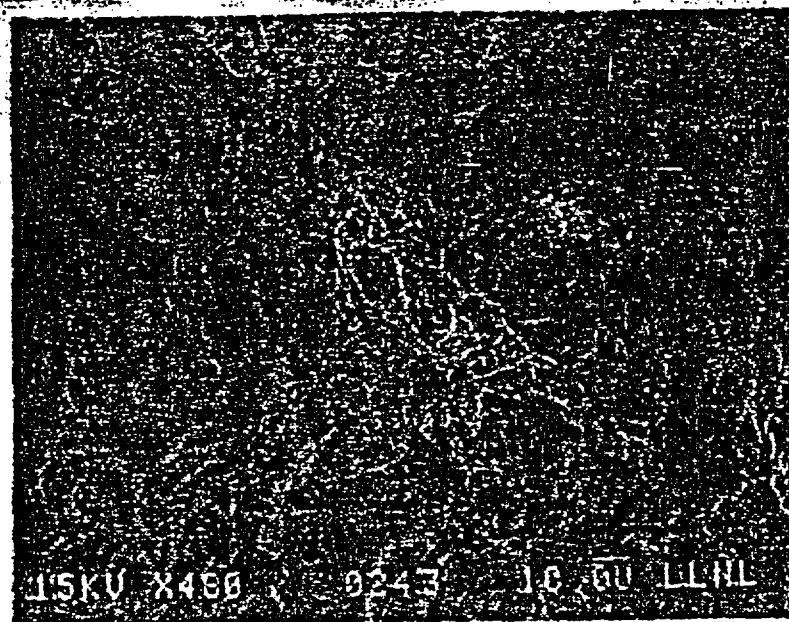
Solution Annealed Specimens

Environment	Strain Rate	Reduction of Area, Percent	Elongation Percent	Yield Strength, ksi	Ultimate Strength, ksi
J-13[1]	10^{-4}/s	80.5	54.0	25.8	68.4
J-13	10^{-4}/s	78.4	52.0	27.1	68.2
J-13	2×10^{-7}/s	68.7	48.0	28.4	67.7
J-13	2×10^{-7}/s	72.9	46.3	26.7	68.2

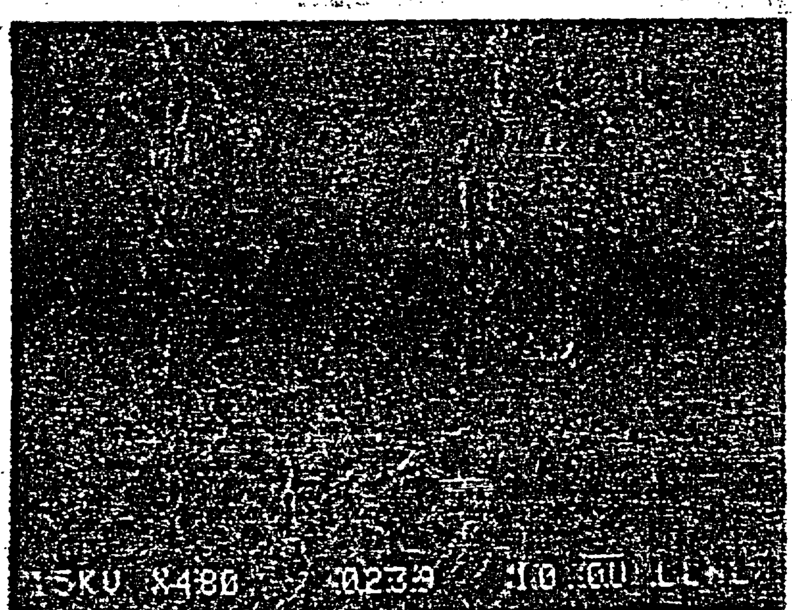
Solution Annealed and Sensitized Specimens

Environment	Strain Rate	Reduction of Area, Percent	Elongation Percent	Yield Strength, ksi	Ultimate Strength, ksi
Air	10^{-4}/s	73.7	49.0	29.4	68.6
J-13	10^{-4}/s	72.2	49.6	-[2]	-[2]
J-13	10^{-4}/s	74.8	51.6	29.6	69.1
J-13	2×10^{-7}/s	76.0	49.0	26.6	68.8
J-13	2×10^{-7}/s	70.4	48.0	27.2	68.8

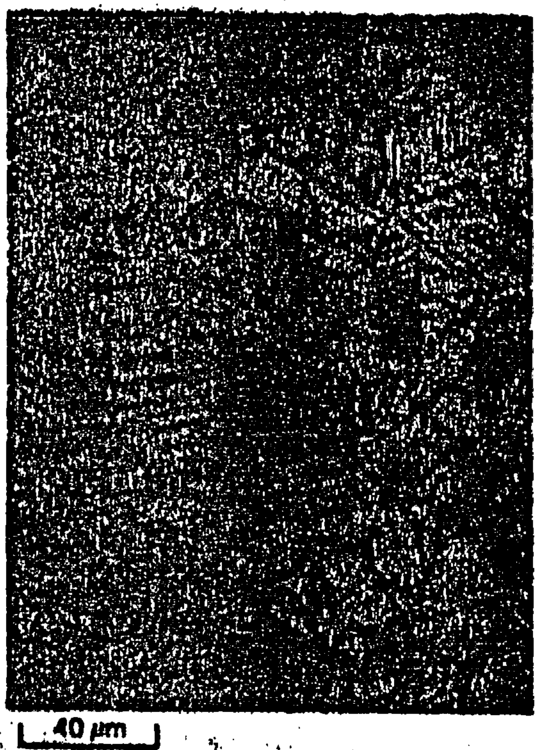
1 Air-sparged J-13 well water.
2 Not determined.



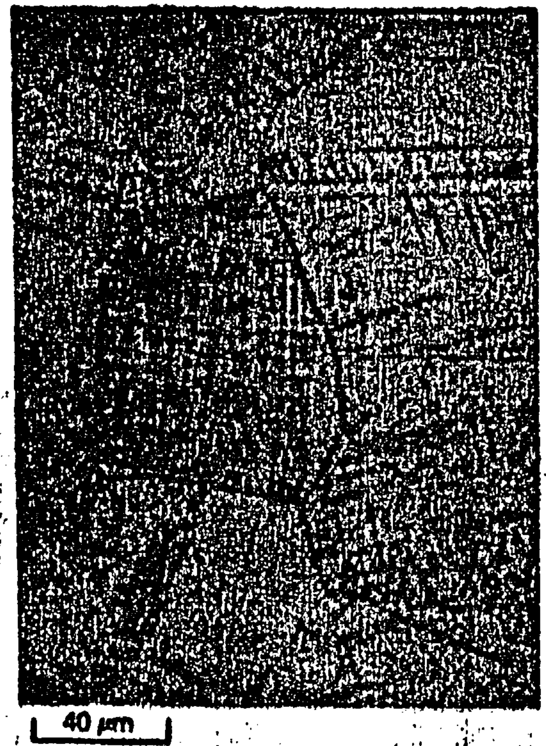
FRACTOGRAPH OF 304L SLOW STRAIN RATE SPECIMEN TESTED AT 150°C IN AIR.
STRAIN RATE = 1×10^{-4}/s. YS = 29.4 KSI UTS = 68.8 KSI ELONG = 49%



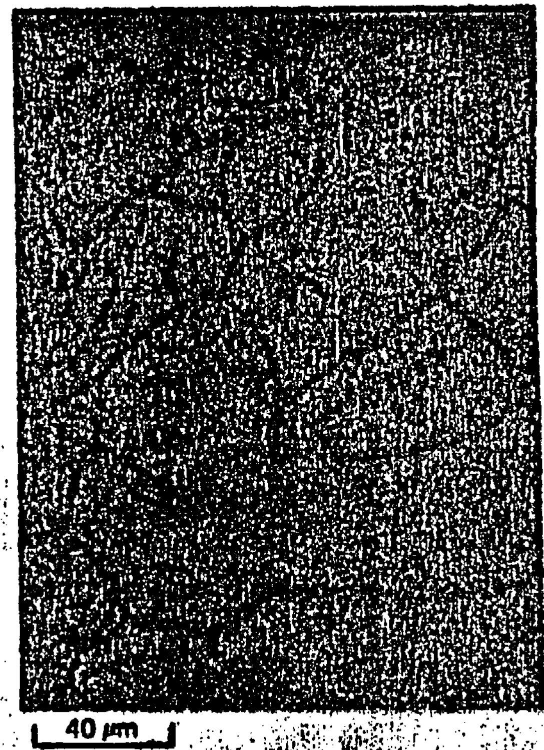
304L SLOW STRAIN RATE SPECIMEN TESTED AT 150°C IN J-13 WELL WATER.
YS = 29.6 KSI UTS = 69.1 KSI ELONG = 51.6%



304: 20% Cold-worked
700°C for 1 week

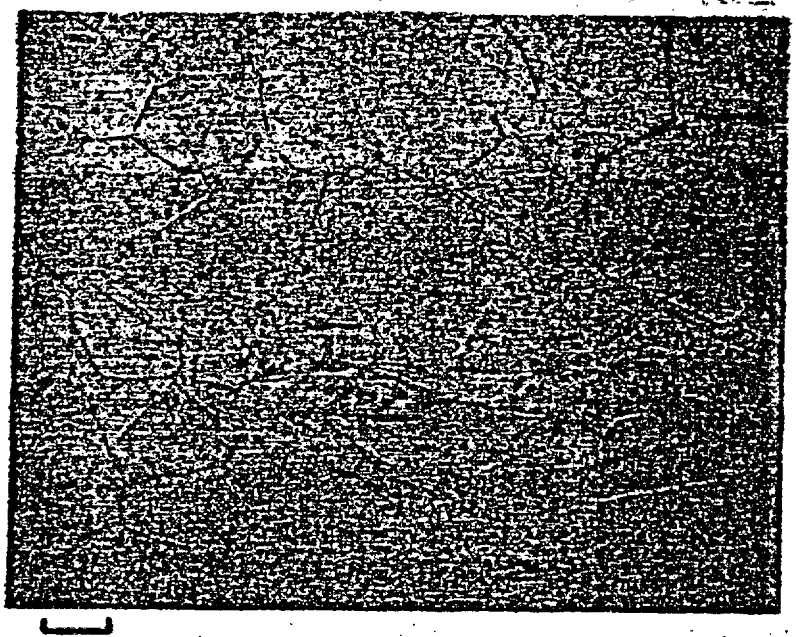


304L: 20% Cold-worked
700°C for 1 week

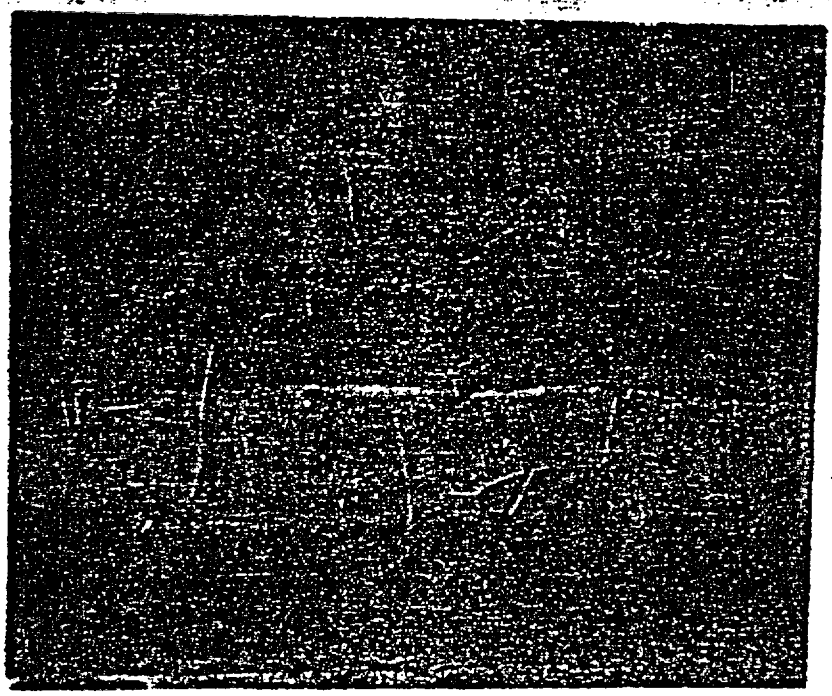


316L: 20% Cold-worked
700°C for 1 week

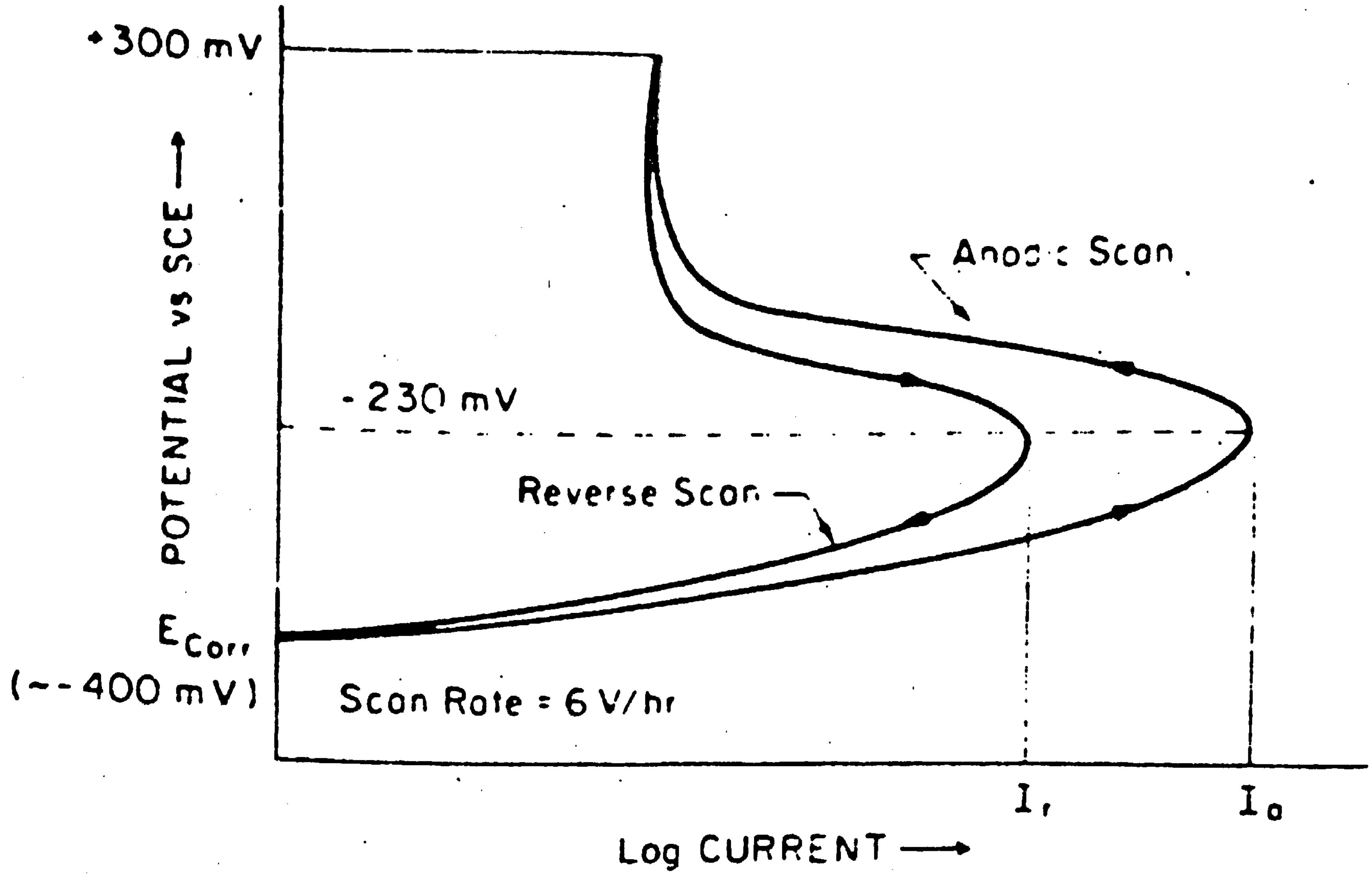
316L 15 min @ 1000°C, AC / 1 day @ 250°C, WQ
(013A)



316L 15 min @ 1000°C, WQ / 1 wk @ 250°C, WQ
(007A)

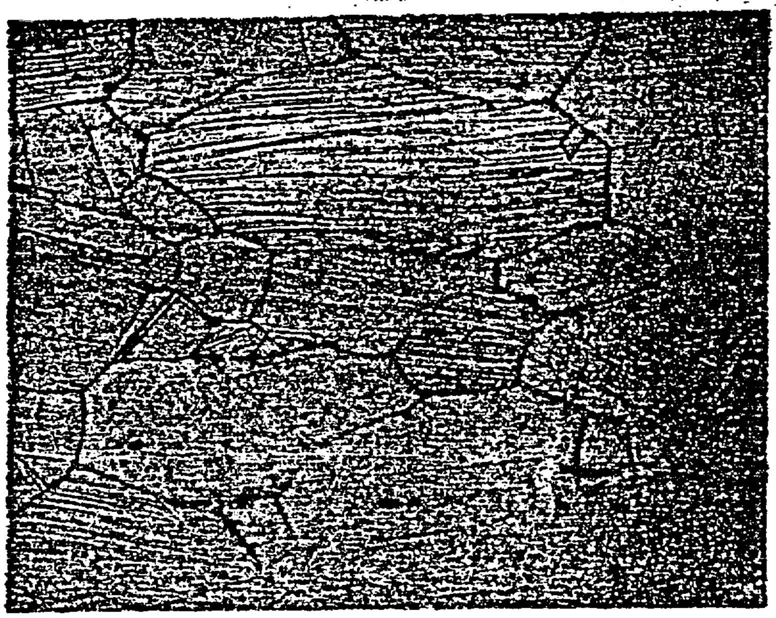


316L 20% CW / 15 min @ 1000°C, AC / 1 day @ 250°C, WQ
(016A)



