GENERAL ELECTRIC

NUCLEAR ENERGY

PROJECTS DIVISION

GENERAL ELECTRIC COMPANY, 175 CURTNER AVE., SAN JOSE, CALIFORNIA 95125
MC 682, (408) 925-3732

MFN-188-79
RLG-100-79
July 20, 1979

U. S. Nuclear Regulatory Commission
Division of Operating Reactors
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. C. Y. Cheng
Engineering Branch

Gentlemen:

SUBJECT: INFORMATION REQUESTED ON PIPE CRACKS

Mr. Bernard Turovlin made several requests on pipe cracks during his visit to San Jose on June 21, 1979. Responses to the questions are attached.

In a subsequent telephone call to you, I have the understanding that you and Mr. Turovlin are cooperating on updating NUREG 0313. Please keep me informed of your progress. Don't hesitate to ask me or H.T. Watanabe for any additional information.

Sincerely,

H.T. Watanabe

for R. L. Gridley, Manager
Operating Plant Licensing

RLG:pes/860

Attachment

cc: Mr. Vincent Noonan, Manager
Engineering Branch
Division of Operating Reactor

Mr. Bernard Turovlin
Metallurgy Section
Division of System Safety

Mr. L. S. Gifford, GE - Bethesda

X601 S 1/1

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7908010 570 .B

ATTACHMENT

INFORMATION REQUESTED DURING
JUNE 21, 1979 MEETING

1. Provide information to allow the NRC to accept the use of 316 NG S.S.

Response:

Pertinent information is provied in: 1) R. L. Cowan's summary "Review of Plant Materials, Related Development Programs", 7/10/79 (copy enclosed) and 2) "Alternate Alloys for BWR Piping Application, Third Semi-Annual Progress Report", NEDC-23750-5. The latter report was left with Mr. Turovlin during his meeting with R. L. Cowan and N. C. Shirley on July 10, 1979.

2. Provide corrosion information of ferritic pipe.

Response:

Ferritic piping is provided by the Architect-Engineer, therefore, out of GE scope.

3. Define which joints will be solution heat treated.

Response:

This information is shown on Drawing No. 767E212 which was distributed at Progress Report Meeting No. 6 held in San Jose on April 3-4, 1979.

4. Provide more data to demonstrate acceptability of Heat Sink Welding, ECK, and IHSI.

Response:

ECK (EPR) is an NRC program (Mr. Mascara is the Program Manager). IHSI is under development and is not currently applied.

Information on heat sink welding is provided in the first report cited in Item 1.

5. Ensure NRC has the latest GE positions on Regulatory Guides addressing piping materials, e.g., RG 1.44, 1.45 and 1.46.

Response:

GE has transmitted comments on all three guides to the NRC.

6. Provide more correlation data to establish the validity of the Stress Rule Index.

Response:

To date, stress rule values have been calculated for three BWR

489 012

piping systems: Core spray line, recirculation bypass line, and recirculation systems. No failures have occurred where stress rule index was below one. Failures did occur where the stress rule index exceeded one. Also, the failure rate increases as the stress rule index increases.

Of the 4,252 welds evaluated for BWR/1, 3, and 4, there were 3,240 welds (76%) with a stress rule index exceeding one. Figure 1 shows the failure rate for these welds as a function of the stress rule index. This figure strongly supports the validity of stress rule index for evaluating IGSCC occurrences.

7. Provide justification for not making the recirculation system service sensitive.

Response:

There is not sufficient justification for reclassifying the main recirculation and recirculation-riser piping to the non-conforming, service-sensitive category. To date, there have been no recorded instances of cracking in these piping in the United States.

8. Provide recommendations for late-in-life inservice inspection requirements.

Response:

GE's recommended inspection requirements would be in accordance with NUREG 0313 and/or an alternative plan mutually and technically acceptable by the Utilities and NRC. The alternative inspection plan would be based on degree of susceptibility to cracking, carbon content, stress level, and previous service/failure history. When this plan has been firmed, GE will request a meeting with the NRC for detailed discussions.

9. Provide recommendations on avoidance of resin intrusion into the primary system.

Response:

Several BWR/4's had occurrences of resin intrusion into the primary system. In 1976, GE issued Service Information Letter (SIL) No. 159, copy enclosed, which included recommended actions. Resin intrusion has not been a problem since the issuance of the SIL.

10. Provide reference material on O_2 control.

Response:

A copy of "BWR Coolant Oxygen Control", NEDO-23631, June 1977 is enclosed.

