Calvert Cliffs Nuclear Power Plant
Administrative Procedure

EROSION/CORROSION MONITORING OF SECONDARY PIPING

MN-3-111

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Writer: T. Denson

Sponsor: P.G. Chabot, Superintendent - Technical Support

Approved ______________________ 8/19/94
Superintendent - Technical Support   Date

9512210281 951215
PDR ADOCK 05000317
P PDR

RECORD OF REVISIONS AND CHANGES

Revision	Change	Summary of Revision or Change
0	0	Initial issue. Replaces ME&A IP 5.05, Erosion/Corrosion Monitoring Program. Meets the requirements of NRC Generic Letter 89-08, Erosion/Corrosion Induced Pipe Wall Thinning, requiring the establishment of a secondary piping erosion/corrosion monitoring program. Reflects changes in organizational responsibility for Erosion/Corrosion Monitoring.

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1.0 INTRODUCTION

1.1 Purpose

To ensure nuclear and personnel safety by early identification and prevention of secondary system pipe wall thinning caused by flow accelerated corrosion, cavitation, or erosion that could lead to ruptures in high energy piping by:

- Identifying secondary piping systems with potential for wall thinning resulting from flow accelerated corrosion, cavitation, or erosion;
- Quantifying the extent of any wall thinning;
- Establishing a systematic approach for assessing pressure boundary deterioration, and
- Recommending corrective actions. **[B-1] [B-2]**

1.2 Scope/Applicability

This procedure is applicable to all Calvert Cliffs Nuclear Power Plant and contractor personnel who are involved with:

- Selection of secondary piping locations to be inspected for wall thinning
- Performance of that inspection
- Evaluation of the results

This procedure is applicable to secondary piping systems at Calvert Cliffs Nuclear Power Plant.

2.0 REFERENCES

2.1 Developmental References

A. EPRI NP-3944, Erosion/Corrosion in Nuclear Plant Steam Piping: Causes and Inspection Program Guidelines, April 1985

B. NRC Generic Letter 89-08, Erosion/Corrosion Induced Pipe Wall Thinning

C. MN-3, Pressure Boundary Codes and Special Processes Program

2.2 Performance References

A. MN-3, Pressure Boundary Codes and Special Processes

B. MN-3-101, Nondestructive Examination

C. MN-3-104, Program MN-3 Procedures and Personnel Qualification

D. PR-3-100, Records Management

E. QL-2-100, Issue Reporting and Assessment

2.2 Performance References (Continued)

F. CCI-142, Outage Management

G. M-601, Piping Class Summary

3.0 DEFINITIONS

A. **Control Parameters**

Secondary side parameters known to control the Erosion/Corrosion rate.

B. **Erosion/Corrosion Inspection Point**

Locations that have been identified to have a significant potential for wall thinning due to flow accelerated corrosion, cavitation or erosion and, therefore, require periodic wall thickness measurements. An inspection point can include one or more components.

C. **Erosion/Corrosion Inspection Point List**

List of all active inspection points.

D. **Grid Points**

Intersection of grid lines marked on components to be inspected for pipe wall thinning.

E. **Red Alert**

Inspection point classification that results when the predicted pipe wall thickness will be less than the required minimum thickness in 24 to 48 months.

F. **Satisfactory**

Inspection point classification that results when the predicted pipe wall thickness will be greater than the required minimum thickness for 72 or more months.

G. **Ultrasonic Thickness Measurement Record**

Form used to record thickness measurements and define the grid layout.

H. **Unsatisfactory**

Inspection point classification that results when the current measured pipe wall thickness or the predicted pipe wall thickness will be less than the required minimum thickness in less than 24 months.

I. **Yellow Alert**

Inspection point classification that results when the predicted pipe wall thickness will be less than the required minimum thickness in 48 to 72 months.

3.0 DEFINITIONS (Continued)

J. **Zone**

Identifiable portion of piping at an inspection point. Could be a portion of a component; for example, the branch portion of a tee could be a zone.