IHI-DOS RATIO TEST

Ratio = I_r / I_a



20 μm

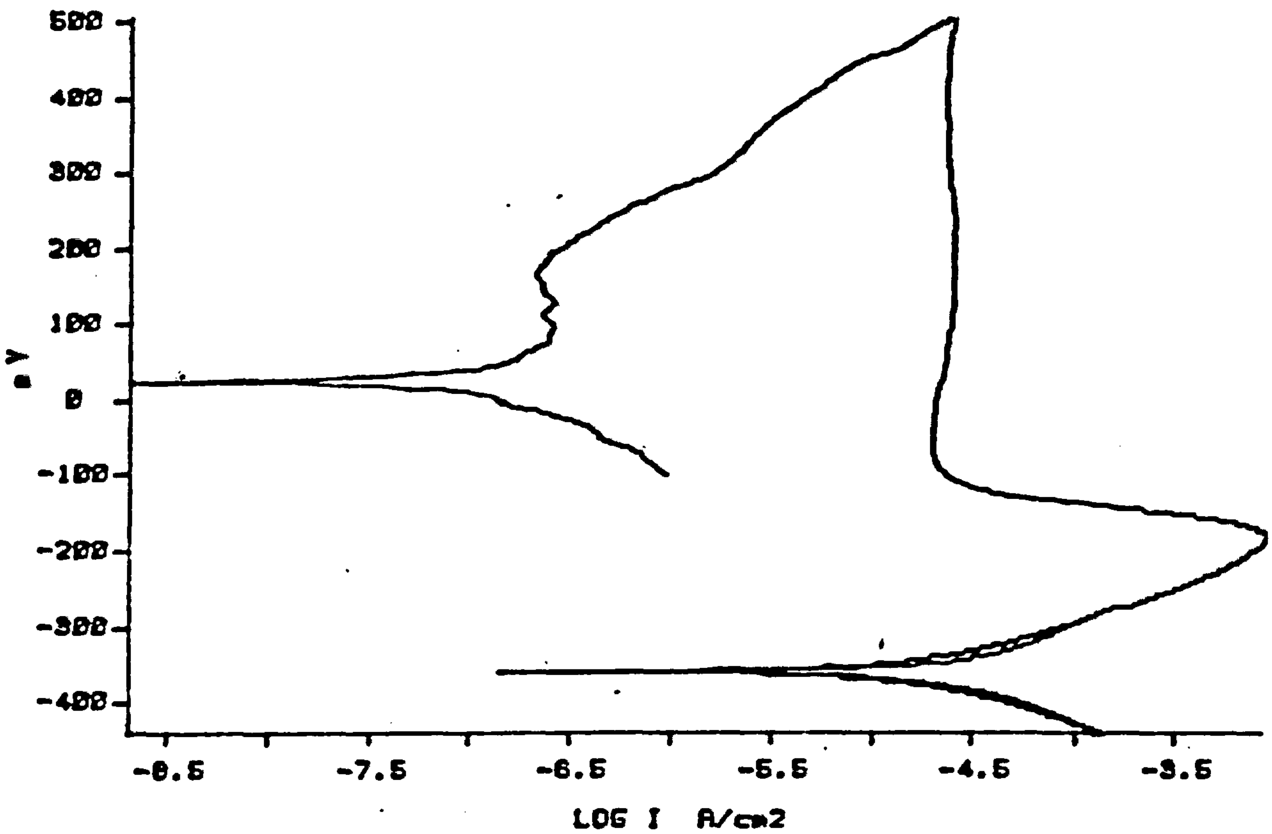
316L 20% CW/ 15 min @ 1000°C, WQ / 1 wk @ 250°C,WQ
(011A)

MODEL 351
CORROSION MEASUREMENT SYSTEM

001B

20 JUN 1985

COMMENT:
316L 15MIN-1000C VQ 1DAY-250C VQ .5M H2SO4 ,.01M KSCN

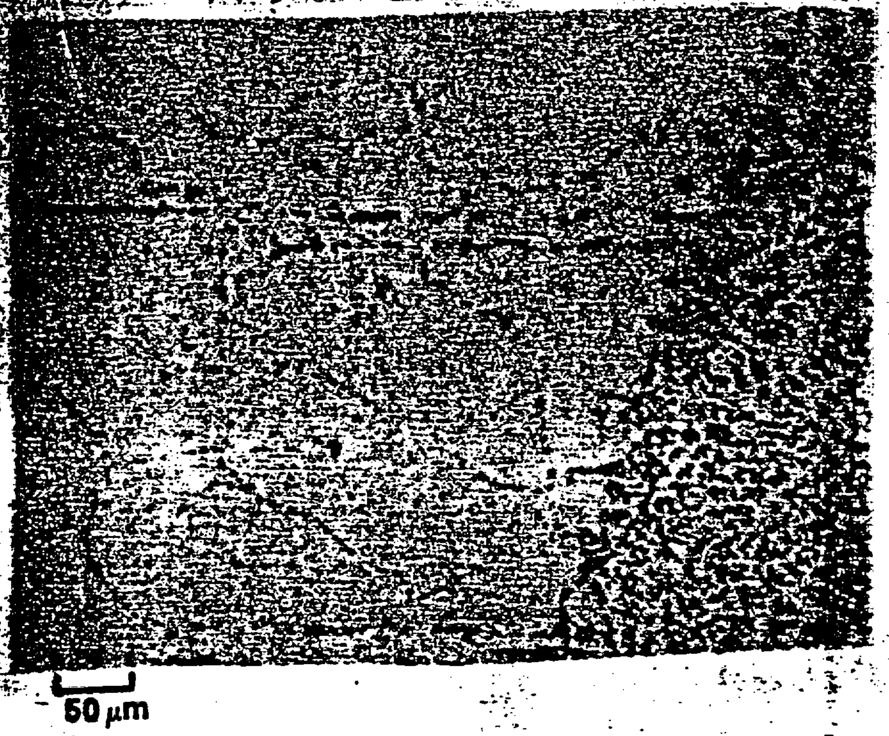


CYCLIC POLARIZATION

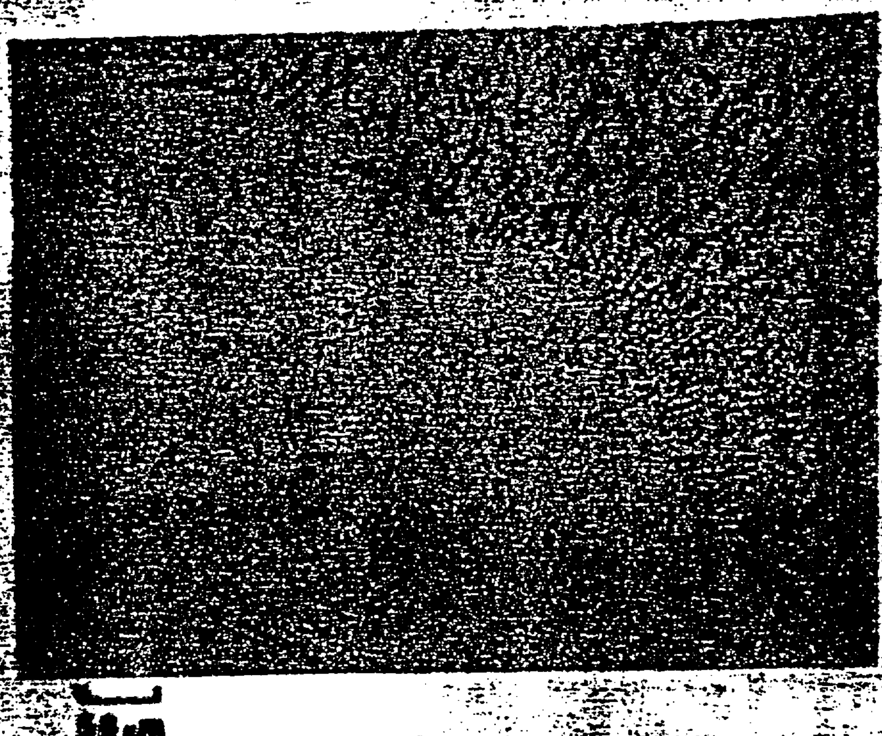
DATE CREATED		20 JUN 1985
IR COMP	=	DISABLED
VERTEX DELAY	=	0 SEC
VERTEX I	=	PASS
VERTEX E	=	500 mV
FINAL E	=	-100 mV
INITIAL E	=	-100 mV ~ Ec
INITIAL DELAY	=	120 SEC
SCAN RATE	=	1.67 mV/SEC
EQUIV WEIGHT	=	27.93 g/EQUIV
DENSITY	=	7.98 g/cm3
AREA	=	1 cm2

DATE RAN		20 JUN 1985
ANODIC-BETA	=	0.098
CATHODIC-BETA	=	0.103
Ecorr	=	-0.342
E(I=0)	=	-0.358
Icorr	=	22.1 E-6
CORR RATE	=	10.1 E0 MPY
$I_a = 10^{-3.073}$	=	8.452×10^{-4} A/cm²
$I_r = 10^{-6.593}$	=	2.60×10^{-7} A/cm²
I_r/I_a	=	.000302

EG&G
PRINCETON APPLIED RESEARCH



316L Weld 8hrs @ 800°C, WQ / 1 wk @ 750°C, WQ



8 hrs @ 800°C, WQ / 24 hrs @ 750°C, WQ

316L Weld

8 hrs @ 800°C
1 wk @ 750°C

$M_{23}C_6$ & some Sigma

5 μm

Sigma phase

1.0 μm

316L Weld

8 hrs @ 800°C
24 hrs @ 750°C

possibly sigma

5 μm

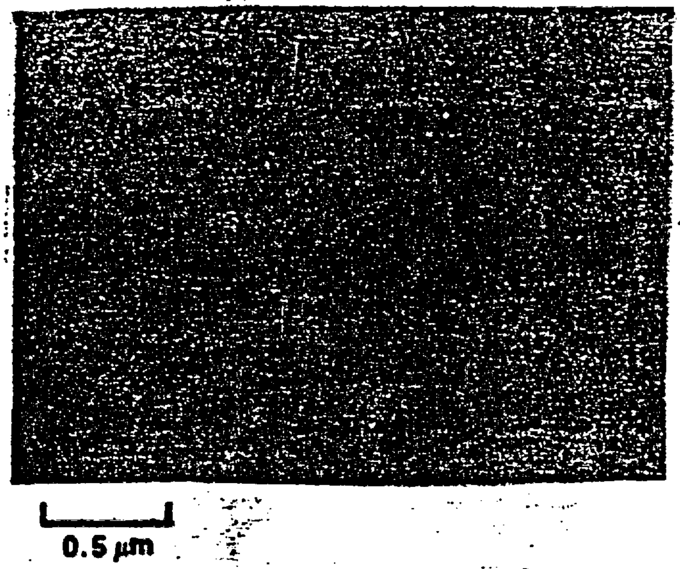
Sigma phase

0.5 μm

316L Weld

8 hrs @ 800°C
1 wk @ 750°C

$M_{23}C_6$



$M_{23}C_6$ along GB

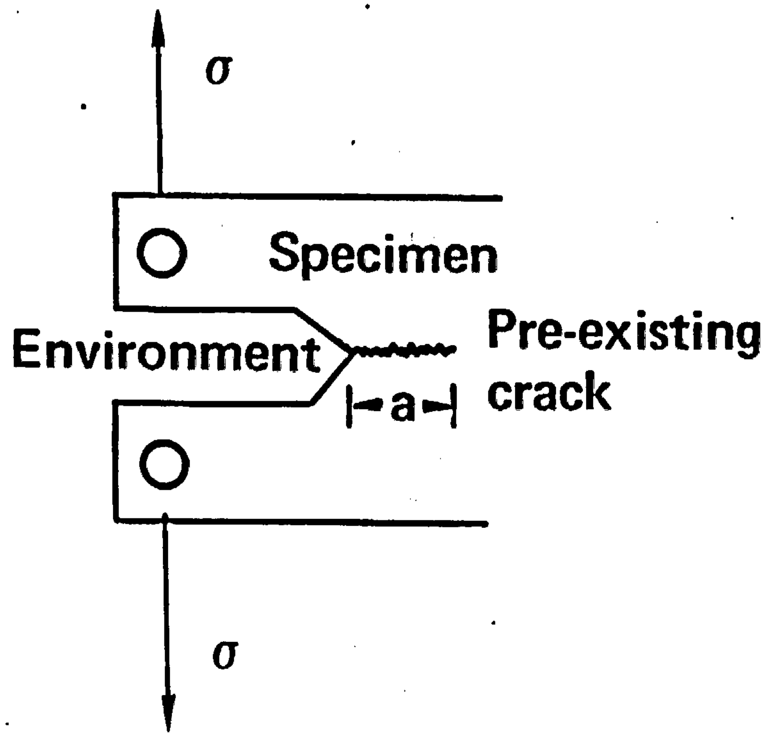
Intragranular ppts.