RLG:pes/861-862

Enclosures

489 013

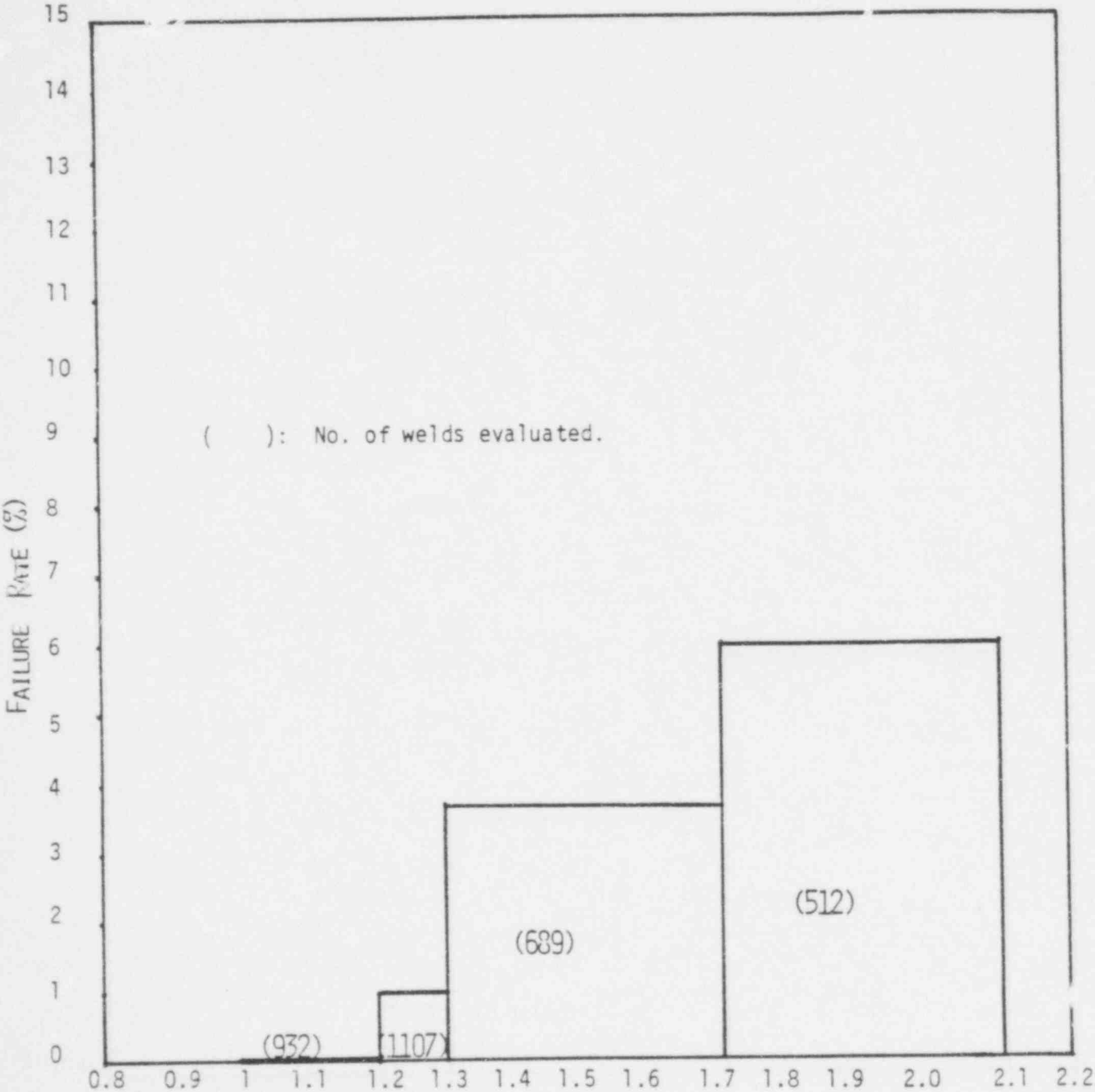


Figure 1. Stress Rule Index (per new Residual Stress)

JHL 5/79

489 014

GENERAL ELECTRIC COMPANY

NUCLEAR TECHNOLOGY DEPARTMENT

REVIEW OF PLANT MATERIALS RELATED DEVELOPMENT PROGRAMS

7/10/79

R.L.COWAN

489 015

PLANT MATERIALS DEVELOPMENT PROGRAMS

- EVALUATION OF STRESS CORROSION CRACKING OF BWR MATERIALS.
  - FUNDAMENTAL UNDERSTANDING
  - PARAMETRIC STUDIES
  - SHORT TERM REMEDIES
  - ALTERNATE MATERIALS
  - IMPROVEMENTS APPLICABLE TO OPERATING PLANTS
- EFFECT OF ENVIRONMENT ON FATIGUE PROPERTIES.
  - LOW AND HIGH CYCLE
  - INITIATION AND PROPAGATION
- WEAR RESISTANT ALLOYS WITH LOW COBALT.
- WELDING TECHNIQUES.
- NON DESTRUCTIVE TEST TECHNIQUES.

> - FOCUS ON INCREASED AVAILABILITY
> - COMPREHENSIVE
> - UTILITY COOPERATION EXCELLENT

489 016

7/10/79

R.L.COWAN

OUTSIDE FUNDED PROGRAMS IN

PLANT MATERIALS AREA

NRC
- ELECTROCHEMICAL METHOD FOR DETECTION OF DEGREE OF SENSITIZATION IN STAINLESS STEEL.

EPRI
- PARAMETRIC PIPING STUDIES OF STAINLESS
- QUALIFICATION OF NEAR TERM PIPING REMEDIES
- ALTERNATE PIPING MATERIAL QUALIFICATION PROGRAM
- CARBON STEEL FATIGUE
- LARGE DIAMETER PIPE SCC MARGIN
- PIPING RESIDUAL STRESS IMPROVEMENT

DOE (AS SUBCONTRACTOR)

- ALTERNATE BWR WATER CHEMISTRY

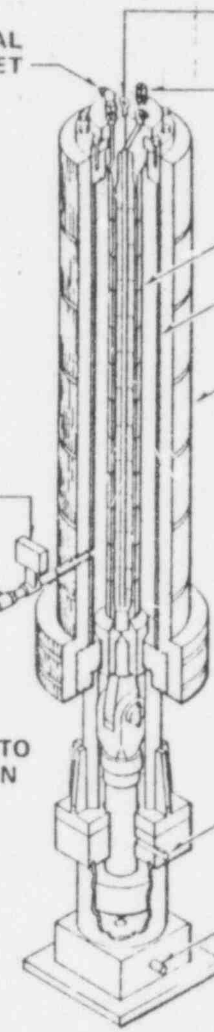
> - HELPS FOCUS DEVELOPMENT WORK ON COMMON OBJECTIVES
> - ACCELERATES APPLICATION

489 017

7/10/79

R.L.COWAN

4 in. VERTICAL PIPE TEST STAND



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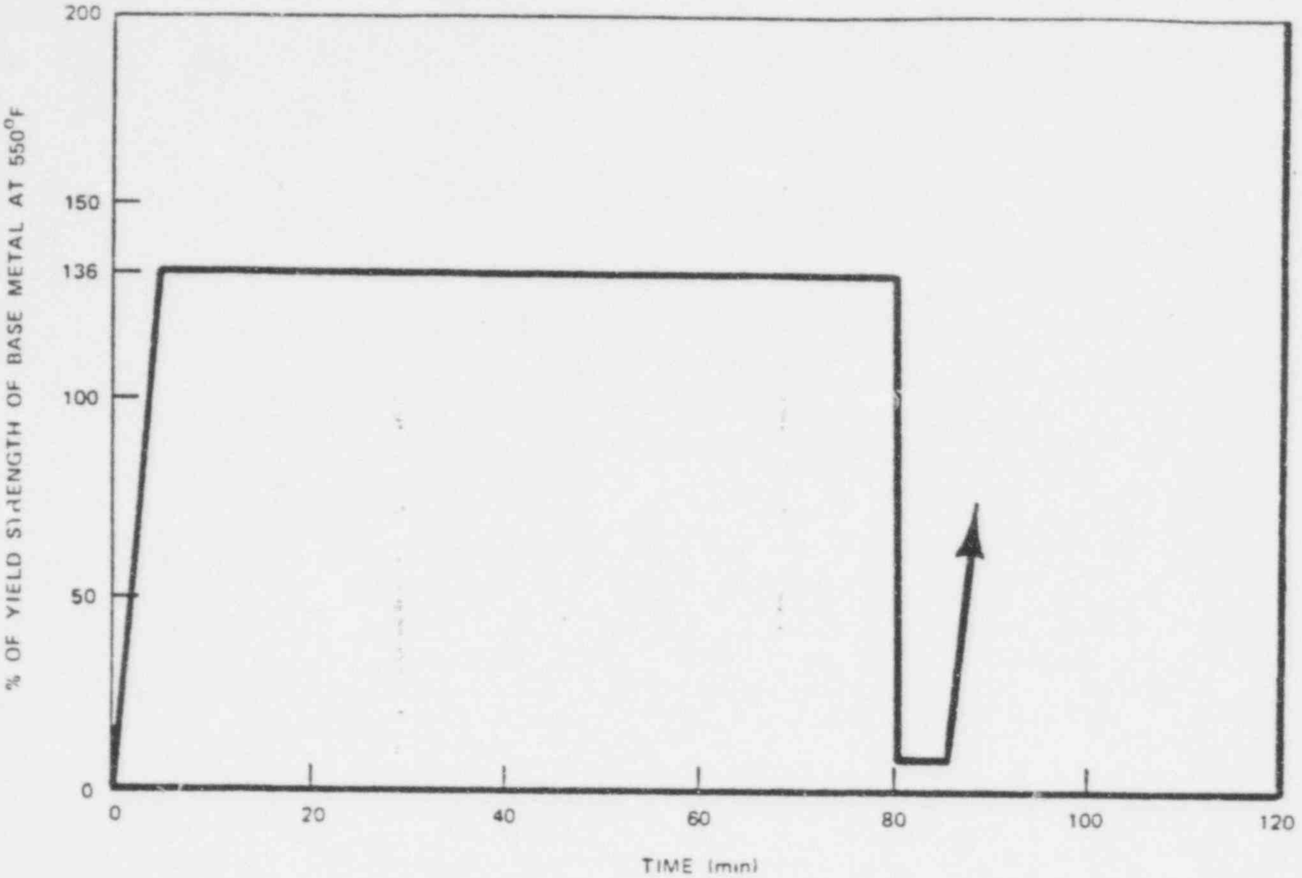