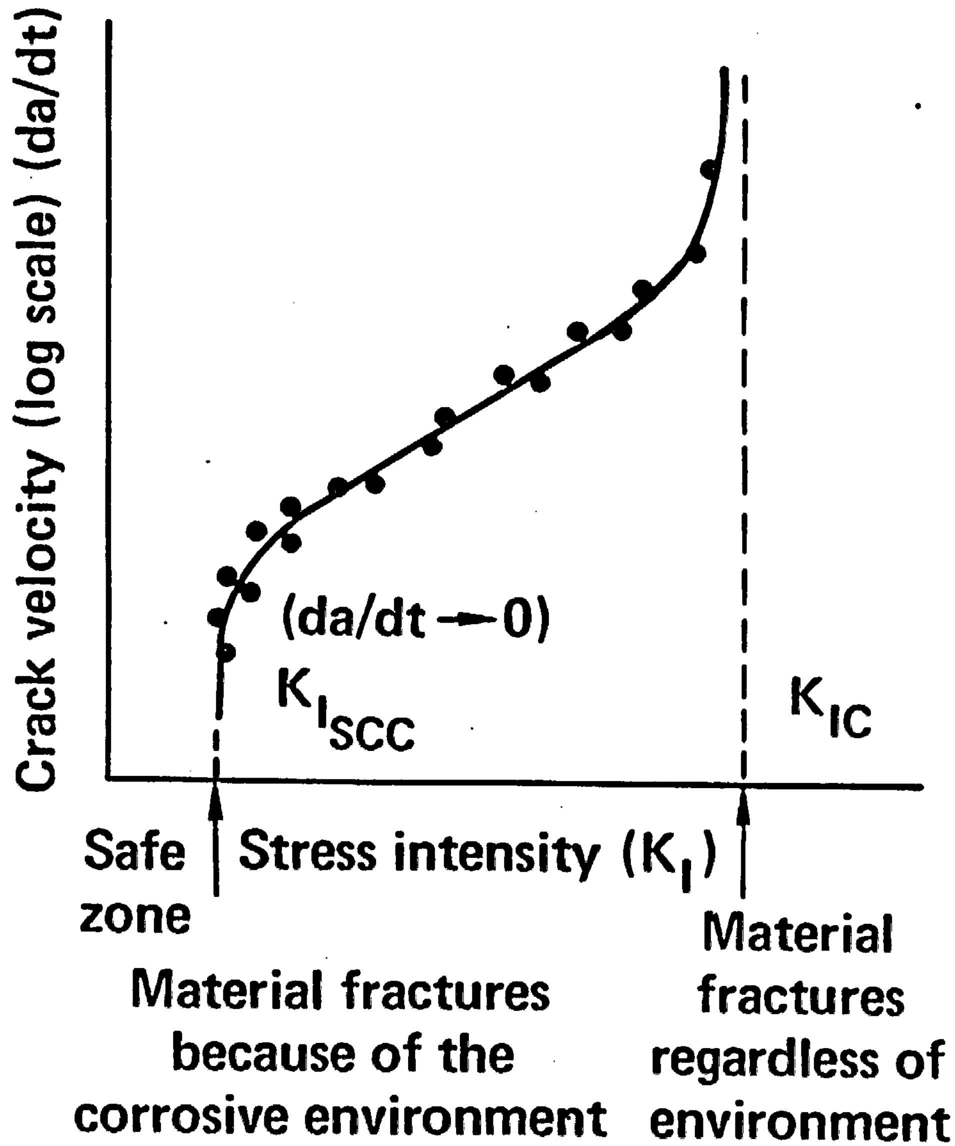
maybe Mo_2C

FUTURE WORK

* IRRADIATED SLOW STRAIN RATE TESTS
* SLOW CRACK GROWTH STUDIES, DA/DT
* INITIATION STUDIES, K_{1SCC}

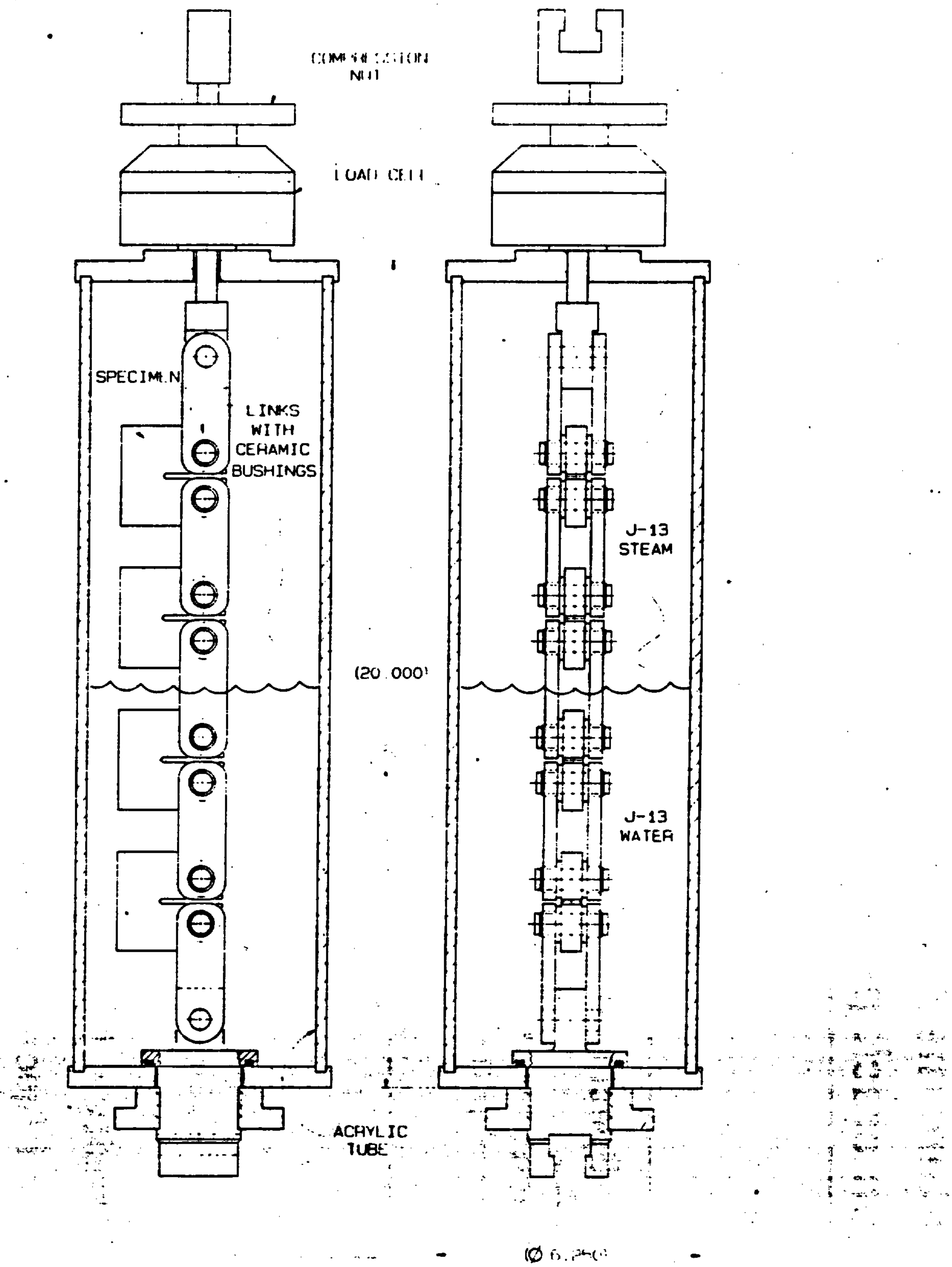
Use fracture mechanics test methods to predict stress corrosion crack propagation rate





Stress intensity = K_I

$K_I = \sigma \sqrt{\pi a}\, f\,(\text{geometry})$



SLOW CRACK GROWTH
TEST FIXTURE

Composition of AISI 316L Stainless Steel

(Exp #45)

C	0.022
Mn	1.50
P	0.029
S	0.010
Si	0.47
Cr	17.30
Ni	10.66
Cu	0.27
Mo	2.00
Co	0.20
N	0.065

** All mat'l is unwelded.

** DeLong equivalents: Cr eq = 20.00

Ni eq = 14.02

Ferrite Number = 4

IMPORTANT MILESTONES IN METAL BARRIERS SUB-TASK

FY 85	REPORT ON FEASIBILITY OF COPPER/COPPER ALLOYS FOR WP CONTAINERS IN TUFF
FY 86	DECISION ON WHETHER TO PURSUE ADDITIONAL WORK ON COPPER
FY 87	RECOMMEND CANDIDATE(S) FOR ADVANCED DESIGN WP CONTAINERS

METAL BARRIERS - SUMMARY OF TEST RESULTS 26 JUNE 1985

STAINLESS STEELS :

- RESULTS TO DATE INDICATE MATERIALS BEHAVE AS EXPECTED
- GENERAL CORROSION RATES PREDICT CONTAINMENT FOR WELL OVER 1000 YRS. FOR VARIETY OF GRADES IN WATER AND STEAM ENVIRONMENTS 50-150°C
- CORROSION RATES NOT ENHANCED BY GAMMA RADIATION (LIMITED TEST RESULTS)
- HIGH-CARBON HIGHLY-SENSITIZED AISI 304 DOES STRESS CORROSION CRACK (SCC) IN IRRADIATED AND NON-IRRADIATED ENVIRONMENTS; THUS FAR, L-GRADES DO NOT SCC.
- VERY PROLONGED TIMES AT ELEVATED TEMPERATURES (600-800°C) ARE NEEDED TO SENSITIZE L-GRADES; EVEN THEN, ONLY PARTIAL DEGREE OF SENSITIZATION IS OBTAINED.
- SIMILARLY, POTENTIALLY DAMAGING BRITTLE PHASES DO NOT READILY TRANSFORM FROM AUSTENITE

SUMMARY (CONTINUED)

S.S. (CONT'D)

- HOWEVER, PROJECTION OF LOW-TEMPERATURE SENSITIZATION (LTS) BEHAVIOR INDICATES 304L MAY BE MARGINALLY CLOSE TO SENSITIZING IN CONTAINMENT PERIOD; "316 FAMILY" OF S.S. MAY OFFER CONSIDERABLE RESISTANCE TO LTS.
- AS EXPECTED, 316 GRADES OFFER INCREASED RESISTANCE TO LOCALIZED ATTACK. 316 LN DOES NOT PIT IN IRRADIATED 100-X J-13 WATER
- "CLEANER" PREMIUM GRADES OF AISI 316LN OFFER HIGH RESISTANCE TO CREVICE AND PITTING ATTACK.

COPPER:

- VERY LIMITED NUMBER OF RESULTS AVAILABLE
- GENERAL CORROSION RATES IN NON-IRRADIATED J-13 WATER ARE HIGHER THAN THOSE FOR S.S. (EXPECTED RESULT), BUT EXTRAPOLATION OF THESE INDICATES 1000-YR CONTAINMENT
- AL BRONZE AND CUPRONICKEL MORE RESISTANT
- NOT YET RESOLVED: LOCALIZED CORROSION, CORROSION IN γ-RADIATION

APPENDIX A - TABLE FOR SUBPART B

TABLE 1 - RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS
(Cumulative Releases to the Accessible Environment
for 10,000 Years After Disposal)

Radionuclide	Release Limit per 1000 MTHM or other unit of waste (curies)
Americium-241 or -243	100
Carbon-14	100
Cesium-135 or -137	1000
Iodine-129	100
Neptunium-237	100
Plutonium-238, -239, -240, or -242	100
Radium-226	100
Strontium-90	100
Technetium-99	10000
Thorium-230 or -232	10
Tin-126	1000
Uranium-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1000

PWR SPENT FUEL ASSEMBLY RADIONUCLIDE INVENTORIES AT 1000 YEARS[a]

RADIONUCLIDE[b]	% OF TOTAL 1000-YEAR ACTIVITY	CUMULATIVE %
Am-241	51.84	51.84
Am-243	1.75[c]	53.59
Pu-240	26.87	80.46
Pu-239	17.37	97.83
Pu-242	0.10	97.93
Pu-238	0.06	97.99
Tc-99	0.77	98.76
Ni-59	0.252	
Ni-63	0.021	
Zr-93	0.181	
Nb-94	0.074	
C-14	0.076[d]	
U-234	0.113	
U-238	0.018	
U-236	0.015	
Np-237	0.058	
Sn-126	0.045	
Se-79	0.023	
Cs-135	0.022	
Sm-151	0.013	
Pd-107	0.006	
I-129	0.0018	

[a] BASED ON ORIGEN DATA REPORTED IN ORNL/TM-6008[2] FOR 33,000 MWd/MTM BURNUP PWR ASSEMBLY.

[b] RADIONUCUDES WITH 1000-YEAR ACTIVITY LESS THAN ^{129}I OR HALF-LIFE LESS THAN 1 YEAR OMMITED.

[c] INCLUDES ACTIVITY OF ^{239}Np DAUGHTER PRODUCTS.

[d] ^{14}C ACTIVITY MAY VARY CONSIDERABLY DEPENDING ON AS-FABRICATED NITROGEN IMPURITIES.

HEDL 8503-151.1

TABLE 3

SPENT FUEL RADIONUCLIDE CONTENT* IN ORDER OF DECREASING ACTIVITY AT 1000 YEARS
(33 MWd/kgU PWR Fuel)

Radionuclide	μCi/kgU at Years from Discharge[10] 10 yr	1000 yr	10,000 yr	half life[11] (years)
^{241}Am	1.7×10^6	9.3×10^5	10.6	458
^{240}Pu	5.3×10^5	4.8×10^5	1.9×10^5	6580
^{239}Pu	3.2×10^5	3.1×10^5	2.4×10^5	24,400
^{243}Am**	1.7×10^4	1.6×10^4	7.0×10^3	7370
^{99}Tc	1.4×10^4	1.4×10^4	1.3×10^4	2.1×10^5
^{93}Zr	3.0×10^3	3.0×10^3	3.0×10^3	1.5×10^6
^{234}U	1.2×10^3	2.0×10^3	2.0×10^3	2.5×10^5
^{242}Pu	1.9×10^3	1.9×10^3	1.8×10^3	3.8×10^5
^{14}C***	1.5×10^3	1.4×10^3	4.6×10^2	5730
^{238}Pu	2.2×10^6	1.0×10^3	---	86
^{237}Np	3.3×10^2	1.0×10^3	1.2×10^3	2.1×10^6
^{126}Sn	8.0×10^2	8.0×10^2	7.5×10^2	$\sim 10^5$
^{79}Se	4.2×10^2	4.2×10^2	3.8×10^2	6.5×10^4
^{135}Cs	3.8×10^2	3.8×10^2	3.8×10^2	3×10^6
^{151}Sm	3.6×10^5	2.3×10^2	---	93
^{107}Pd	1.2×10^2	1.2×10^2	1.2×10^2	7×10^6
^{129}I	32	32	32	1.7×10^7
^{241}Pu	8.0×10^7	21	10	13
^{230}Th	0.1	16	164	8×10^4
^{226}Ra****	3.3×10^{-4}	3	128	1600
^{210}Pb	4.0×10^{-5}	3	128	

*Includes radionuclides with half-lives greater than 1 year and with activities greater than 10^{-8} of total 1000-year activity.

**^{243}Am decay followed by 2-day half-life ^{239}Np daughter product decay.

***^{14}C activity will vary depending on initial fuel nitrogen content.

****Relatively rapid (~22 year) 8-step decay chain from ^{226}Ra to stable ^{206}Pb, only ^{210}Pb in this chain has a half-life greater than 1 year.

PWR SPENT FUEL ASSEMBLY
RADIONUCLIDE RELEASE per 1000 MTIHM

Nuclide	Inventory at 1000 y Curies	Total Release at 1E-05/y Curies	EPA DRAFT 5 Cumm. Limit	Ratio	Decay Adjusted
Am-241	9.3E+05	8.4E+03	1.0E+02	84	yes
Am-243+d	3.1E+04	2.8E+03	1.0E+02	28	no
Pu-240	4.8E+05	4.3E+04	1.0E+02	434	no
Pu-239	3.1E+05	2.8E+04	1.0E+02	280	N/I
Pu-242	1.8E+03	1.6E+02	1.0E+02	1.6	N/I
Pu-238	1.1E+03	2.2E+00	1.0E+02	0.02	yes
Tc-99	1.4E+04	1.2E+03	1.0E+04	0.12	N/I
Ni-59	4.5E+03	4.1E+02	1.0E+03	0.41	N/I
Ni-63	3.8E+02	6.0E-01	1.0E+03		yes
Zr-93	3.2E+03	2.9E+02	1.0E+03	0.29	N/I
Nb-94	1.3E+03	1.2E+02	1.0E+03	0.12	N/I
C-14	1.4E+03	7.4E+01	1.0E+02	0.74	yes
U-234	2.0E+03	1.8E+02	1.0E+02	1.8	N/I
U-238	3.2E+02	2.9E+01	1.0E+02	0.29	N/I
U-236	2.7E+02	2.4E+01	1.0E+02	0.24	N/I
Np-237	1.0E+03	9.4E+01	1.0E+02	0.94	N/I
Sn-126	8.1E+02	7.3E+01	1.0E+03	0.07	N/I
Se-79	4.1E+02	3.7E+01	1.0E+03	0.04	N/I
Cs-135	3.9E+02	3.6E+01	1.0E+03	0.04	N/I
Sm-151	2.3E+02	4.3E-01	1.0E+03		yes
Pd-107	1.1E+02	9.7E+00	1.0E+03	0.010	N/I
I-129	3.2E+01	2.9E+00	1.0E+02	0.029	N/I

Decay Adustments: N/I = not important, half life over 10000 years
For short half lives, release calculated by
Total = (.00001*2T)*Inventory at 1000 y

For C-14, release estimated using 0.6*Inventory for 9000 y

Candidates for Sorption, Solubility, or Isotope Exchange Control

Element	Factor to reduce ratio to 0.05
Americium	1680
Plutonium	8680
Technetium	2.4
Nickel	8.2
Zirconium	5.8
Niobium	2.4
Carbon	14.8
Uranium	36
Neptunium	18.8
Tin	1.4

BASIS FOR RELATING LABORATORY MEASUREMENTS TO NRC - EPA REQUIREMENTS

1. DETERMINE ANNUAL RELEASE RATE FROM WASTE FORM.

2. MODEL RESULTS FROM RELEASE RATE TESTING TO ALLOW EXTRAPOLATION TO LONGER TIMES.

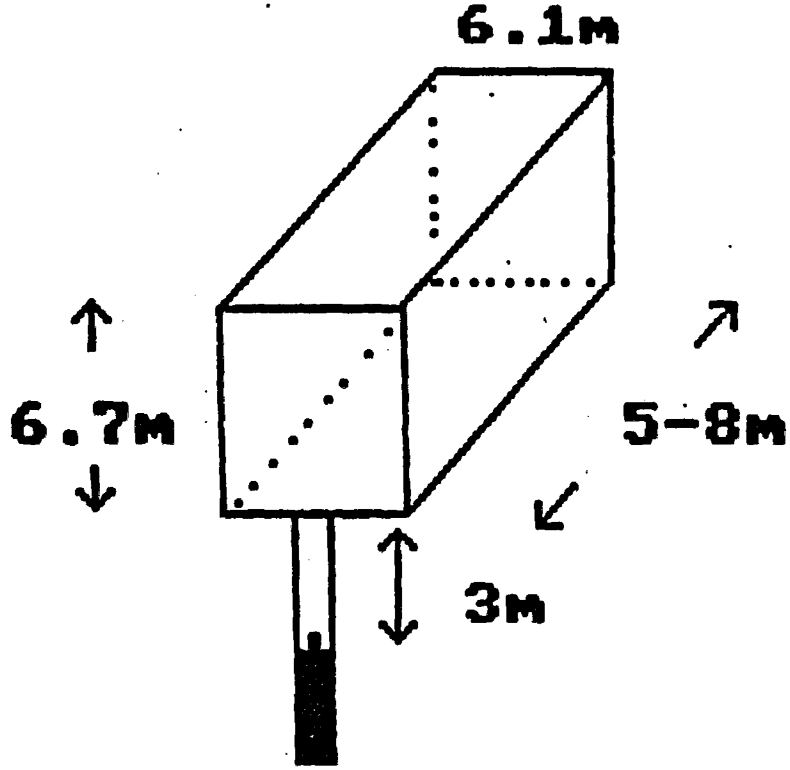
3. IF RESULT FROM STEP 2 SHOWS RELEASE IS ALWAYS LESS THAN 1 PART IN 10^5 PER YEAR, NRC REQUIREMENT IS MET.

4. IF NRC REQUIREMENT IS MET, THE EPA REQUIREMENT IS MET AT THE BOUNDARY OF THE ENGINEERED BARRIER SYSTEM FOR ALL NUCLIDES EXCEPT Am-241, Am-243, Pu-239, Pu-240, Pu-242.

5. DO SORPTION STUDIES ON Pu, Am AND Np TO DETERMINE THE DISPERSION AND RETARDATION OF THOSE NUCLIDES ALONG THE PATH TO THE ACCESSIBLE ENVIRONMENT.

6. MODEL TRAVEL PATH AND TRAVEL TIMES FOR WATER PLUS SORPTION RESULTS FOR Am, Pu AND Np TO SHOW THAT EPA REQUIREMENTS ARE MET.

Vertical Emplacement



Open area per package - average

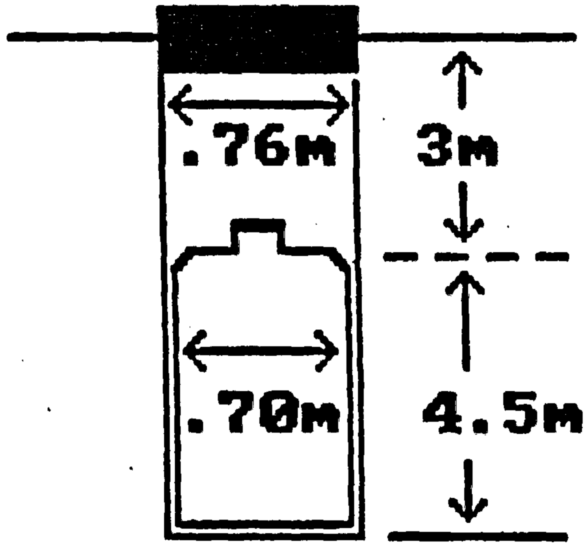
40 m^2

Water volume to open area per yr.

Influx rate	Volume per year
1mm/yr	40 l
2mm/yr	80 l
8mm/yr	320 l

For 1 mm/yr infiltration rate, water volume directly to borehole is 0.5 l/yr.