COOLANT DESCRIPTION		
	OXYGEN	6 ± 2 ppm
	TEMPERATURE	540 + 10°F (282°C ± 5°C)
	ph	5.5 ± .0.5
LOADING MODE:		
	AXIAL	136% OF σ_{ys} AT 550°F (288°C)
	PRESSURE	$pr/2t$ ~ ? ksi

QUALIFICATION OF ALTERNATE ALLOY FOR BWR WELDED PIPING

PROGRAM OBJECTIVE

SELECT, QUALIFY, AND IMPLEMENT INTO BWR SERVICE ALTERNATE ALLOYS FOR TYPE-304 STAINLESS STEEL WHICH WILL NOT EXPERIENCE INTERGRANULAR STRESS CORROSION CRACKING WITHIN THE PLANT DESIGN LIFETIME.

METHOD OF ACCOMPLISHMENT:

1. SCREENING STUDIES AND SELECTION.

   - CHOOSE CANDIDATE ALTERNATE ALLOYS AND PERFORM SCREENING STUDIES.
   - SELECT ALTERNATE ALLOYS FOR QUALIFICATION USING DECISION MODEL.

2. QUALIFICATION.

   - PERFORM STRINGENT TESTS TO DEFINE IGSCC MARGIN OF SELECTED ALTERNATE ALLOYS.
   - PERFORM IN-DEPTH PHYSICAL AND METALLURGICAL CHARACTERIZATION OF ALTERNATE ALLOY PIPING OF VARIOUS SIZES AND MANUFACTURING METHODS.

3. IMPLEMENTATION INTO BWR SERVICE.

   - PROVIDE NUCLEAR GRADE MATERIAL SPECIFICATIONS.
   - QUALIFY MATERIAL SUPPLIERS.
   - ASSURE CODE AND REGULATORY ACCEPTANCE.

CANDIDATE ALTERNATE ALLOYS

304L/NUCLEAR GRADE

316

316L/NUCLEAR GRADE

347

CF-3

XM-19

489 022

SCREENING STUDIES

- PIPE TESTING
- FATIGUE INITIATION TESTING
- STATIC CRACK GROWTH
- CYCLIC CRACK GROWTH
- CONSTANT EXTENSION RATE

FINAL PIPE TEST RESULTS – SCREENING

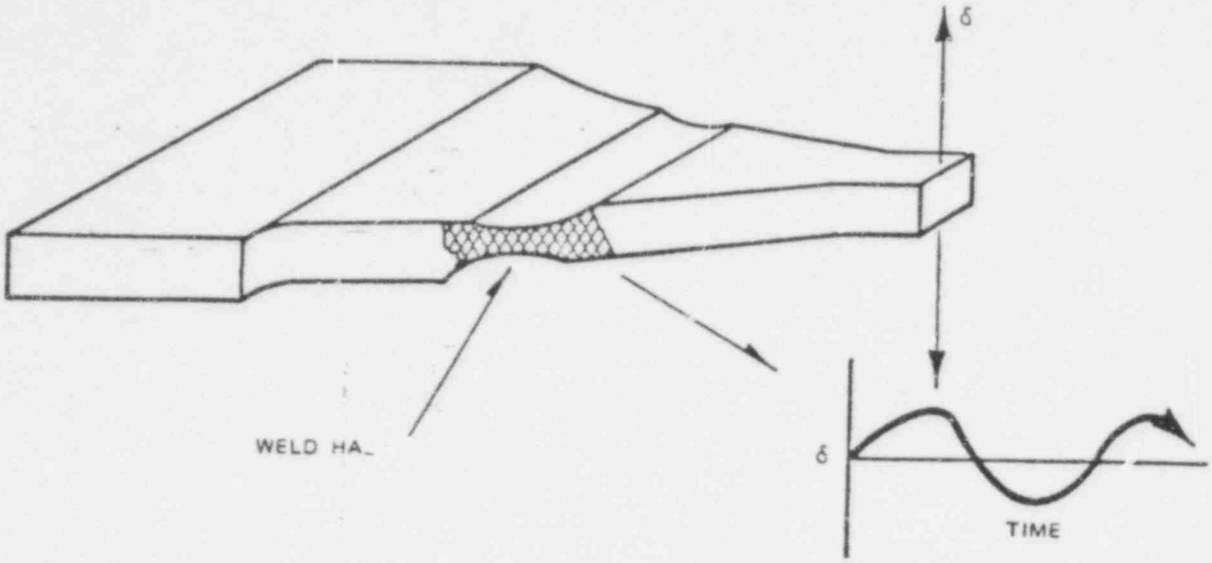
ALLOY	PIPES TESTED	PIPES FAILED BY IGSCC	MAXIMUM HOURS ACCUMULATED	FACTOR OF IGSCC IMPROVEMENT
REFERENCE TYPE 304	19	14	7800*	1
REFERENCE TYPE 316L/ NUCLEAR GRADE	11	0**	8500	>20
REFERENCE TYPE 304L/ NUCLEAR GRADE	9	0	7800	>20
REFERENCE TYPE 347	8	0***	6900	>20
REFERENCE TYPE 316	3	0	1900	>20
REFERENCE TYPE CF-3	8	0	7400	>20

*MEAN TIME TO FAILURE FOR REFERENCE TYPE 304 WITH 0.05 TO 0.08% CARBON = 239 HOURS.