Water to Fuel Ratio



Void volume per hole

1800 l

Fuel weight per pkg

3140 kg UO_2

R = 1.74 kg/l of water if borehole full

Ratio for experiments:

Turkey Point, DIW	R = 0.16 kg/l
Turkey Point, J-13	R = 0.11 kg/l
H.B.Robinson, J-13	R = 0.33 kg/l

THREE PART SOURCE TERM for SPENT FUEL

1. Elements controlled by matrix dissolution, such as U, Pu, Am, Np.

2. Elements present in the pellet cladding gap. Release will be immediate upon breach of cladding for gases and nearly immediate upon contact with water for others such as Ts, Cs, I.

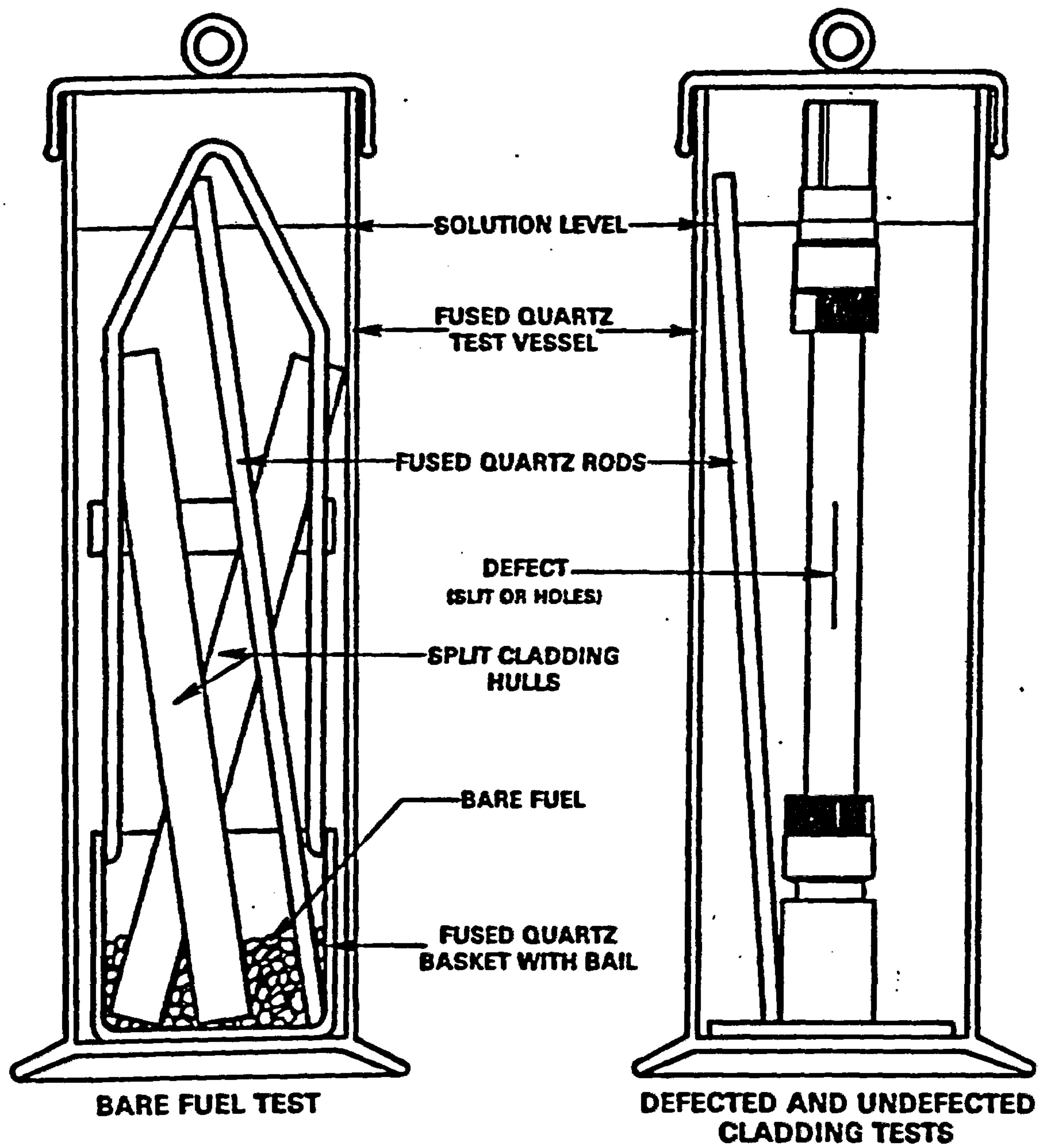
3. Elements that can be released into air without water present, such as C-14 from metal parts.

TEST METHODS

- SEMI-STATIC LEACH TESTS USING SPENT FUELS WITH VARIOUS INDUCED CLADDING DEFECTS OR STATES OF DEGRADATION WHICH MAY OCCUR DURING LONG TERM NNWSI REPOSITORY STORAGE
- MEASURE RADIONUCLIDE RELEASE
  - PERIODIC SOLUTION SAMPLES (UNFILTERED, 0.4 μm FILTERED, AND 18Å FILTERED)
  - FUSED QUARTZ ROD SAMPLES
  - TEST VESSEL AND APPARATUS 8M HNO_3 STRIP SAMPLES
  - RINSE SAMPLES
  - RADIOCHEMISTRY: pH, U, $^{239+240}Pu$, ^{241}Am, ^{244}Cm, ^{237}Np, ^{99}Tc, ^{14}C, ^{129}I (NAA), AND GAMMA SPECTROMETRY (^{137}Cs,...)
- POST-TEST SAMPLE ANALYSES
  - RADIOMETALLURGY
  - ELECTRON MICROSCOPY

HEDL 8502-021.8

TEST APPARATUS



TEST SPECIMENS

- **BARE FUEL WITH SPLIT CLADDING**
- **SLIT DEFECT, 150 μm WIDE BY 2 cm LONG**
- **HOLE DEFECTS, TWO LASER DRILLED HOLES ~200 μm DIAMETER**
- **UNDEFECTED ROD SEGMENTS**

SPECIMENS WERE PREPARED FROM 12.7 cm LONG PWR SPENT FUEL ROD SEGMENTS

HEDL 8408-198.11

TEST SERIES

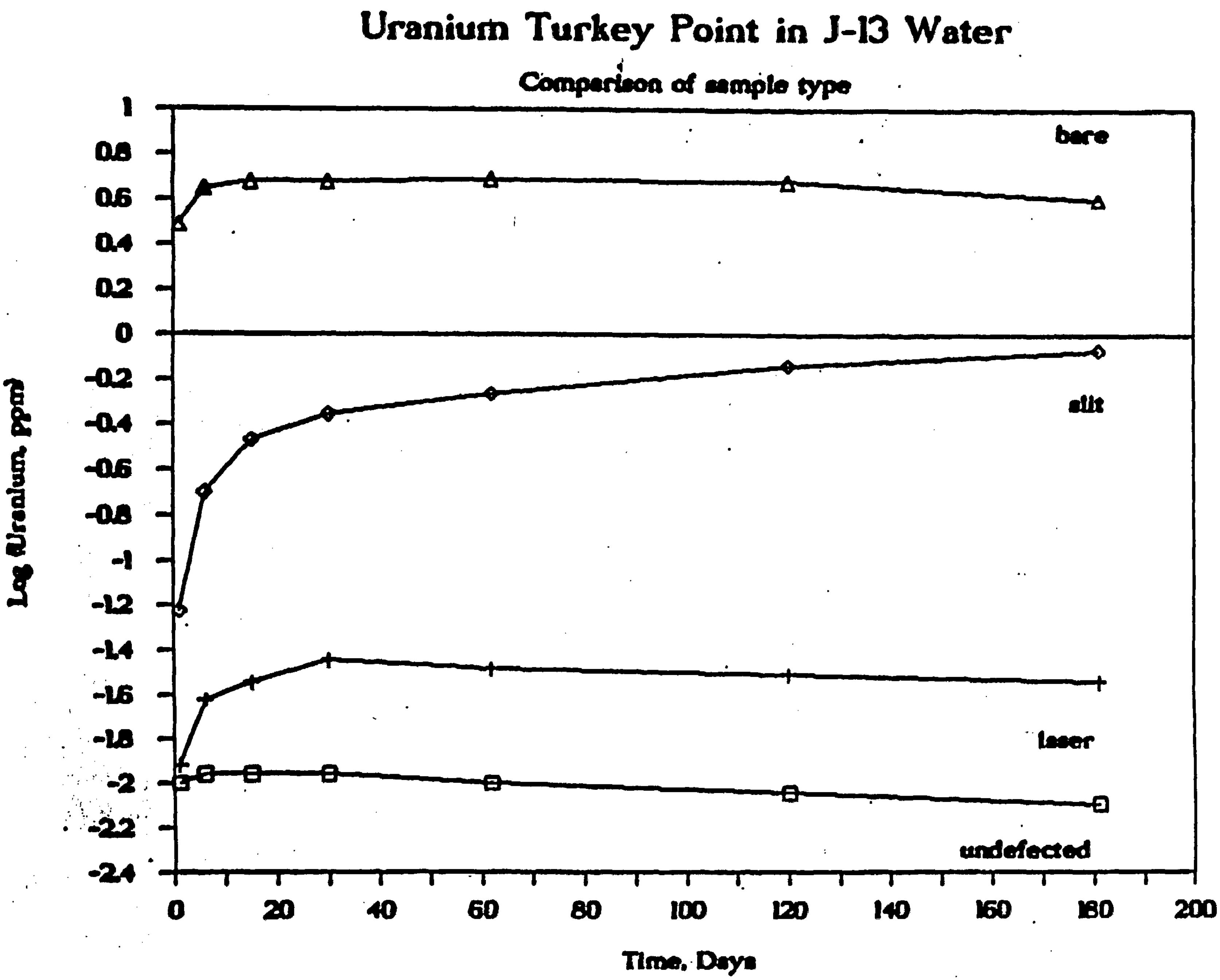
- SERIES 1 — TURKEY POINT FUEL IN DEIONIZED WATER (25°C), RUN ~250 DAYS, RESTARTED IN FRESH DEIONIZED WATER AND RUN FOR 128 DAYS.
- SERIES 2A — H.B. ROBINSON FUEL IN J-13 WELL WATER (25°C), RUN 223 DAYS, RESTARTED IN FRESH J-13 WELL WATER ON JANUARY 23, 1985.
- SERIES 2B — TURKEY POINT FUEL IN J-13 WELL WATER (25°C), RUN 181 DAYS, RESTARTED IN FRESH J-13 WELL WATER ON FEBRUARY 6, 1985.
- SERIES 3 — H.B. ROBINSON FUEL IN J-13 WELL WATER AT 70-90°C, START JUNE 1985.
- SERIES 4 — USE PARTIALLY OXIDIZED SPENT FUEL, START IN FY-1986.
- FUTURE TESTS
  - DIFFERENT FUELS, SUCH AS BWR AND HIGH FISSION GAS RELEASE FUEL
  - INCLUDE TUFF ROCK

HEDL 8502-021.6

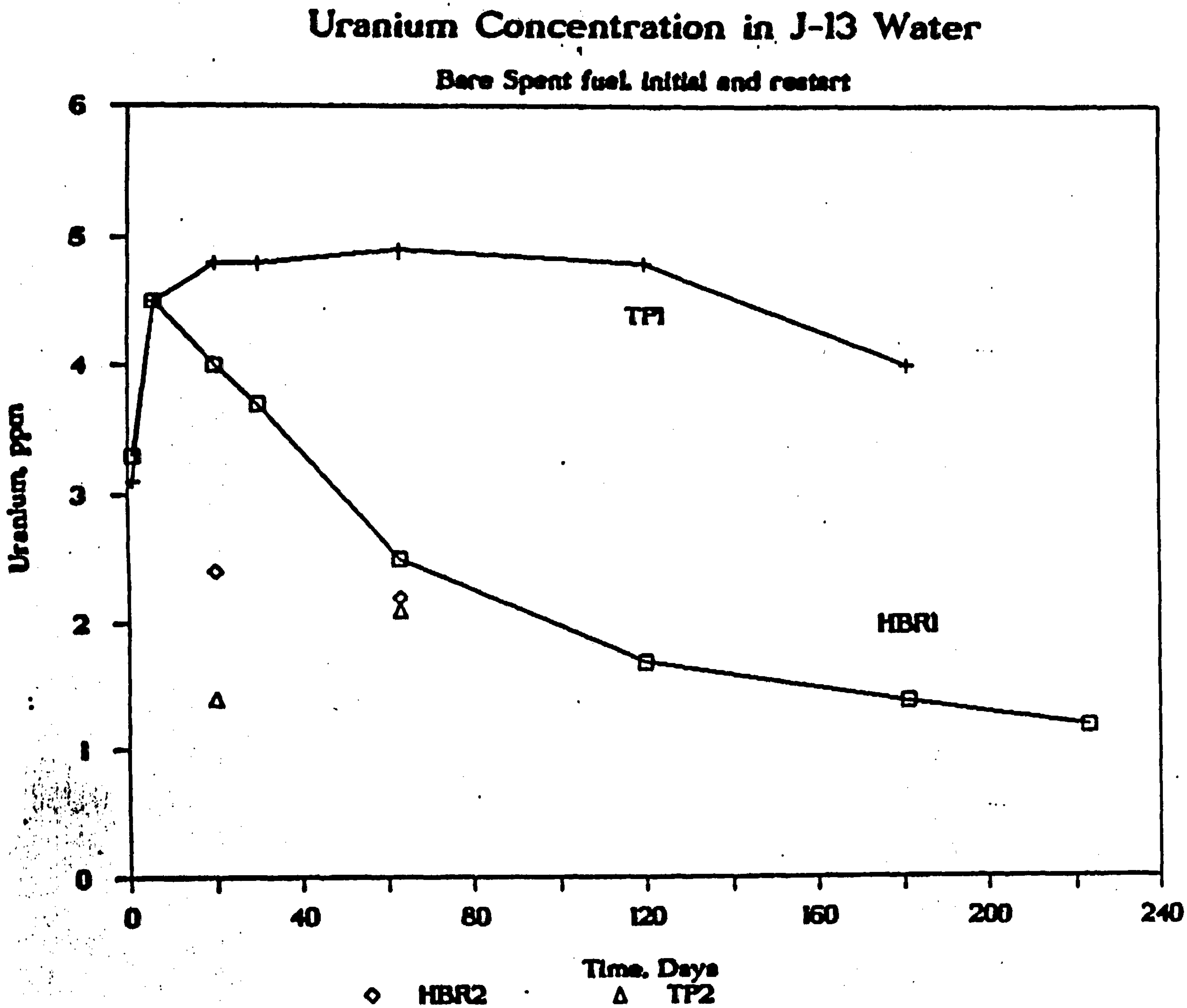
CHARACTERISTICS OF H.B. ROBINSON UNIT 2 AND TURKEY POINT UNIT 3 FUELS

CHARACTERISTIC	H.B. ROBINSON	TURKEY POINT
FUEL TYPE	PWR 15 x 15	PWR 15 x 15
DISCHARGED	MAY, 1974	NOVEMBER, 1975
ESTIMATED BURNUP	31 MWd/kgM	27 MWd/kgM
FISSION GAS RELEASE	~0.2%	~0.3%
INITIAL ENRICHMENT	2.55 wt% ^{235}U	2.559 wt% ^{235}U
INITIAL PELLET DENSITY	92% TD (UO_2)	92% TD (UO_2)
ROD DIAMETER	10.7 mm	10.7 mm
CLADDING	ZIRCALOY-4	ZIRCALOY-4
SPECIMEN SECTION LENGTH	5 INCHES	5 INCHES
SPECIMEN FUEL LENGTH	5 INCHES	2-3 INCHES

HEDL 8503-161.2

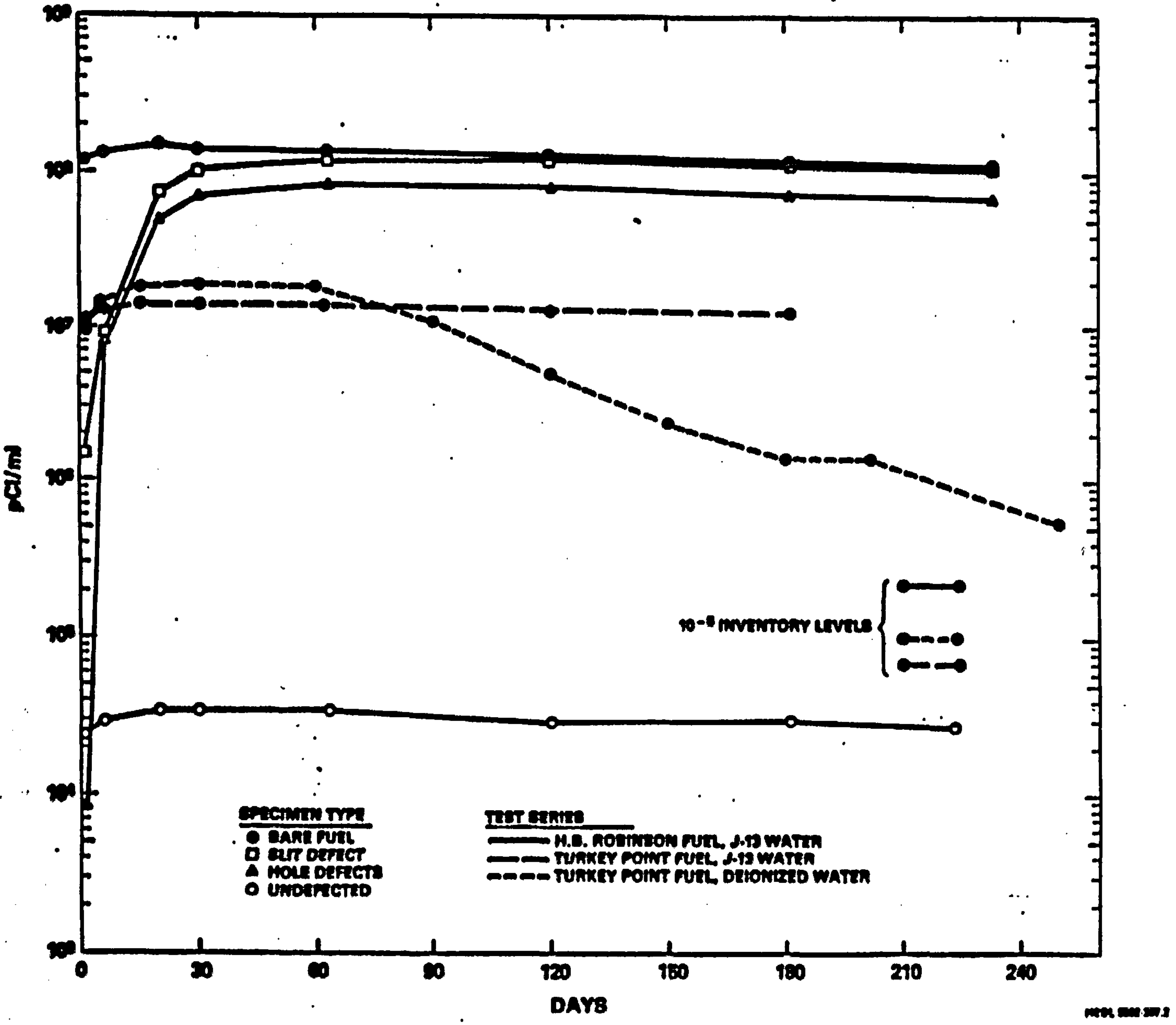


Uranium Turkey Point in J-13 Water
Comparison of sample type
bare
silt
laser
undefected
Log (Uranium, ppm)
Time, Days
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-2.2
-2.4
0
20
40
60
80
100
120
140
160
180
200