**TWO PIPES FAILED BY TRANSGRANULAR MODE WITH MINOR AMOUNT OF INTERGRANULAR FEATURES.

***ONE PIPE FAILED BY TRANSGRANULAR MODE WITH MINOR AMOUNT OF INTERGRANULAR FEATURES.

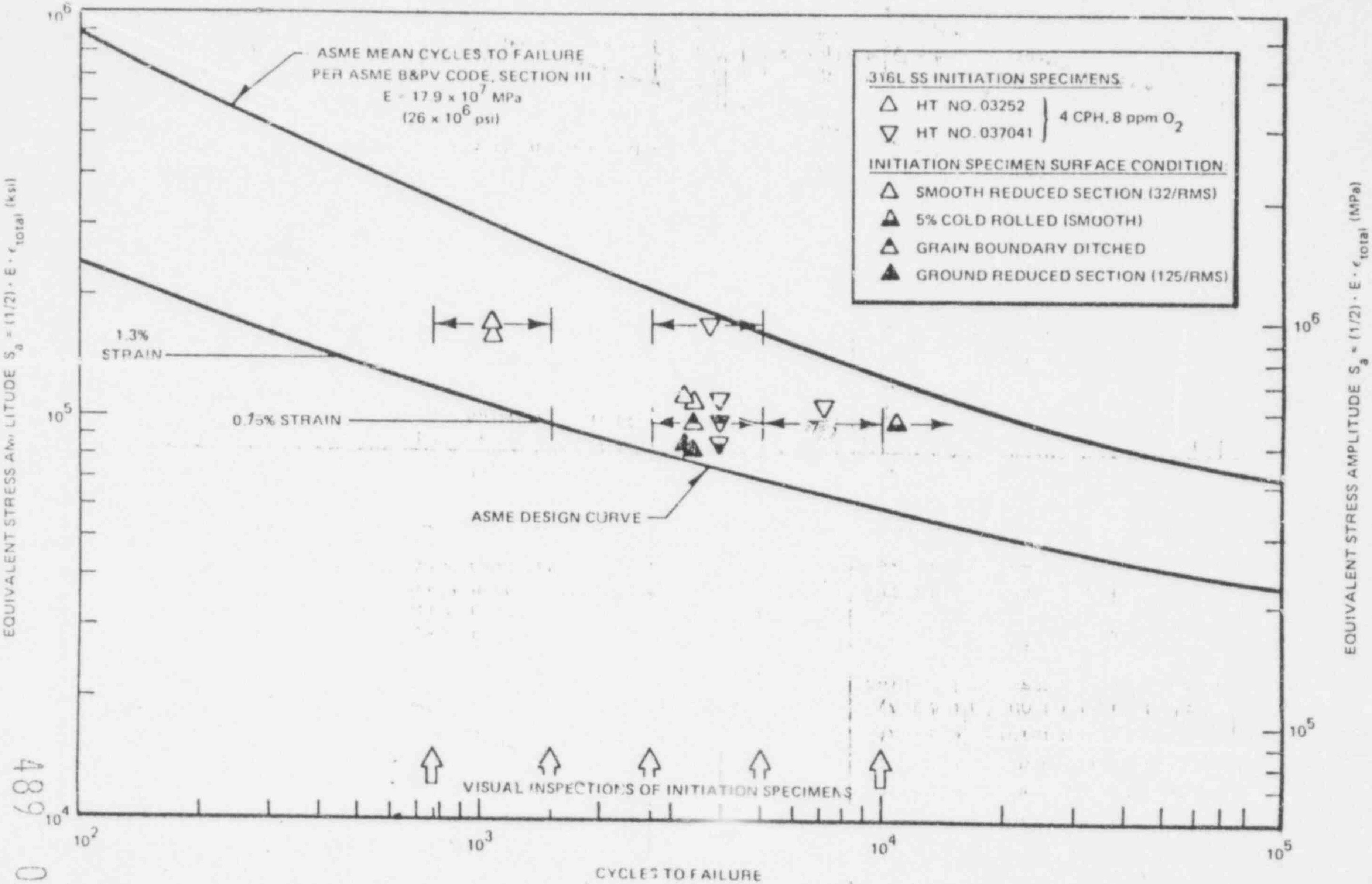
FATIGUE INITIATION TESTING



- SMOOTH (3/4%, 1-1/4% STRAIN)
- INTERGRANULAR ATTACK, COLD WORKED, AND WELDED
- ALL SAMPLES HAVE 932°F/24 hr LOW TEMPERATURE SENSITIZATION AFTER WELDING

ALLOY	COMPOSITION RANGE	NO. OF HEATS
316	0.06%C	1
316 (L	0.020 - 0.030%C	2
304 (L	0.018 - 0.027%C	2
347	0.023 - 0.038%C	2
XM-19	0.05%C	1
CF-3	10% α TO 25% α	2
REFERENCE 304	COMPLETE IN PREVIOUS PROGRAM	
SAMPLES ON TEST JUNE 1978		

489 026


ASME MEAN CYCLES TO FAILURE
PER ASME B&PV CODE, SECTION III
E = 17.9 x 10^7 MPa
(26 x 10^6 psi)
316L SS INITIATION SPECIMENS:
HT NO. 03252
HT NO. 037041
4 CPH, 8 ppm O2
INITIATION SPECIMEN SURFACE CONDITION:
SMOOTH REDUCED SECTION (32/RMS)
5% COLD ROLLED (SMOOTH)
GRAIN BOUNDARY DITCHED
GROUND REDUCED SECTION (125/RMS)
1.3% STRAIN
0.75% STRAIN
ASME DESIGN CURVE
VISUAL INSPECTIONS OF INITIATION SPECIMENS
EQUIVALENT STRESS AMPLITUDE Sa = (1/2) · E · ε total (ksi)
EQUIVALENT STRESS AMPLITUDE Sa = (1/2) · E · ε total (MPa)
CYCLES TO FAILURE
10^2
10^3
10^4
10^5
10^6

489 027

SELECTION OF ALTERNATE ALLOYS FOR QUALIFICATION

TYPE-316 NUCLEAR GRADE

TYPE-304 NUCLEAR GRADE

CARBON $\leq$0.020%
NITROGEN* 0.06 – 0.16%

*NITROGEN CURRENTLY RESTRICTED TO $\leq$0.10% BY ASME SA-240.

SUMMARY

- ALL CANDIDATE ALTERNATE ALLOYS EVALUATED (EXCEPT HIGH CARBON TYPE-316) WOULD BE MORE THAN ADEQUATE REPLACEMENTS FOR TYPE-304 STAINLESS STEEL, BASED SOLEY ON IGSCC RESISTANCE.

- CONSIDERING ADVANTAGES AND DISADVANTAGES OF EACH CANDIDATE ALLOY, AS DEFINED AND WEIGHTED BY THE DECISION ANALYSIS, TYPE-316 NUCLEAR GRADE WAS SELECTED AS THE BEST BALANCED CHOICE TO REPLACE TYPE-304 IN THE BWR.

COUNTERMEASURES FOR 304 SS

PROGRAM STATUS AS OF 6/79

MATERIALS CONDITION	NO. HEATS	WELDS FAILED/ WELDS TESTED	FACTOR OF IMPROVEMENT*
REFERENCE TYPE 304 SS (ALL HEATS)	3	23/53	1
CORROSION RESISTANT CLAD PLUS SOLUTION HEAT TREATMENT (SHOP REMEDY)	3	0/33	~65
CORROSION RESISTANT CLAD AS DEPOSITED (FIELD REMEDY)	2	0/22	~6
REFERENCE TYPE 304 SS SENSITIZED MATERIAL	1	4/11	1
CORROSION RESISTANT CLAD DEPOSITED ON SENSITIZED MATERIAL	1	4/13	~6

*TO DATE

489 030

COUNTERMEASURES FOR 304 SS

PROGRAM STATUS AS OF 6/79

MATERIALS CONDITION	NO. HEATS	WELDS FAILED/ WELDS TESTED	FACTOR OF IMPROVEMENT*
REFERENCE TYPE 304 SS (ALL HEATS)	3	23/53	1
SOLUTION HEAT TREATMENT	3	0/33	~ 65
HEAT SINK WELDING	1	2/24	~ 15

*TO DATE

- RECOMMENDED COUNTERMEASURES ARE EFFECTIVE
- GENERIC RECIRCULATION PIPING RECOMMENDATION MADE TO ALL BWR PROJ...

489 031

EQUATION USED FOR FACTOR OF IMPROVEMENT CALCULATIONS

$$\text{LOG TEST TIME} = F + G + \sigma\left[-Q + U(1/n + r)^{1/2}\right]$$

WHERE: F = MEAN LOG TIME TO FAILURE OF REFERENCE WELDS

G = LOG OF DESIRED IMPROVEMENT FACTOR

σ = STANDARD DEVIATION OF LOG TIMES TO FAILURE OF REFERENCE WELDS

Q = FACTOR ON σ FOR EXPECTED LOCATION OF FIRST ORDER STATISTIC (Q = 1.5864 FOR n OF 11)

U = NORMAL DISTRIBUTION COEFFICIENT FOR 90% ONE-SIDED LIMIT (U = 1.282)

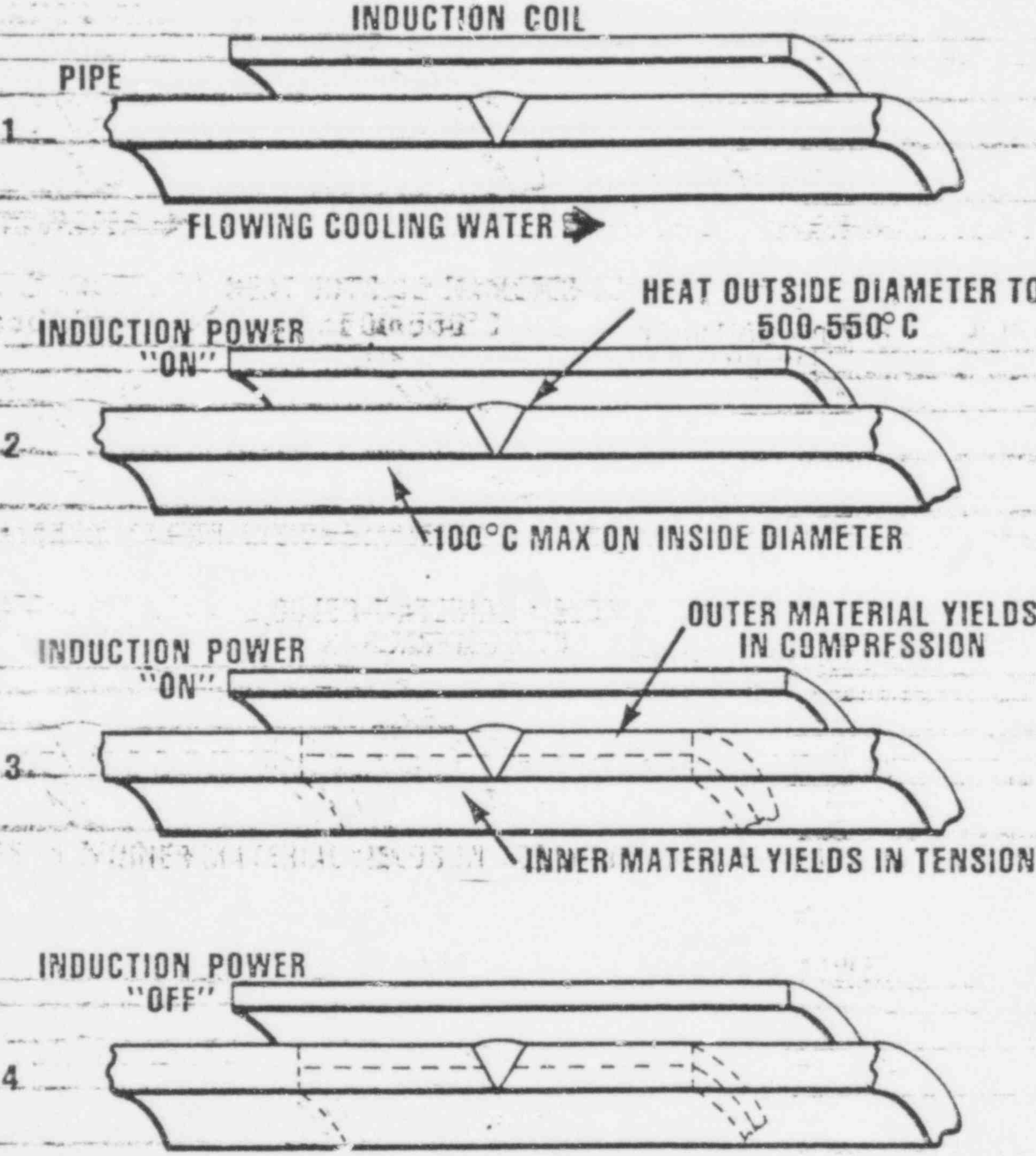
n = NUMBER OF TEST WELDS PER CONCEPT (n = 11)

r = FACTOR ON σ^2 FOR VARIANCE OF FIRST ORDER STATISTIC (r = 0.3332) FOR n = 11)

489 032

POOR ORIGINAL

INDUCTION HEATING (RSI) PROCESS



AFTER COOLDOWN
COMPRESSIVE RESIDUAL STRESS ON INSIDE,
TENSILE RESIDUAL STRESS ON OUTSIDE.