Uranium Concentration in J-13 Water
Bare Spent fuel, initial and restart
Uranium, ppm
0
1
2
3
4
5
6
0
40
80
120
160
200
240
Time, Days
TP1
HBR1
◇ HBR2
Δ TP2

^{137}Cs IN UNFILTERED SOLUTION



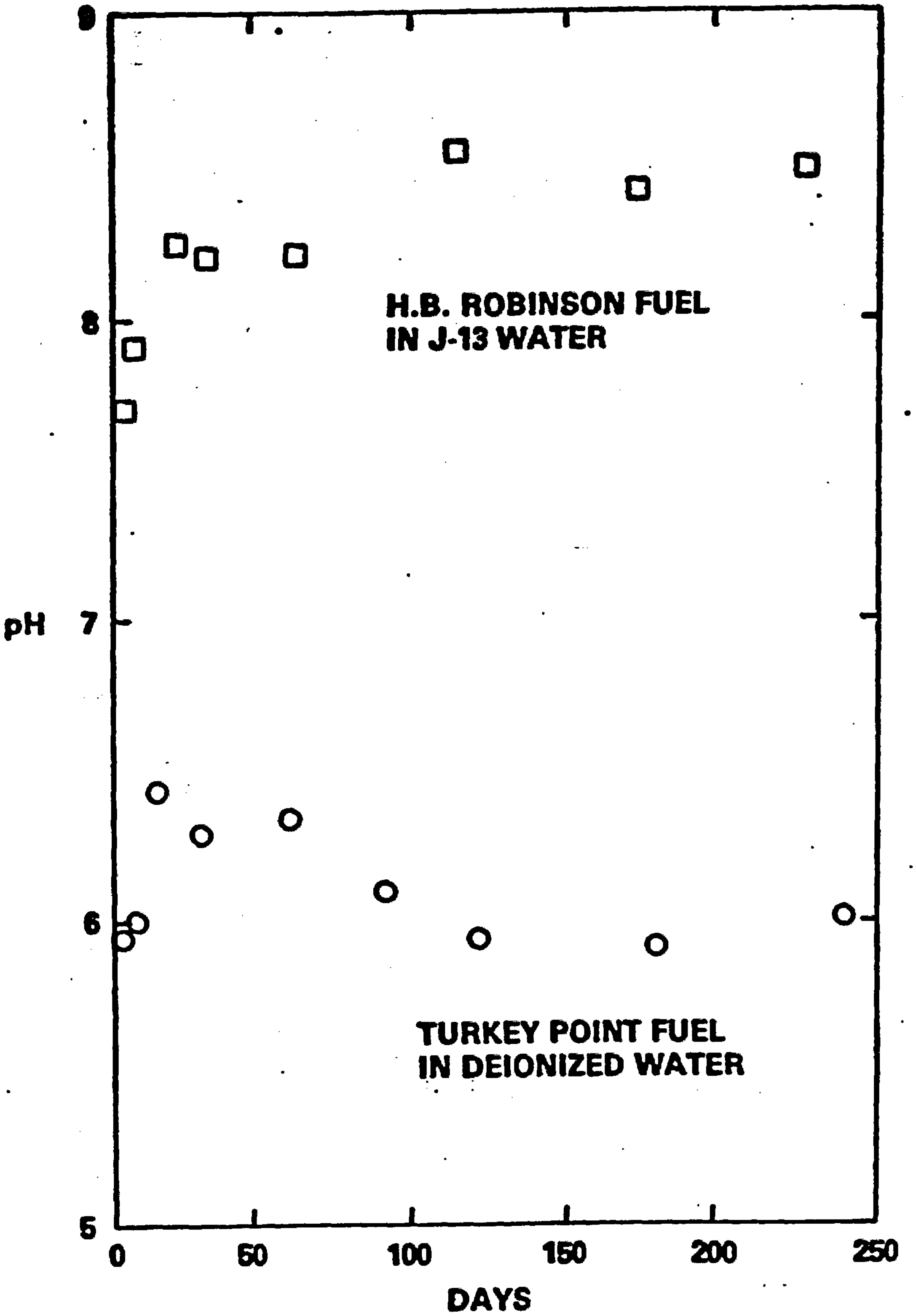
SOLUTION CHEMISTRY* FOR THE H.B. ROBINSON BARE FUEL TEST IN J-13 WATER

	STARTING J-13 WATER	30 DAYS	120 DAYS	223 DAYS
pH	7.2	8.2	8.5	8.5
Al	0.11	0.09	0.10	< 0.08
Ca	15.0	12.7	12.1	12.3
Fe	--	0.21	0.15	0.08
K	5.5	4.5	2.8	2.2
Mg	2.1	1.8	2.1	2.0
Mo	--	0.26	0.21	0.20
Na	49.5	41.6	44.5	45.5
Sr	--	--	--	0.06
Si	31.9	24.5	26.2	32.7
Cl	7.3	7.8	7.3	7.6
F	2.7	2.4	2.1	2.2
PO_4	2.8	--	--	--
NO_2	--	--	~0.5	~0.6
NO_3	8.7	7.4	8.1	8.3
SO_4	18.8	18.8	18.6	18.5
CO_3	118.0	--	120.0	118.0

*UNITS IN μg/ml, 0.4 μm FILTERED.

HEDL 8503-151.11

pH IN BARE FUEL TESTS



HEDL 8602-021.11

EFFECTS OF FILTRATION ON 223-DAY J-13/HBR AND 202-DAY DIW/TP BARE FUEL TEST SOLUTION SAMPLES

	SERIES	UNFILTERED	0.4 μm	18A
URANIUM (μg/ml)	J-13/HBR	1.2	1.2	1.2
	DIW/TP	0.3	0.003	0.002
$^{239+240}Pu$ (pCi/ml)	J-13/HBR	112	76	26
	DIW/TP	2240	2180	1810
^{241}Am (pCi/ml)	J-13/HBR	286	151	3.6
	DIW/TP	9860	1430	97
^{244}Cm (pCi/ml)	J-13/HBR	410	231	0.9
	DIW/TP	21,100	2860	163
^{99}Tc (pCi/ml)	J-13/HBR	450	490	450
	DIW/TP*	2250	2250	2200

*250 DAY SOLUTION SAMPLE

HEDL 8603-151.3

H.B. ROBINSON FUEL IN J-13 WATER URANIUM RELEASE DATA (μg)

	BARE FUEL	SLIT DEFECT	HOLE DEFECTS	UNDEFECTED
Σ SOLUTION SAMPLES	211	4.3	0.50	1.26
Σ ROD SAMPLES	34	0.3	0.17	0.19
FINAL SOLUTION [U (μg/ml)]*	300 (1.2)	23.8 (0.095)	1.50 (0.006)	3.25 (0.013)
STRIP	2700	1.5	0.60	0.60
RINSE	550**	1.8	0.60	0.27
Σ ABOVE	3795	31.7	3.37	5.57
DIVIDED BY 10^{-5} INV.	5.42	0.044	0.0047	0.008

*UNFILTERED 223-DAY FINAL SOLUTION URANIUM CONTENT IN μg/ml GIVEN IN PARENTHESES.
**0.4 μm FILTERED

HEDL 8503-151.5

Table 1: Uranium release data for Turkey Point Fuel in J-13 water. All units in micrograms U except for fractional release.

	Bare Fuel	Slit Defect	Hole Defects	Undefected
Total Solns.	350.5	35.8	2.26	0.76
Total Rods	15.4	0.5	0.19	0.10
Final Soln.	1000	212.5	7.25	2.00
Water Rinse	366	10.2	0.60	0.60
Acid strip	960	15.9	2.70	0.30
Total	2691.9	274.9	13.0	3.8
Fractional	11.67	0.65	0.03	0.011

RELEASE DATA FOR H.B. ROBINSON BARE FUEL IN J-13 WATER (nCi)

	$^{239+240}Pu$	^{241}Am	^{244}Cm	^{99}Tc
Σ SOLUTION SAMPLES	42.9	93.9	126.0	~24
Σ ROD SAMPLES	56.2	125.1	138.2	0.6
FINAL SOLUTION	27.9	71.5	102.5	112.5
STRIP	4054.1	9600.0	8970.0	28.4
RINSE*	253.8	532.0	564.6	18.6
Σ ABOVE	4434.9	10,422.5	9900.3	183.6
DIVIDED BY 10^{-5} INV.	7.04	7.76	6.54	20.2

*RINSE SOLUTION 0.4 μm FILTERED.

HEDL 8503-151.6

Table 2: Bare Fuel release data for Turkey Point Fuel in J-13 water. All units in nanocuries except for fractional release.

	Pu-239+Pu-240	Am-241	Cm-244	Tc-99	Cs-137
Total Solns.	63	138	138	8	1.0E+06
Total Rods	22	42	38	n.m.	2.7E+03
Final Soln.	114	243	250	53	3.1E+06
Water Rinse	63	111	104	11.6	7.9E+05
Acid strip	1140	2180	1610	6.1	1.4E+05
Total	1401	2714	2140	79	5.0E+06
Fractional Release, parts in 100,000	7.30	6.87	7.44	29.7	295

^{129}I MEASURED IN J-13/HBR SOLUTION SAMPLES

TEST	DAYS	^{129}I (pCi/ml)*	÷ 10^{-5} INVENTORY**
BARE FUEL	63	0.52	5.6
	223	0.72	7.5
SLIT DEFECT	63	0.29	3.0
	223	0.38	4.0
HOLE DEFECTS	63	0.0019	0.020
	223	0.0050	0.053
UNDEFECTED	63	0.0060	0.064
	223	0.0054	0.057

*AVERAGE FOR 2 REPLICATE SAMPLES MEASURED BY NEUTRON ACTIVATION ANALYSIS.
**(pCi/ml) (250 ml)/(10^{-5} OF SPECIMEN INVENTORY).

HEDL 8503-151.4

TEST	DAYS	^{14}C (nCi)
BARE FUEL	63	5.0
	223	6.5
SLIT DEFECT	63	3.3
	223	14.0
HOLE DEFECTS	63	1.4
	223	24.0
UNDEFECTED	63	5.5
	223	5.0

SPECIMEN INVENTORY ESTIMATED AT 28 μCi IN THE FUEL AND 10 μCi IN THE CLADDING BASED ON SINGLE SPECIMEN ANALYSIS.

HEDL 8604-088.1

SLIDE 14. ^{14}C Measured in J-13/HBR Solution.

Table 4: Summary of fractional release data for all sample types. Units are parts in 100,000 of the inventory in the test specimen. DIW/TP = Turkey Point fuel in deionized water (Wilson, 1985). J-13/HBR = H. B. Robinson fuel in J-13 water (Wilson and Oversby, 1985).

Nuclide	Series	Bare Fuel	Slit	Holes	Control
Uranium	J-13/HBR	5.63	0.05	0.005	0.009
	J-13/TP	11.7	0.65	0.030	0.011
	DIW/TP	21.2	0.07	0.032	0.010
239 + 240 Pu	J-13/HBR	7.04	0.01	0.003	0.002
	J-13/TP	7.30	0.11	0.022	0.006
	DIW/TP	22.4	0.20	0.042	0.021
241 Am	J-13/HBR	7.76	0.01	0.002	0.003
	J-13/TP	6.87	0.12	0.023	0.004
	DIW/TP	17.2	0.15	0.019	0.008
244 Cm	J-13/HBR	6.54	0.01	0.001	0.002
	J-13/TP	7.44	0.13	0.026	0.005
	DIW/TP	21.5	0.35	0.026	0.006
237 Np	J-13/HBR	<6.4	<2.5	---	---
	J-13/TP	<7.4	<3.4	---	---
	DIW/TP	18	0.2	---	---
137 Cs	J-13/HBR	739	633	400	0.18
	J-13/TP	295	137	7.6	0.13
	DIW/TP	230	110	50	0.04
99 Tc	J-13/HBR	19.9	2.4	<1.5	---
	J-13/TP	29.7	<13.7	<2	---
	DIW/TP	152	8.1	---	---

ASSUMPTIONS FOR RELEASE RATE CALCULATIONS

1. Carbon-14 release begins as soon as air enters container.

   Two release rates: Initial pulse of about 0.2% of inventory will be controlled by rate of container breach.

   Further release is controlled by Zircaloy and spent fuel oxidation and dissolution rates.

2. Cesium-135 release rate will consist of 2 components.

   Gap-grain boundary release, approximated by the fission gas release for the fuel.

      Use 0.5% gas release and cladding breach rate of 0.1% per year.

   Bulk of inventory will have release rate controlled by the matrix dissolution rate.

3. Technetium and iodine.

   Some inital preferential release, but less than that for cesium. For initial model use cesium release rate as upper bound for Tc and I.

4. Activation products.

   Controlled by the dissolution rate of the matrix (Zircaloy, Inconel, Stainless steel)

5. All other elements.

   Controlled by the dissolution rate of the UO_2 matrix

CALCULATION OF MATRIX DISSOLUTION RATE

MODEL ASSUMPTIONS

1. Dissolution Rate controlled by Uranium solubility of 5 ppm.

   Basis: Ambient temperature spent fuel dissolution in J-13 water.

2. Semi-Static dissolution conditions with 40 liters of fresh water replacing same volume of Uranium-saturated water each year.

   Basis: Infilitration rate of 1 mm/y, Vertical emplacement geometry. All water reaching open area collects in emplacement hole.

3. Fuel to water ratio is 1.7 kg/l.

   Basis: Emplacement hole does not drain, All open volume in hole fills with water.

RESULTS

Initial Dissolution

1.74 Kg fuel/liter of water

Dissolution - 5 mg of UO_2/liter of water

Years to fill void volume = 1800 l/ 40 l per year

= 45 years

Rate = 5 mg/1.74 kg in 45 years

6.4E-08 per year

Subsequent dissolution

40 liters of water per year

3140 kg UO_2 per package

Rate = (5 mg/l * 40 l) / 3140 kg

6.4E-08 per year

CESIUM RELEASE RATE CALCULATION

MODEL ASSUMPTIONS

1. Following cladding breach, the release rate is 0.5% for the first year and decreases by 1 order of magnitude per year until the matrix dissolution rate of 6×10^{-8} per year is reached.

2. Cladding breach rate is 0.1% per year.

RESULTS

First year - $0.001 \times 0.005 = 5 \times 10^{-6}$ per year

Second year - $0.001 \times 0.005 + 0.001 \times 0.0005 = 5.5 \times 10^{-6}$ per year

Third year - $0.001 \times 0.005 + 0.001 \times 0.0005 + 0.001 \times 0.00005 =$

5.55×10^{-6} per year

Etc.

Release rate will be about 5.55×10^{-6} per year until all cladding is breached. (Under the model assumptions, this will take 1000 years). Then rate will drop to the matrix dissolution rate.

IMPLICATIONS OF A RELEASE RATE OF 1 PART IN 10,000,000 PER YEAR

PWR SPENT FUEL ASSEMBLY RADIONUCLIDE RELEASE per 1000 MTIHM

Nuclide	Inventory at 1000 y Curies	Total Release at 1E-07/y Curies	EPA DRAFT 5 Cumm. Limit	Ratio	Decay Adjusted
Am-241	9.3E+05	8.4E+01	1.0E+02	1	yes
Am-243+d	3.1E+04	2.8E+01	1.0E+02	2.83E-01	no
Pu-240	4.8E+05	4.3E+02	1.0E+02	4	no
Pu-239	3.1E+05	2.8E+02	1.0E+02	3	N/I
Pu-242	1.8E+03	1.6E+00	1.0E+02	1.61E-02	N/I
Pu-238	1.1E+03	2.2E-02	1.0E+02	2.15E-04	yes
Tc-99	1.4E+04	1.2E+01	1.0E+04	1.24E-03	N/I
Ni-59	4.5E+03	4.1E+00	1.0E+03	4.07E-03	NON-FUEL
Ni-63	3.8E+02	6.0E-03	1.0E+03		yes
Zr-93	3.2E+03	2.9E+00	1.0E+03	2.92E-03	N/I
Nb-94	1.3E+03	1.2E+00	1.0E+03	1.19E-03	N/I
C-14	1.4E+03	7.4E-01	1.0E+02	7.36E-03	yes
U-234	2.0E+03	1.8E+00	1.0E+02	1.82E-02	N/I
U-238	3.2E+02	2.9E-01	1.0E+02	2.91E-03	N/I
U-236	2.7E+02	2.4E-01	1.0E+02	2.42E-03	N/I
Np-237	1.0E+03	9.4E-01	1.0E+02	9.36E-03	N/I
Sn-126	8.1E+02	7.3E-01	1.0E+03	7.27E-04	N/I
Se-79	4.1E+02	3.7E-01	1.0E+03	3.71E-04	N/I
Cs-135	3.9E+02	3.6E-01	1.0E+03	3.55E-04	N/I
Sm-151	2.3E+02	4.3E-03	1.0E+03		yes
Pd-107	1.1E+02	9.7E-02	1.0E+03	9.69E-05	N/I
I-129	3.2E+01	2.9E-02	1.0E+02	2.91E-04	N/I
Total	1.79E+06	Sum minus Am+Pu		0.052	

Candidates for Sorption, Solubility, or Isotope Exchange Control

Element	Factor to reduce ratio to 0.05
Americium	20
Plutonium	80

TEST SERIES FOR DETERMINING THE CONTROL OF RELEASE RATE FROM SPENT FUEL WHICH IS CONTAINED IN ZIRCALOY WITH MINOR DEFECTS

COMPLETED: (25°C)

- DETERMINE THE RELATIVE RELEASE RATE FROM BARE FUEL VS. FUEL IN ZIRCALOY CLADDING WITH PIN HOLE AND SLIT DEFECTS IN DEIONIZED WATER.

IN PROGRESS:

- CONDUCT CORROSION TESTS IN YUCCA MOUNTAIN GROUNDWATER TO DETERMINE THE DEGRADATION RATE OF THE DEFECTS IN CLADDING (90°C).
- CONDUCT RELATIVE RELEASE RATE TESTS IN REFERENCE GROUNDWATER (25°C).
- DETERMINE OXIDATION RATE FOR SPENT FUEL UNDER REPOSITORY CONDITIONS.

TEST SERIES FOR DETERMINING THE CONTROL OF RELEASE RATE FROM SPENT FUEL WHICH IS CONTAINED IN ZIRCALOY WITH MINOR DEFECTS

PLANS:

- DETERMINE DEPENDENCE OF RELEASE RATE ON FUEL TO WATER RATIO.
- INVESTIGATE RELEASE RATE FROM BWR AND HIGH GAS RELEASE FUEL RODS.
- CONDUCT CORROSION TESTS OF ZIRCALOY UNDER CONDITIONS RELEVANT TO INTACT CONTAINMENT BARRIER WITH WATERLOGGED FUEL PIN.
- CONDUCT TESTS AT HIGHER TEMPERATURES TO DETERMINE VARIATION OF RELEASE RATE WITH TEMPERATURE.

WHY STUDY SPENT FUEL OXIDATION?

$UO_2 \longrightarrow U_4O_9 \longrightarrow U_3O_7 \longrightarrow U_3O_8 \longrightarrow UO_3$

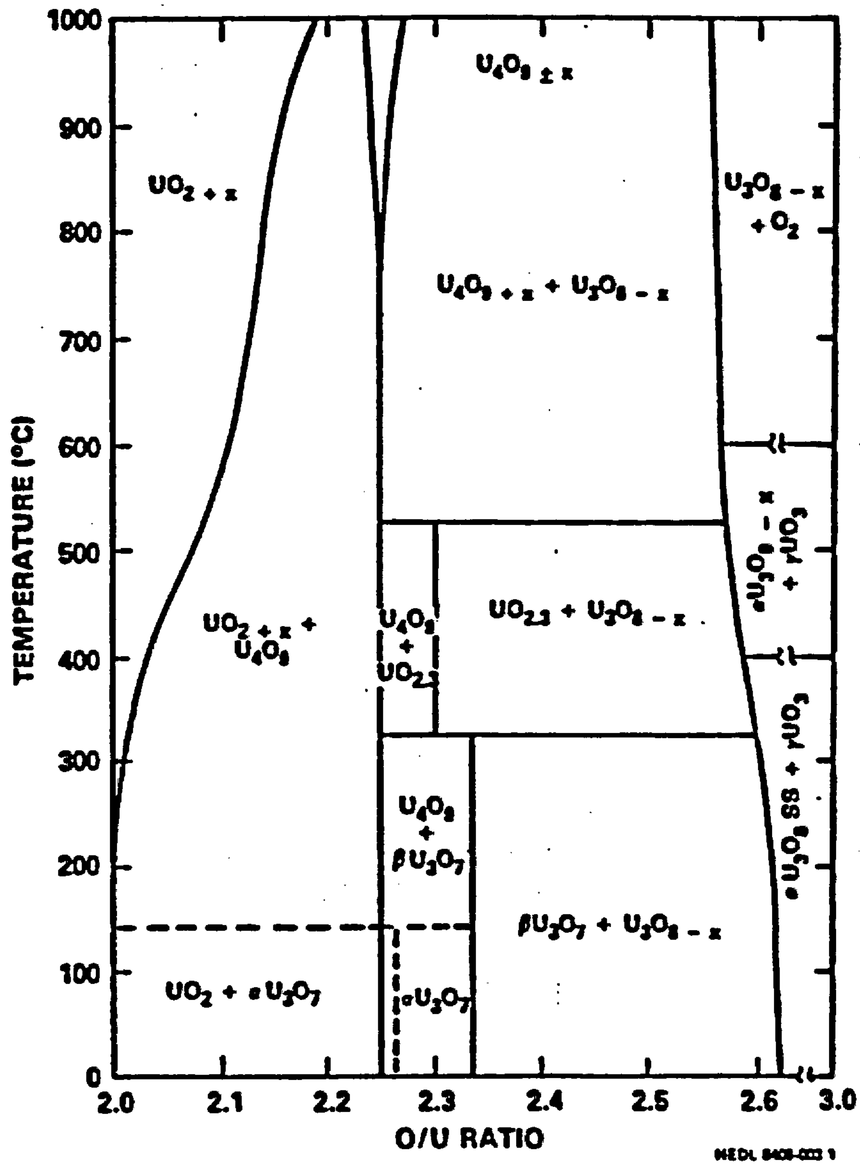
- UO_2 WILL OXIDIZE TO UO_3 UNDER TUFF REPOSITORY CONDITIONS GIVEN ENOUGH TIME
- LOWER DENSITY U_3O_8 FORMATION CAN SPLIT CLADDING AND EXPOSE MORE FUEL TO GROUNDWATER
- HIGHER OXIDES OF UO_2 MAY LEACH FASTER THAN UO_2

HEDL 8602-032.7

OUTSTANDING QUESTIONS

- RATE OF OXIDE FORMATION AND MIXTURE OF PHASES AS FUNCTION OF TIME AND TEMPERATURE
- OXIDATION MECHANISMS OPERATIVE AT REPOSITORY TEMPERATURES
- EFFECT OF HUMIDITY AND FUEL VARIABILITY ON LONG-TERM, LOW-TEMPERATURE MECHANISMS
- RADIOLYSIS EFFECTS IN MOIST INERT HIGH TEMPERATURE ATMOSPHERES

HEDL 8602-032.2



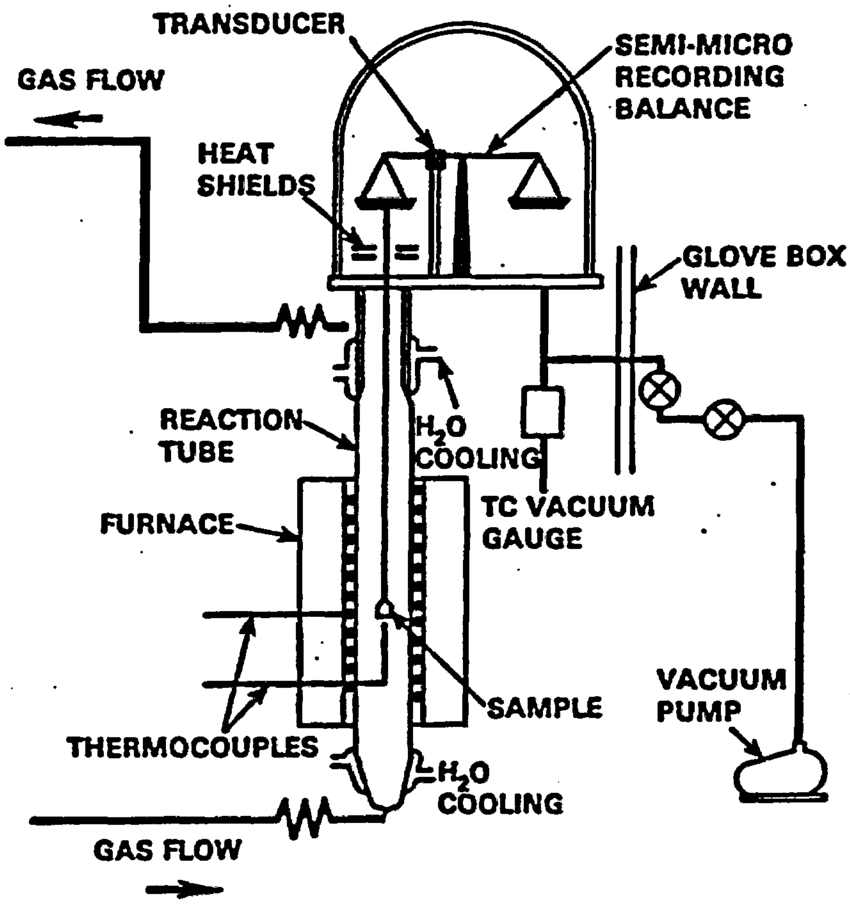
GURE 1. Phase Diagram for Uranium-Oxygen System Adapted from References 15 and 16.

POSSIBLE OXIDATION MECHANISM

- GRAIN BOUNDARY DIFFUSION
- BULK DIFFUSION
- NUCLEATION AND GROWTH
- CRITICAL OXIDE LAYER THICKNESS
- MANY OTHERS

HEDL 8602-032.4

TGA SYSTEM



HEDL 8502-032.9

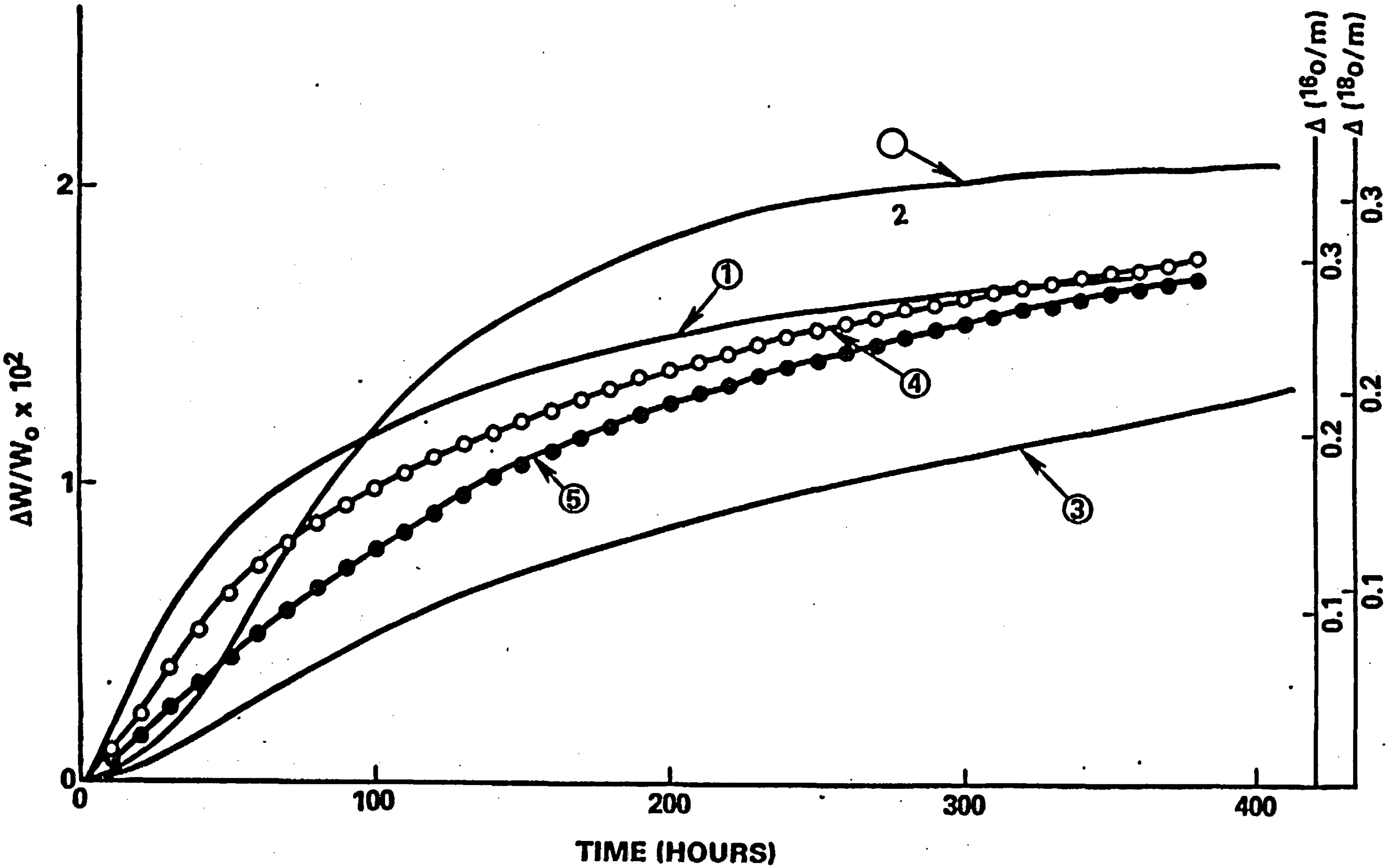
TABLE 3
TEST PARAMETERS

	RUN I	RUN II	RUN III	RUN IV	RUN V
TEMPERATURE (°C)	225	224	200	225	225
DURATION (hrs)	356	408	737	387	428
ATMOSPHERE	AIR	AIR	80% N_2 + 20% $^{18}O_2$	AIR	AIR
DEW POINT (°C)	14.5	14.5	14.5	−69.8	14.5
FUEL IDENTIFICATION*	G7-27-2	I9-24-1	I9-24-2	G7-14-3-1	G7-14-3-2
INITIAL WEIGHT (mg)	195.2	228.5	227.6	214.6	211.5
SAMPLE CONDITION	PULVERIZED FUEL	SINGLE FRAGMENT	SINGLE FRAGMENT	TWO FRAGMENTS	FOUR FRAGMENTS

*G7, I9 REFER TO THE FUEL ROD IDENTIFICATION

HEDL 8502-032.8

TGA TEST SAMPLE WEIGHT CHANGES



HEDL 8602-032.10

EXAMINATION TECHNIQUES

- CERAMOGRAPHY
- SEM
- X-RAY DIFFRACTION
- ELECTRON MICROPROBE
- ION MICROPROBE
- GAS ANALYSIS

HEDL 8502-032.6

PRELIMINARY CONCLUSIONS FROM INITIAL TGA TESTING

- TGA SYSTEM SUFFICIENTLY STABLE FOR OXIDATION STUDIES
- SIZE OF SAMPLE DOES NOT APPEAR CRITICAL. GRAIN BOUNDARY DIFFUSION OPENS MOST GRAIN SURFACES TO OXIDIZING ATMOSPHERE
- 3 TO 16,000 ppm MOISTURE CONTENT OF AIR HAS ONLY MINOR EFFECT ON SHORT-TERM OXIDATION RATES

HEDL 8602-032.8

TABLE 4

TEST MATRIX

Test		Temp (°C)	Fuel	BU (GWD/MTa)	Moisture (DP)	Test Duration	No. of Samples
Oven		105	Turkey Point	~30	DP < 10°C	2 yrs	6
No.1		115	Turkey Point	~30	DP < 10°C	2 yrs	6
		130	Turkey Point	~30	DP < 10°C	2 yrs	6
TGA	a)	170	Turkey Point	~30	-70	3 Months	1 to 4
	b)	170	Turkey Point	~30	25	3 Months	1 to 4
No.2	c)	170	Turkey Point	~30	0	3 Months	1 to 4
	d)	150	Turkey Point	~30	-70	3 Months	1 to 4
	e)	150	Turkey Point	~30	25	3 Months	1 to 4
	f)	150	Turkey Point	~30	0	3 Months	1 to 4
Oven		105	Turkey Point	30	-70, 90	2 yrs	12
(if indicated)		115	Turkey Point	30	-70, 90	2 yrs	12
No.3		130	Turkey Point	30	-70, 90	2 yrs	12
TGA	a)	200	BWR	25	25	3 Months	1 to 4
No.4	b)	200	PWR	10	25	3 Months	1 to 4
	c)	200	BWR	10	25	3 Months	1 to 4
Oven (if indicated)		105	BWR	25	-70,10,90	2 yrs	18
		115	BWR	25	-70,10,90	2 yrs	18
No.5		130	BWR	25	-70,10,90	2 yrs	18
		105	PWR	25	-70,10,90	2 yrs	18
		115	PWR	10	-70,10,90	2 yrs	18
		130	PWR	10	-70,10,90	2 yrs	18
		105	BWR	10	-70,10,90	2 yrs	18
		115	BWR	10	-70,10,90	2 yrs	18
		130	BWR	10	-70,10,90	2 yrs	18