489 033

POOR ORIGINAL

Program Summary

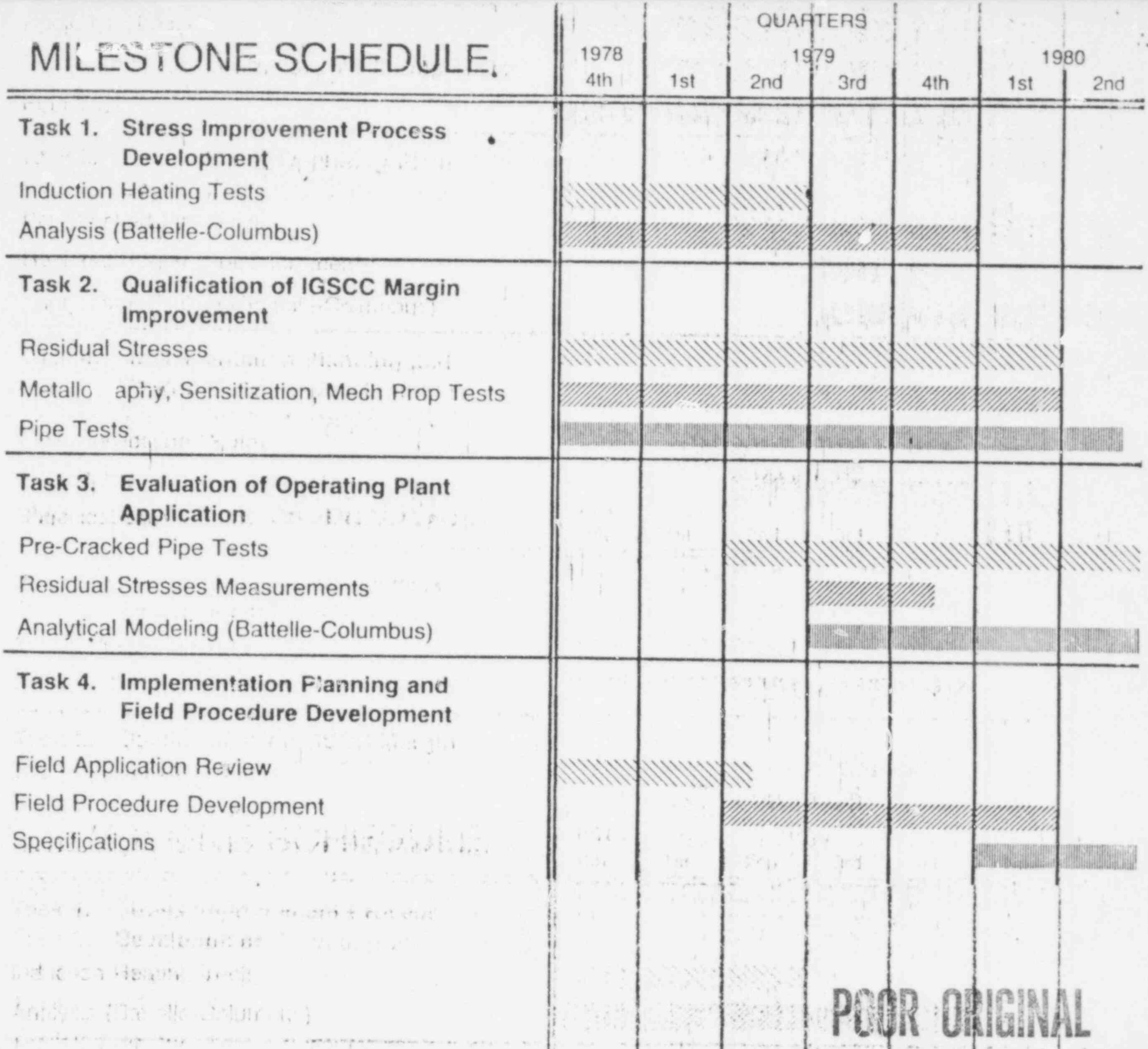
TASK 1 **Process Development and Optimization**

TASK 2 **Evaluation of IGSCC Margin Improvement**

TASK 3 **Evaluation of Operating Plant Application**

TASK 4 **Implementation Planning and Field Procedure Development**

MILESTONE SCHEDULE



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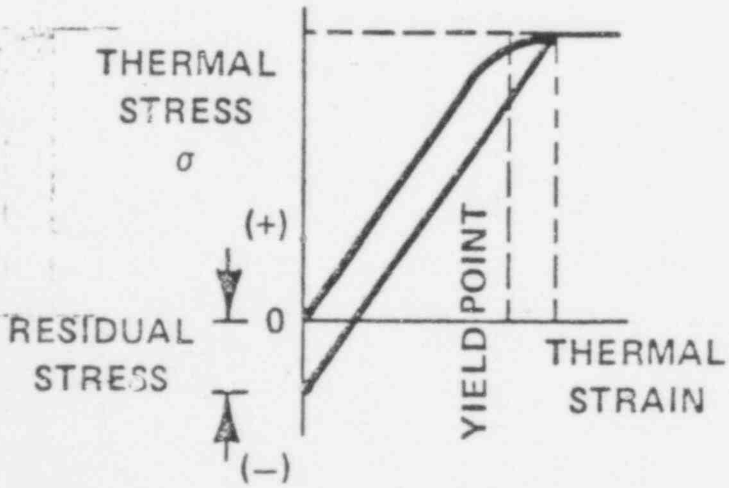
BASIS FOR SELECTION OF TEMPERATURE DIFFERENTIAL BETWEEN OUTER AND INNER PIPE SURFACES (ΔT)

PREMISE: THE THERMAL STRESS MUST EXCEED YIELD STRESS

THERMAL STRESS (σ) – LINEAR GRADIENT •

$$\sigma = \frac{E\,\alpha \cdot \Delta T}{2\,(1 - \nu)}$$

E – YOUNGS MODULUS
α – THERMAL EXPANSION COEFFICIENT
ν – POISSONS RATIO
ΔT – TEMPERATURE DIFFERENCE



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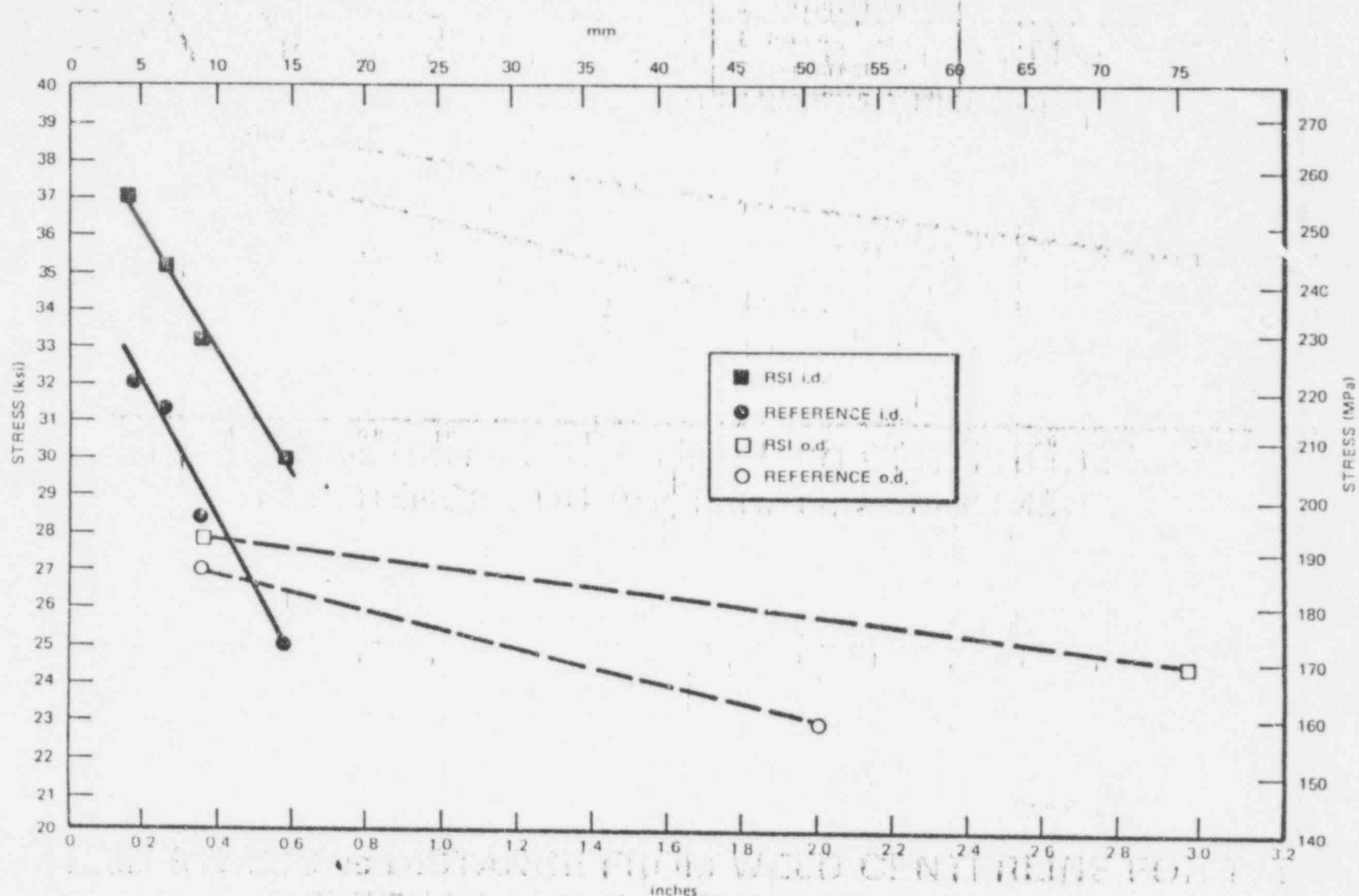
OPTIMIZATION TEST RESULTS