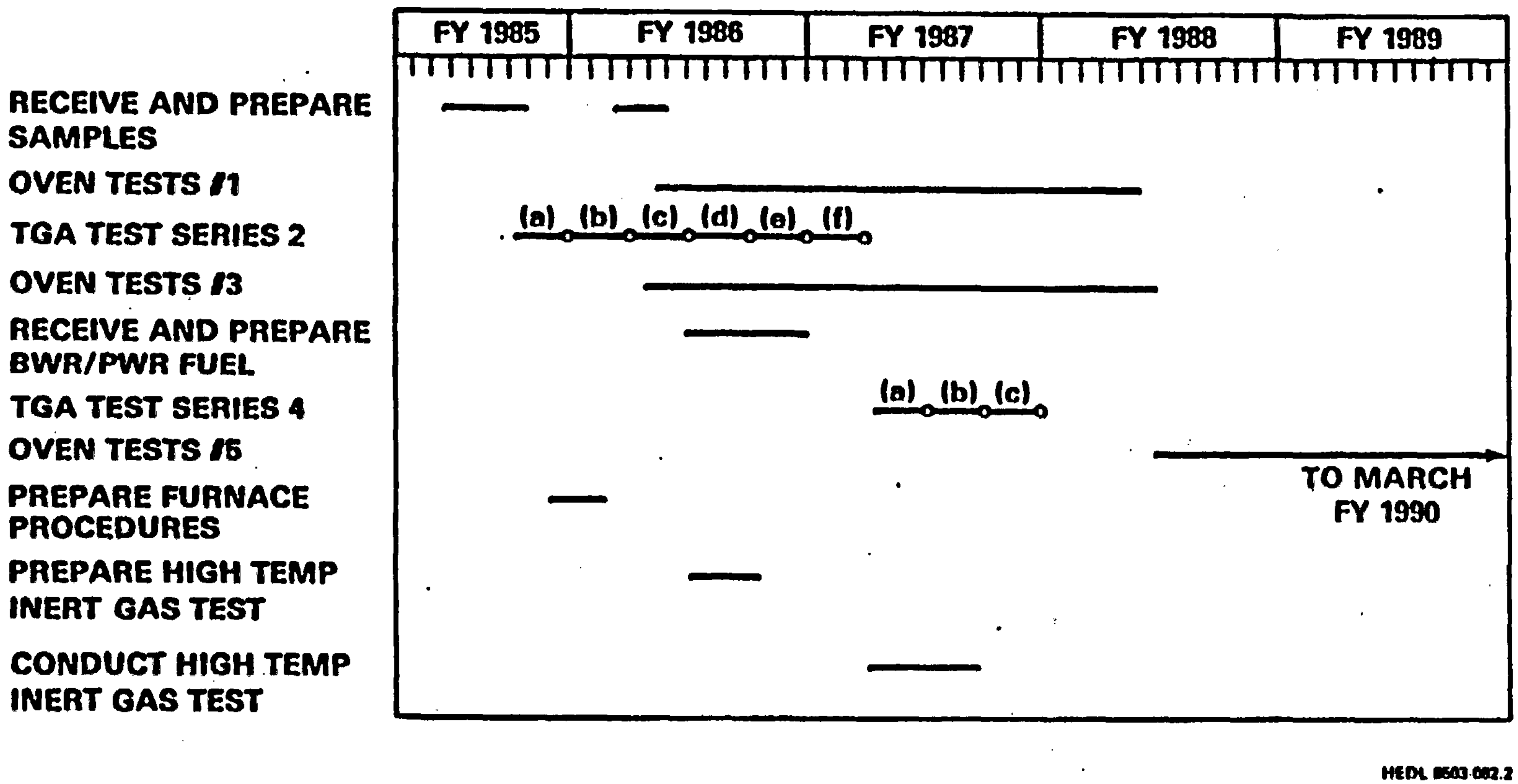
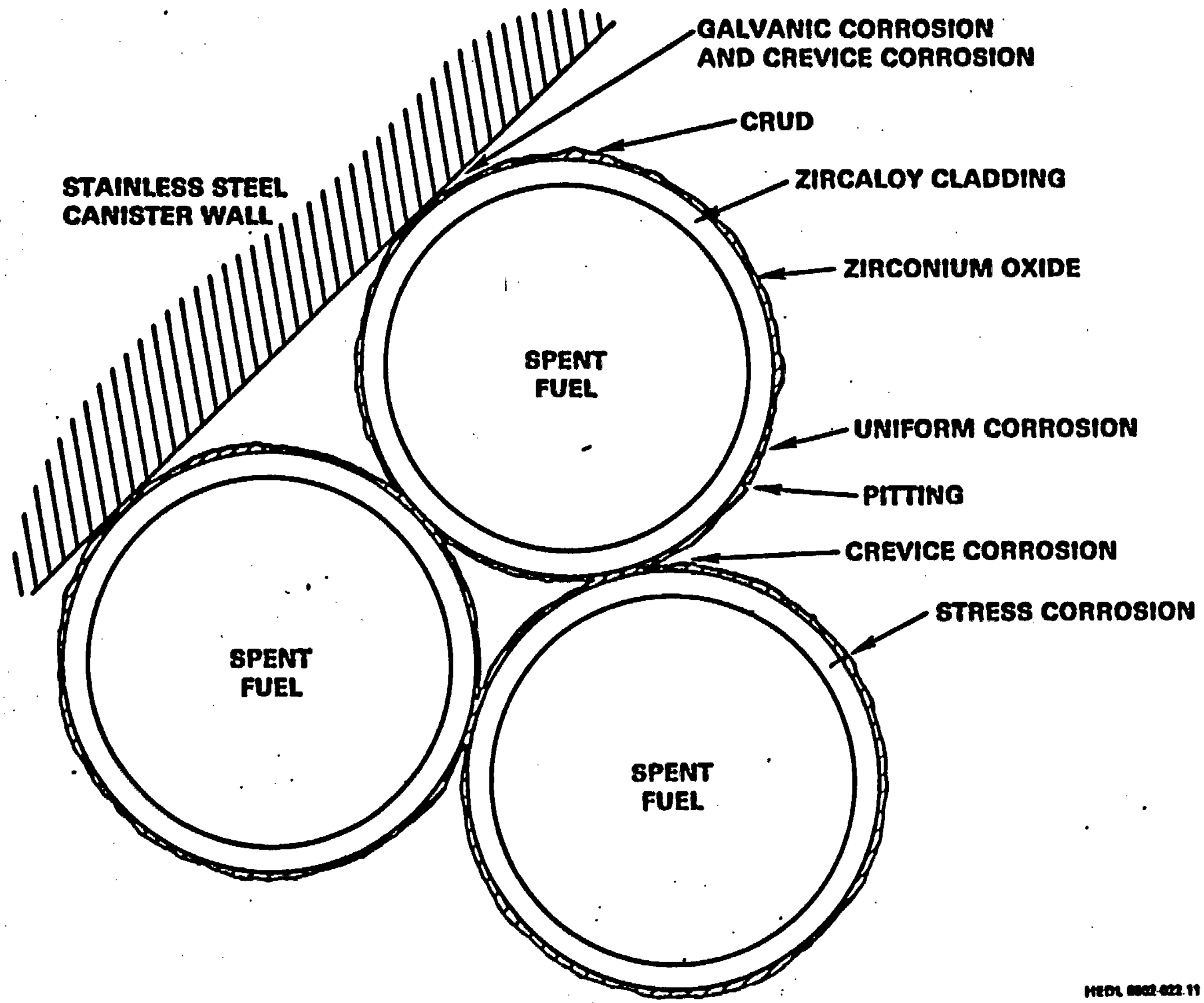


FIGURE 7. Schedule for Spent Fuel Oxidation Studies.

ZIRCALOY CLADDING CORROSION

H.D. SMITH

WESTINGHOUSE HANFORD COMPANY



HEDL 8802-022.11

OBJECTIVES

- IDENTIFY ACTIVE CORROSION PROCESSES ON ZIRCALOY SPENT FUEL CLADDING UNDER TUFF REPOSITORY CONDITIONS
- ESTABLISH CORROSION RATES (OR UPPER BOUNDS) FOR POTENTIAL CORROSION PROCESSES. FOR SCC, STRESS INTENSITY FACTOR THRESHOLD VALUES ARE TO BE DETERMINED.

OVERVIEW OF APPROACH

I. ANALYZE ENVIRONMENTAL TIME LINE OF THE REPOSITORY FOR CRITICAL CORROSION ENVIRONMENTS.

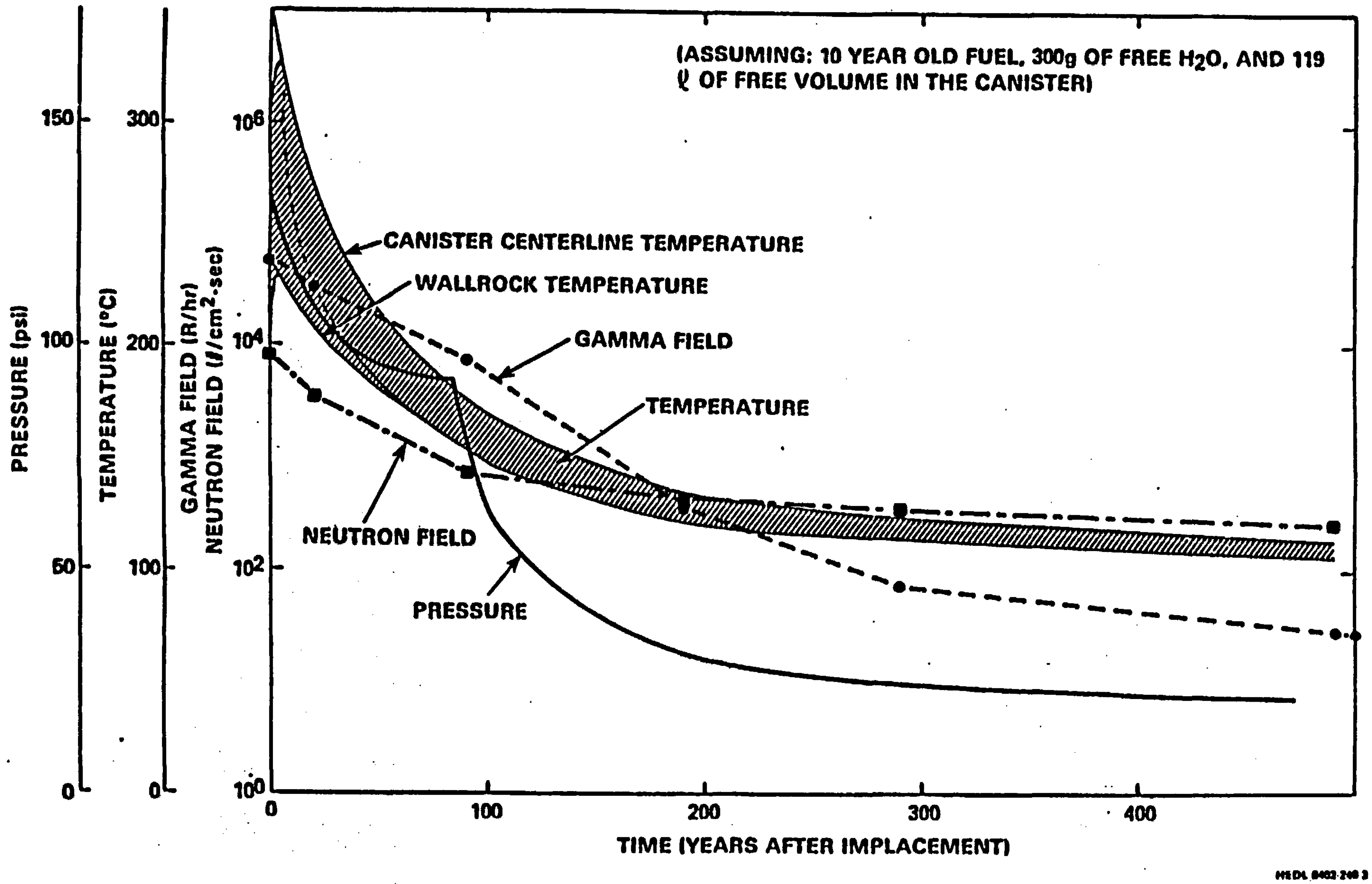
II. IDENTIFY POTENTIAL CORROSION MECHANISMS.

III. DEVELOP BASIC EXPERIMENTS TO EVALUATE CLADDING CORROSION IN THE CRITICAL ENVIRONMENTS.

IV. PLAN AND IMPLEMENT EXPERIMENTAL PROGRAM TO EVALUATE CORROSION IN THE CRITICAL REPOSITORY ENVIRONMENTS.

HEDL 8602-022.8

EXPECTED - RADIATION - PRESSURE - TEMPERATURE - TIME RELATIONS IN A TUFF REPOSITORY



CORROSION ENVIRONMENTS

	PERIOD I	PERIOD II	PERIOD III
APPROXIMATE CORROSION PERIOD (YRS)	~0 TO 90	~90 TO 1,000	1,000 TO 10,000 AND BEYOND
TEMPERATURE (°C)	175-350	95-175	AMBIENT — 95
γ-FIELD (R/hr)	$5 \times 10^3 - 3 \times 10^4$	$4.0 - 5 \times 10^3$	4.0
η-FIELD (n/cm²-sec)	$9.3 \times 10^2 - 4 \times 10^3$	250-930	250
POTENTIAL CANISTER INTERNAL PRESSURE (psi)	120-135	15-120	15
ENVIRONMENT AT CLADDING SURFACE	GAS	GAS AND LIQUID H_2O	GAS AND LIQUID H_2O
RELATIVE CORROSIVITY	LEAST	MOST	MOST

HEDL 8501-227.3

CORROSION TEXT MATRIX

		PWR	BWR	OTHER*
PERIOD II	EXTERNAL SCC	P	L	L
	ELECTROCHEMICAL	P	P	L
PERIOD III	EXTERNAL SCC	P	L	L
	ELECTROCHEMICAL	P	P	L

* – ~5% OF SPENT FUEL RODS ARE CLAD WITH STAINLESS STEEL

HEDL 8502-022.1

PLANNED CORROSION EXPERIMENTS

STRESS CORROSION CRACKING

1. SCOPING EXPERIMENT
   - STRESS DEFUELED CLADDING IN PERIOD III ENVIRONMENT
   - PRODUCE BASELINE DATA USING "C-RING" SYSTEM
2. PERIOD III ENVIRONMENT
   - EXPOSE PRESSURIZED FUELED CLADDING
3. PERIOD II ENVIRONMENT
   - EXPOSE PRESSURIZED FUELED CLADDING USING AUTOCLAVE

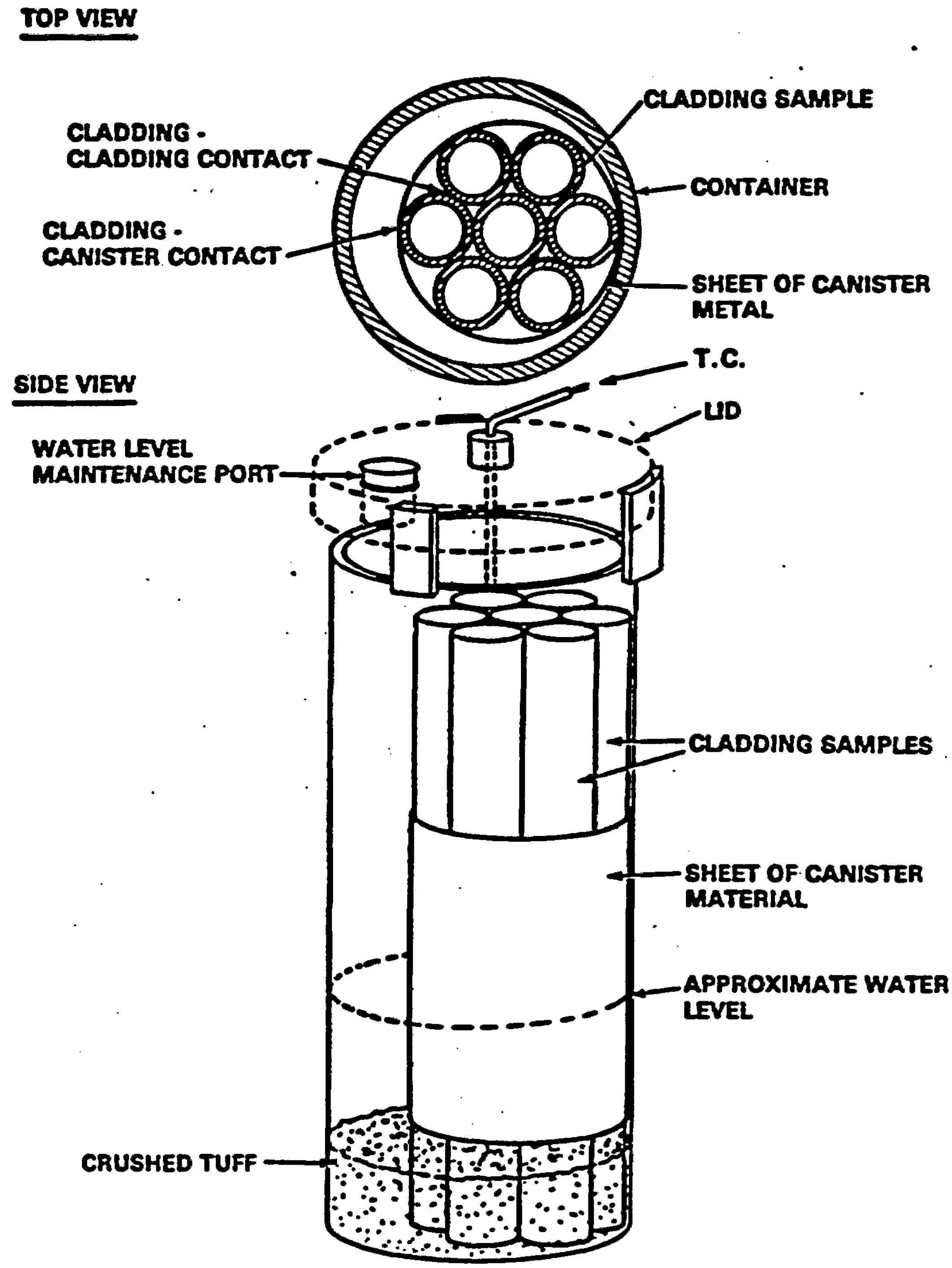
HEDL 8602-022.8

PLANNED CORROSION EXPERIMENTS

ELECTROCHEMICAL

1. SCOPING EXPERIMENT
   - EXPOSE DEFUELED CLADDING TO PERIOD III ENVIRONMENT
   - PRODUCE BASELINE DATA, REFINE TECHNIQUE
2. PERIOD III ENVIRONMENT
   - EXPOSE FUELED CLADDING
3. PERIOD II ENVIRONMENT
   - EXPOSE FUELED CLADDING USING AUTOCLAVE

CORROSION CELL (NOT TO SCALE)



HEDL 8602-022.9

ELECTROCHEMICAL CORROSION SCOPING TEST RESULTS

- 2 MO., 6 MO. TEST COMPLETE
- CHEMICAL DATA
  - pH
  - CONDUCTIVITY
  - IONIC SPECIES
- MACROSCOPIC APPEARANCE
- MICROSCOPIC ELALUATION TO DATE
  - EXPOSED MATERIAL — SEM
  - UNEXPOSED MATERIAL — SEM/STEM

  } IDENTIFY CORROSION BY COMPARISON
- CONCLUSIONS (TO DATE)
  - WITHIN THE LIMITS OF DETECTABILITY, NO CORROSION HAS BEEN OBSERVED

REQUIREMENTS

DOE/HQ:

HQ APPROVAL OF SCP BY MARCH 28, 1986

NNWSI:

PARTICIPANT INPUT AND COMMENT RESPONSE MUST FOLLOW THE SCHEDULE

INPUT MUST BE IN ACCORDANCE WITH THE WORK INSTRUCTIONS

Comment Resolution & Production - CR&P

TECHNICAL DATA AND DESIGN CHAPTERS
CONCERNS FROM INITIAL REVIEWS

- COMPLIANCE WITH THE ANNOTATED OUTLINE
- COMPLIANCE WITH THE STYLE GUIDE
- CROSS-REFERENCING: WITHIN CHAPTER
  BETWEEN TD&D CHAPTERS
  WITH CHAPTER 8 (8.3)
- MORE EXTENSIVE REFERENCING
- REFERENCES, GLOSSARY, ABBREVIATIONS
- COPYRIGHT CLEARANCES

GUIDELINES TO MEET THE SCHEDULE

- CHAPTER REVIEWS SHOULD BE DONE IN GROUPINGS
- 8.3 SUBSECTIONS SHOULD BE REVIEWED IN THEIR BEST AVAILABLE FORM WITH THE DATA/DESIGN CHAPTERS
- CHAPTER REVIEWS (INTERNAL AND HQ) SHOULD TAKE 2 TO 3 WEEKS EACH
- TOTAL DOCUMENT REVIEW (INTERNAL AND HQ TOGETHER) SHOULD TAKE 4 WEEKS

SCP SCHEDULE

CHAPTER/ SECTION	INITIAL INPUT	INTERNAL REVIEW DISTR.	INTERNAL REVIEW MTG.	CRAP 1	HQ REVIEW DISTR.	HQ REVIEW MTG.	CRAP 2
2	-	-	-	7/2 - 8/9	8/12	8/28-30	9/2 - 10/25
3	6/16	7/15	7/24-26	7/29 - 8/30	9/2	9/19-20	9/23 - 10/25
5	6/28	7/15	7/22-23	7/29 - 8/30	9/2	9/18	9/23 - 10/25
7	5/31	6/24	7/16-19	7/22 - 8/30	9/2	9/16-17	9/23 - 10/25
8.3.4	7/12	7/12	7/16-19	7/22 TO LLNL	-	-	- -
8.3.1 HYD	7/12	7/15	7/22-26	7/29 TO USGS	-	-	- -
8.4,8.7	6/28	7/15	7/25-26	7/29 - 8/30	9/2	9/18	9/23 - 10/25
0	7/26	8/12	8/19-20	8/26 - 9/20	9/23	10/8	10/14 - 12/6
6	7/19	8/12	8/21-23	8/26 - 9/20	9/23	10/10-11	10/14 - 12/6
8.1,8.2	7/19	8/12	8/19-20	8/26 - 9/20	9/23	10/9	10/14 - 12/6
8.3.2	7/29	8/12	8/21-23	8/26 TO SNL	-	-	- -
8.3.3	7/29	8/12	8/21-23	8/26 TO SNL	-	-	- -
8.6	8/6	8/12	8/21-23	8/26 - 9/20	9/23	10/8	10/14 - 12/6
1	7/12	8/26	9/9-11	9/16 - 10/18	10/21	10/29-30	11/4 - 12/6
4	7/19	8/26	9/11-13	9/16 - 10/18	10/21	10/31-1	11/4 - 12/6
8.3.1 GEO	8/2	8/26	9/9-11	9/16 TO USGS	-	-	- -
8.3.1 CHEM	8/2	8/26	9/11-13	9/16 TO LANL	-	-	- -
8.3.5	8/16	9/2	9/16-17	9/19 TO SNL	-	-	- -
8.3.1	9/23	9/26	10/3-4	10/7 TO SAIC	-	-	- -
8.3	9/23	10/14	10/23-25	10/28 - 11/22	11/25	12/4-6	12/9 - 1/10
8.5	9/26	10/14	10/22	10/28 - 11/22	11/25	12/3	12/9 - 1/10

TOTAL DOCUMENT SCHEDULE

Document Consolidation	1/13 - 1/17
HQ/Internal Reviews	1/20 - 2/7
Comment Consolidation	2/10 - 2/14
Comment Resolution	2/17 - 2/28
Production	3/3 - 3/14
HQ Approval	3/17 - 3/28

— COMMITMENTS TO SCP

DELIVERABLES:

	LAB FORECAST DATE	DROP DEAD DATE
CHAPTER __	(DATE)	(DATE) **
SECTION __	(DATE)	(DATE)
8.3.1 INDO*	(DATE)	(DATE)

MANPOWER COMMITMENTS:

1. INTERNAL REVIEWS
   - 1 OR 2 MAY BE PART OF TAG FOR OTHER INTERNAL REVIEWS
   - AUTHOR(S) + TASK LEADER AT IRC MEETINGS FOR OWN CHAPTERS
2. HQ REVIEWS - COMMENT CONSOLIDATION (AUTHORS AND/OR TASK LEADERS)

   CHAPTER __
   SECTION __ (HQ MEETING DATE)

   - ONE OR MORE MAY BE PART OF TAG FOR OTHER HQ REVIEWS
3. TOTAL DOCUMENT REVIEW 1/20 - 2/14/86
   - TASK LEADERS AND TAG OVERVIEWERS
4. COMMENT RESOLUTION FOLLOWING EACH OF THE THREE REVIEWS
   - AUTHORS + TASK LEADERS

* INFORMATION NEED DATA OUTLINE

** TIED TO SCHEDULED INTERNAL REVIEW

POTENTIAL PROBLEMS

- PARTICIPANT INPUT
- HQ CHANGES
- NRC WORKSHOPS
- EA CONFLICTS
- COMMENT RESPONSE AND PRODUCTION

Paul

PERFORMANCE OBJECTIVES SET DOWN IN 10 CFR 60 REGULATIONS

1. FOR THE FIRST 300 TO 1000 YEARS AFTER CLOSURE, CONTAINMENT OF THE RADIONUCLIDES SHALL BE SUBSTANTIALLY COMPLETE.

2. FOR THE PERIOD FOLLOWING THE CONTAINMENT PERIOD, THE RELEASE RATE OF RADIONUCLIDES FROM THE ENGINEERED BARRIER SYSTEM SHALL BE CONTROLLED SO THAT RELEASE IS LIMITED TO LESS THAN 1 PART IN 100,000 OF THE 1000 YEAR INVENTORY OF ACTIVITY PER YEAR.

ENVIRONMENTAL PROTECTION AGENCY REQUIREMENTS

RELEASE OF RADIONUCLIDES TO THE ACCESSIBLE ENVIRONMENT MUST BE LESS THAN THE LIMITS PRESCRIBED BY THE EPA. THESE ARE LISTED ON A NUCLIDE SPECIFIC BASIS, AND ARE MET AUTOMATICALLY FOR ALL NUCLIDES EXCEPT AM AND PU ISOTOPES IF RELEASE RATES ARE LESS THAN ONE PART IN 100,000 PER YEAR FROM THE ENGINEERED BARRIER SYSTEM.

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LICENSING UPDATE

JUNE 26, 1985

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LICENSING UPDATE

TOPICS

- NRC MEETINGS
  - APPROACH
  - STATUS

- PLANS AND PROCEDURES STATUS
  - IMPLEMENTATION PROCEDURES/APPENDIX 7
  - REGULATORY COMPLIANCE PLAN

- SEISMIC/TECTONIC PAPER
  - 6/20-21 MEETING
  - REVIEW PANEL

- REGULATIONS AND POSITIONS
  - 40CFR191
  - 10CFR39
  - GROUND WATER TRAVEL TIME TP

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NRC MEETINGS

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NNWSI PROJECT/NRC TECHNICAL MEETINGS

APPROACH

PROCESS

1. MEETINGS SCHEDULED 4 MONTHS IN ADVANCE

2. ONCE SCHEDULED - DATES TREATED AS FIRM NNWSI PROJECT COMMITMENT

   - RESIST NRC ATTEMPTS TO CHANGE

3. NNWSI PROJECT OBJECTIVES DEVELOPED AND SENT TO NRC

   - NRC OBJECTIVES PROVIDED TO PROJECT

4. NNWSI PROJECT PROPOSED AGENDA DEVELOPED AND SENT TO NRC

5. REFERENCES PROVIDED 4 WEEKS PRIOR TO MEETING

6. FINAL AGENDA PREPARED ACCOMMODATING:

   - DOE OBJECTIVES
   - NRC OBJECTIVES

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NNWSI PROJECT/NRC TECHNICAL MEETINGS
PRINCIPLES

- COMMITMENT BY ALL PARTIES TO SCHEDULE
- MINIMIZE "GENTLEMAN'S AGREEMENTS"
  - DOCUMENT/FORMALIZE
- OBJECTIVES INDEPENDENTLY DEVELOPED
  - EXCEPT AS AGREED TO IN MANAGEMENT MEETINGS
- NEGOTIATION/FLEXIBILITY
  - RESPONSIBLE PARTICIPANT TECHNICAL LEAD

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NNWSI PROJECT/NRC TECHNICAL MEETING STATUS

1. WASTE PACKAGE - 7/23-24

2. EXPLORATORY SHAFT DESIGN - 8/27-28

   - NNWSI OBJECTIVES - 7/1
   - AGENDA/REFERENCES - 7/12

3. ESTP - 9/17-18

   - OBJECTIVES - 7/23
   - AGENDA/REFERENCES - 8/6

4. HYDROLOGY/GEOCHEMISTRY - 9/23-26

   - NRC "LEAD"

5. PAP - 10/1-4

   - OBJECTIVES - 7/30
   - AGENDA/REFERENCES - 8/20

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OTHER

DOE/NRC MEETINGS

- NNWSI PROJECT ATTENDANCE
  - GENERIC
  - OTHER PROJECTS
- NNWSI PROJECT PARTICIPATION AND SUPPORT
  - SEISMIC/TECTONICS - 8/20-21
  - SCP ISSUE RESOLUTION STRATEGY AND DATA NEEDS - OCT/NOV (T)

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PLANS AND PROCEDURES STATUS

PLANS AND PROCEDURES

1. SITE SPECIFIC AGREEMENT PROCEDURES

TO WMPO FOR REVIEW 6/6/85

AP 1.5, NNWSI PROJECT/NRC TECHNICAL MEETINGS (SECTION 2A OF AGREEMENT)

AP 1.6, NNWSI PROJECT/NRC MANAGEMENT MEETINGS (SECTION 2B OF AGREEMENT)

AP 1.7, REPORT INVENTORY (SECTION 3A OF AGREEMENT)

AP 1.8, FIELD AND LABORATORY TESTING SCHEDULE (SECTION 3C OF AGREEMENT)

AP 1.9, DATA CATALOG (SECTION 3C OF AGREEMENT)

AP 1.10, CONTROLLING INFORMATION RELEASE (SECTION 3C OF AGREEMENT)

AP 1.11, COMMUNICATIONS WITH THE NRC (SECTION 3B OF AGREEMENT)

AP 1.12, NNWSI PROJECT INTERACTIONS WITH THE NRC-OR (SECTION 1 OF THE AGREEMENT)

APPENDIX H, NNWSI PROJECT/NRC POINTS OF CONTACT (SECTION 3B OF AGREEEMENT)

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PLANS AND PROCEDURES (continued)

2. APPENDIX 7 - (OR)

   - DOE/NRC MEETING - 6/14
   - "APPROVED" WITH SOME REVISION TO DOE PROPOSED DRAFT

3. REGULATORY COMPLIANCE PLAN

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SEISMIC/TECTONIC PAPER

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SEISMIC/TECTONIC PAPER

- ANNOTATED OUTLINE TRANSMITTED TO NRC BY DOE/HQ

- WORKING GROUP MEETING - 6/20-21

  - PREPARATION RESPONSIBILITIES AND SCOPE
  - DELPHI APPROACH
  - NEXT MEETING - 7/22-23

    1. PREPARE FOR 8/20-21 MEETING

       - DEFINITIONS
       - TECTONIC ASPECTS OF PERFORMANCE OBJECTIVES
       - ROLE OF PERFORMANCE ASSESSMENT

    2. 1ST DELPHI SESSION

- REVIEW PANEL

  - NEOTECTONICS
  - TECTONICS
  - SEISMIC RESPONSE
  - PERFORMANCE ASSESSMENT
  - REGULATORY

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REGULATIONS AND POSITIONS

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REGULATIONS AND POSITIONS

- 40CRF191
  - DRAFT 6 ISSUED (DATED 6/15/85)
    - ACRS MEETING - 6/18
  - 100 SQUARE km/5 km NEAREST APPROACH FOR CONTROLLED AREA
  - ASSURANCE REQUIREMENTS (191.14) NOW RELEGATED TO NRC FOR LICENSED FACIILTIES
  - EPA UNDER COURT ORDER TO ISSUE FINAL DRAFT RULE(?) BY AUGUST (NRDC SUIT)
- PROPOSED 10CFR39 - RADIOACTIVE MATERIALS IN WELL LOGGING
  - COMMENTS TO DOE/HQ - 6/24
  - APPLICABILITY (?)
- NRC GROUNDWATER TRAVEL TIME POSITION
  - 10CFR60.113(a)(2) - 1000 YEAR LIKELY TRAVEL TIME
  - SIGNIFICANCE OF DISTRIBUTION (EXTREMES OF DISTRIBUTION)

UNCLASSIFIED

SCIENCE APPLICATIONS
INTERNATIONAL CORPORATION
2769 S. Highland
Las Vegas, Nevada 89109

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FROM: M. GLORA

TO: J. Szymanski WMPO

TO:

TO:

TO:

TO:

TO:

TO:

TO:

NUMBER OF PAGES EXCLUDING COVER 4

DATE 6/25

Jerry
Do you have a copy of this?
May
6-20

DRAFT

Department of Energy
Washington, D.C. 20585

JUNE 11, 1985

Mr. Mel Knapp
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Knapp:

Here is a suggested replacement for the second paragraph starting immediately after the quotation from 10 CFR Part 60.

Sincerely,

Ralph Stein, Director
Engineering and Licensing Division
Office of Civilian Radioactive
Waste Management

Enclosure

M

June 10, 1985

In applying this part of the regulation, the staff recognizes that there is a number of different flow paths between the disturbed zone and the accessible environment. Consequently, there will be a statistical distibution of ground water travel times. Since it is not possible to measure these travel times, it will be necessary to estimate or calculate them using models and measured parameters.

The calculated values for the ground water travels times may be different than the actual travel times as a result of the uncertainty in our understanding of the geologic system, considerable uncertainty in measured parameters such as porosity, permeability and gradient, and the temporal variation in flow due to unusual storms, droughts, and the like. The factors are expected to cause the distribution of possible ground water travel times to span as much as several orders of magnitude.

MK/85/05/28/1

DRAFT

Mr. Ralph Stein, Director
Engineering and Licensing Division
Repository Projects Team
NE-330
Department of Energy
Washington, DC 20545

Dear Mr. Stein:

As you requested, this letter documents the licensing staff's position regarding the groundwater travel time requirement in 10 CFR Part 60.

As you know, 10 CFR Part 60.113(a)(2) reads:

> The geologic repository shall be located so that pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1000 years or such other time as may be approved or specified by the Commission.

In applying this part of the regulation, the staff considers that there is going to be a distribution of possible groundwater travel times. This distribution will result from uncertainty in our understanding of the geologic system, considerable uncertainty in measured parameters, such as porosity, permeability, and gradient, and temporal variation in flow due to unusual storms, droughts, and the like. These phenomena are expected to cause the distribution of possible groundwater travel times to span as much as several orders of magnitude.

At the upper and lower limits of this distribution, there will be possible groundwater travel times which, although theoretically possible, are unlikely paths for radionuclides travel, and are therefore inappropriate measures for characterizing the geologic setting. The NRC therefore anticipates excluding the extremes of the distribution of possible groundwater travel times in determining whether the performance objective has been met.

The staff is currently drafting a technical position consistent with the above discussion, which I anticipate will be completed later this year.

I also note 10 CFR Part 60.113(b) which permits the Commission to approve or specify other groundwater travel times on a case-by-case basis, providing the overall system performance objective has been met. This provision is intended, in part, to ensure that an otherwise excellent repository site does not fail to be licensed on a technicality.

Sincerely,

Robert E. Browning, Director
Division of Waste Management