SELECTED RSI PARAMETERS

	PIPE SIZE AND SCHEDULE			
	4 in. PIPE	10 in. PIPE	16 in. PIPE	26 in. PIPE
ΔT	400°C ± 50°	400°C ± 50°	400°C ± 50°	400°C ± 50°
MAX o.d. TEMP	500°C +50° −0°	500°C	500°C	500°C
AXIAL TEMP LENGTH	3 in.	4 in.	6 in.	10 in.
TIME TO REACH TEMP	< 13 sec	< 40 sec	< 80 sec	< 200 sec
INDUCT FREQUENCY	3 kHz	3 kHz	3 kHz	3 kHz
COIL DESIGN*	SINGLE TURN	SINGLE TURN	SINGLE TURN	SINGLE TURN
i.d. WATER FLOW	1/2 m/s	1/2 m/s	1/2 m/s	1/2 m/s
COIL AXIAL LENGTH	4 in.	6 in.	10 in.	14 in.
HEATING POWER	120 kW	250 kW	370 kW	390 kW
PRE-HEAT MAX TEMP	< 200°C	< 200°C	< 200°C	< 200°C

* ALTHOUGH SINGLE TURN COILS ARE SPECIFIED FOR UNIFORMITY IN TEST SPECIMEN TREATMENT, THERE IS NO RESTRICTION IN THE USE OF MULTI-TURN COILS IN PRACTICE

YIELD STRESS vs DISTANCE FROM WELD CENTERLINE FOR THE REFERENCE AND RSI-TREATED SPECIMEN



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PIPE TESTING

- SIMULATE SERVICE EXPOSURE
- ESTABLISH TIME TO FIRST FAILURE FOR TREATED AND REFERENCE PIPES
- ESTABLISH MARGIN OF IMPROVEMENT

489 039

FABRICATION VARIABLES

- LOW TEMPERATURE SENSITIZATION
- INSIDE DIAMETER GRINDING
- RESIDUAL STRESS IMPROVEMENT TREATMENT

PROGRESS

PIPE TESTING, REFERENCE SPECIMEN

- TEST CONDITIONS:

  STRESS, 136% OF 288°C Y.S.
  OXYGEN, 8 PPM.
  TEMPERATURE, 288°C.
  CYCLIC RATE, 0.67 CPH.

- FIRST REFERENCE FAILURE (THROUGHWALL CRACK) AFTER 456 CYCLES AT JOINT E.
- VISUAL AND U.T. EXAMINATION PERFORMED: ALL JOINTS EXCEPT HSW SHOWED SOME DEGREE OF CRACKING.
- SPECIMEN REPAIRED AND TESTING RESUMED. SECOND FAILURE (THROUGHWALL CRACK) 14 CYCLES AFTER TEST RESUMPTION (470 CYCLES TOTAL).
- TESTING OF REFERENCE DISCONTINUED AFTER SECOND FAILURE.
- FRACTURE MODE ON BOTH JOINTS, IGSCC.

489 041

PROGRESS

PIPE TESTING, INDUCTION-TREATED SPECIMEN

- FIVE OUT OF SIX JOINTS HAVE ACCUMULATED OVER 2300 CYCLES (>6X REFERENCE).
- ONE FAILURE (THROUGHWALL CRACKING) AFTER 463 CYCLES AT JOINT B.
- NDE EXAMINATION INDICATED NO CRACKING EXCEPT FOR JOINT B.
- FRACTURE MODE ON JOINT B, IGSCC.
- SPECIMEN REPAIRED AND RETURNED TO TEST. NO ADDITIONAL FAILURES TO DATE.

PARAMETRIC STUDIES ON IGSCC OF TYPE-304 STAINLESS STEEL PIPE WELDS

PURPOSE: TO DETERMINE THE EFFECT OF PIPE TEST PARAMETERS AND WELDING RESIDUAL STRESSES ON PIPE TEST RESULTS.

METHOD: PIPE TESTS WILL BE CONDUCTED WITH VARIATIONS OF TEST PARAMETERS AND RESIDUAL STRESSES. RESULTS WILL BE COMPARED TO REFERENCE SPECIMENS TESTED UNDER THE ACCELERATED CONDITIONS NORMALLY SPECIFIED FOR PIPE TESTING.

TASK ORGANIZATION

TASK 1 EFFECT OF APPLIED STRESS, OXYGEN CONCENTRATION, CYCLIC RATE AND TEMPERATURE ON PIPE TEST RESULTS.

TASK 2 EFFECT OF WELDING RESIDUAL STRESSES ON PIPE TEST RESULTS.

TEST SPECIMEN DESCRIPTION

TASK 1
- TEN PIPE SPECIMENS FOR TESTING IN A THREE-YEAR PERIOD.
- EACH STAINLESS-STEEL PIPE WILL HAVE TEN WELD JOINTS.
- ALL JOINTS WILL BE GROUND.
- ALL PIPES FROM ONE SUSCEPTIBLE HEAT OF MATERIAL.

TASK 2
- ONE PIPE SPECIMEN WITH SIX WELDS FOR TESTING IN 1979.
- ONE WELDED SPECIMEN FOR RESIDUAL STRESS MEASUREMENTS.
- BOTH SPECIMEN FROM SAME HEAT OF MATERIAL AS TASK 1.
- NO GRINDING OR LTS WILL BE PERFORMED.
- TESTS ON ONE REFERENCE AND ONE INDUCTION-TREATED PIPE WERE INITIATED IN 1978.

489 044

PROGRAM:

THE GROWTH AND STABILITY OF STRESS CORROSION CRACKS IN LARGE-DIAMETER BWR PIPING - RP 1554-1

SPECIFIC OBJECTIVES:

1. DEVELOP A QUANTITATIVE UNDERSTANDING OF THE SAFETY MARGIN ASSOCIATED WITH PIPES CONTAINING CRACKS UNDER STATIC AND DYNAMIC LOADS.

2. DEVELOP A DETAILED QUANTITATIVE UNDERSTANDING OF FACTORS CONTROLLING THE RATE OF IGSCC IN LARGE-DIAMETER 304 STAINLESS STEEL PIPING.

3. DEVELOP AN OVERALL PREDICTIVE MODEL FOR THE GROWTH AND STABILITY OF CRACKS IN LARGE-DIAMETER BWR PIPING.

TASK 2: CRACK GROWTH/ARREST EVALUATION

SUBTASKS:

1. Fracture Mechanics Modeling
2. Evaluation of Crack Arrest due to Residual Stresses
3. Investigation of Crack Arrest in Weld-Metal
4. Evaluation of Crack Growth Rates Expected for Service Conditions
5. Confirmatory Pipe Tests

ALLOY 600 STUDIES TEST PROGRAM

489 047

SPECIMEN METALLURGY

ALLOY 600 BASE (WITH ALLOY 82-GTAW AND ALLOY 182-(SMAW) AND ALLOY 82 AND 182 WELD METAL

- A W
- A W + P W V H T
- A W + P W V H T + L T S
- A W + L T S

ALLOY 600 BASE METAL

HEAT TREATMENT BEFORE WELDING

- P W V H T + W
- P W V H T + W + L T S

TEST CONDITIONS

GENERAL WATER CHEMISTRY:

288 C (550 F), 6 PPM O_2, 5.5 PH, 1 µMHO/CM COND., CL^- <.1 PPM

CONSTANT LOAD	(2) CREVICED
	(2) NON-CREVICED
CONSTANT EXTENSION RATE	
D O S* TEST	(1) MODIFIED
ASTM G28-72	(1) UNMODIFIED
MECHANICAL PROPERTIES IN 288 C (550 F) AIR	(2)

MECHANICAL PROPERTIES 288 C (550 F) ALSO OF AS RECEIVED AND OF HEAT TREATED BUT NON-WELDED ALLOY 600 BASE MATERIAL

*DEGREE OF SENSITIZATION

IMPROVED CONTROL OF POWDERED RESINS FOR REACTOR WATER CLEANUP FILTER DEMINERALIZERS

As a result of several occurrences at BWR operating plants in which powdered resins from the Reactor Water Clean-Up (RWCU) Filter Demineralizers (F/D) have been introduced into the reactor pressure vessel, General Electric has examined the circumstances which led to the resin carry over.

It was determined that to reduce the probability of recurrence BWR owner-operators should undertake corrective action at their earliest possible convenience. The purpose of this Service Information Letter is to define the conditions causing the problem and to present the corrective action recommendations.

DISCUSSION

During certain modes of reactor water cleanup operation, it is possible for the powdered resins to be accidentally injected into the reactor pressure vessel (RPV) forcing startup delays until reactor water chemistry can be re-established within limits. These modes include:

A. Loss of flow from the Cleanup Recirculation Pumps (CRP) with the bypass line open resulting in a siphon effect which can carry resins into the bypass line where they can later be injected into the RPV.

B. At most BWR operating plants, low flow through the Filter/Demineralizer (F/D) starts the holding pump and opens the flow control valve further to maintain preset treated water flow. If this occurs with the F/D bypass valve open and water is draining to the hotwell or radwaste, loss of the CRPs will result in emptying the top of the F/D vessel, which, in turn, results in loss of suction at the holding pump. The consequence of these events is the siphoning of water and resin from the F/D into the bypass line where restart of the CRPs will inject resin into the RPV.

C. Radical flow transients in the RWCU F/D system caused by the loss of CRPs and/or the sudden opening and closing of valves. With a sudden loss of flow to the F/D vessel, there is inadequate time for the holding pumps to get to rated speed and maintain the precoat on the elements.

D. Loss of power to RWCU F/D System closes all inlet and effluent valves and prevents the holding pump from running unless the latter is on emergency circuit. With restoration of power, even with inlet and outlet valves closed, the holding pump will start recirculating the sludge (insoluble material from filtering action and resin). The sludge is dropped from the elements, due to no-flow condition upon, into, and around the elements and holding pump circuit.

E. Sudden flow surges when placing a newly precoated F/D vessel on line will tend to cause migration of the resin particles through the filter elements.

RECOMMENDED ACTION

General Electric recommends implementation of the following modifications at the earliest convenient outage:

1. Install a "Y" strainer in the normal influent line, up-stream of the F/D vessel and influent valves. The strainer should have 75 micron slots and be installed in the reverse direction. This should prevent gross amounts of resins coming down with siphon water from entering by bypass line. A differential pressure indicator (DPI) would be required to indicate when the strainer screen is clogging due to particulate material from the RPV.

   In certain cases, a swing check valve may be used in place of a "Y" strainer. The special conditions necessary for use of a check valve are:

   a) the valve must have resilient seats

   b) a vertical head minimum of 25 feet of water must be above the check valve

   c) the valve must be mounted in a vertical line

2. Modify the Filter/Demineralizer low flow isolation logic to isolate the F/D by closing the air operated influent and flow control valve when flow through the vessel circuit drops below approximately 40 percent of the preset flow value on the first F/D and 25 percent on the second. This modification should prevent the events described in item B in the discussion from occurring.

3. It should be noted that all F/D vessel circuits have a "low flow" annuciator which shares an initiation signal with the holding pump. The set point for all plants should be 75 percent of normal F/D vessel flow. In addition, logic should be added to automatically transfer the cleanup F/D vessel into a backwash mode if the time interval between low flow annunciation and F/D system isolation is less than 15 seconds. It is not necessary to annunciate holding pump operation or non-operation since system isolation will occur before the cake is lost even if the holding pump circuit fails.

4. Install speed controls on the main stream valves to avoid shocking the in-place precoat by limiting the inrush of water into the F/Ds. The time for opening or closing the main stream valves should be approximately 30 seconds. Many BWR plants, especially those where these valves were supplied by General Electric, have this feature.

5. Install power failure logic in the electrical circuitry which will prevent the operation of the hold pump or filter circuitry until the F/D units are backwashed. Without this logic, the hold pump will begin circulating sludge through partially precoated filters upon restoration of power which can lead to element plugging as well as a poor filter cake.

It should be noted that due to differences in type and configuration of some BWR equipment, the generic changes recommended above need to be evaluated for specific plant applicability. General Electric will be pleased to quote engineering assistance to ascertain and implement the specific changes applicable to your plant. Please contact your local General Electric service representative for such assistance.

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BWR COOLANT OXYGEN CONTROL

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