4.0 RESPONSIBILITIES

The following personnel have responsibilities assigned under this procedure:

A. Superintendent - Technical Support - 5.1 A., 5.6 G.

B. Superintendent - Nuclear Maintenance - 5.3 B.4.a., 5.6 G.

C. General Supervisor - Plant Engineering - 5.1 B.

D. Principal Engineer - Materials Engineering and Inspection - 5.4 C.

E. Principal Engineer - Secondary Systems - 5.1 C., 5.2 A.3.b., 5.2 C.1., 5.2 C.2.b., 5.6 C.

F. Erosion/Corrosion Engineer - 5.2 A., 5.2 A.3.a., 5.2 B., 5.2 C., 5.2 C.2.a., 5.3 A., 5.3 C., 5.4 A., 5.4 A.1., 5.5 A., 5.5 B., 5.5 C., 5.5 D., 5.5 E., 5.5 F., 5.6 A., 5.6 C.1., 5.6 E.1.a., 5.6 E.1.b., 5.7.

G. Secondary Pipe Replacement Project Engineer - 5.6 A., 5.6 B., 5.6 C., 5.6 D., 5.6 E., 5.6 E.1., 5.6 E.2., 5.6 F.

H. Nondestructive Examiner - 5.4 D., 5.4 D.1., 5.4 D.1.a., 5.4 D.2., 5.4 D.3., 5.4 E., Attachment 6.

I. Craft Personnel - 5.4 B.

5.0 PROCESS

5.1 Erosion/Corrosion Monitoring Overview

A. The Superintendent - Technical Support shall ensure procedures are established and administered to ensure nuclear and personnel safety by early identification of flow accelerated corrosion, cavitation, or erosion that could result in rupture of high energy piping.

B. The General Supervisor - Plant Engineering shall ensure a secondary piping erosion/corrosion monitoring program is established and maintained.

C. The Principal Engineer - Secondary Systems shall:

1. Designate a Plant Engineer as Erosion/Corrosion Engineer to monitor flow accelerated corrosion, cavitation, and erosion by identifying and managing the selection and inspection of potential erosion/corrosion points.

5.1 Erosion/Corrosion Monitoring Overview (continued)

2. Designate a Plant Engineer as Secondary Pipe Replacement Project Engineer to determine the scope of secondary piping replacement.

5.2 Inspection Point Identification and Categorization

A. The Erosion/Corrosion Engineer shall establish and maintain an Erosion/Corrosion Inspection Point List of secondary piping locations considered to have potential for wall thinning.

1. The control parameters identified in Attachment 1, Inspection Point Selection, shall be used to select inspection points to be included in the Erosion/Corrosion Inspection Point List.

a. At least one component from each of the systems listed in Attachment 2, Systems Included in the Erosion Corrosion Monitoring Program, shall also be included as an inspection point independent of comparison to Attachment 1.

2. Inspection points shall be added when:

a. Thickness measurements of existing inspection points indicate the need for additional inspection points.

b. Industry experience indicates new critical points and/or control parameters.

3. Inspection points may be moved to inactive status when measured erosion/corrosion rates indicate the minimum thickness will not be violated for the expected remaining life of the unit.

a. The Erosion/Corrosion Engineer shall provide written justification for placing inspection points on the inactive list.

b. The Principal Engineer - Secondary Systems shall review and approve all inspection points identified for inclusion on the inactive list.

c. Existing data shall be retained when any existing inspection point is placed on the inactive list.

B. The Erosion/Corrosion Engineer shall evaluate each inspection point for susceptibility to pipe wall thinning and for the consequences of failure.

5.2 Inspection Point Identification and Categorization (Continued)

1. A determination of high, medium or low susceptibility shall be made based on consideration of the following conditions:

   a. Piping material

   b. Fluid flow pattern

   c. Temperature

   d. Flow path of system

   e. Moisture content

2. A determination of high, medium or low consequences of failure shall be made based on consideration of the following conditions:

   a. Pipe geometry

   b. Operating pressure

   c. Proximity to plant safety systems

   d. Inclusion in plant safety systems

   e. Probability of personnel injury

   f. Cost of damage repair

   g. Impact on plant operations

   h. Loss of revenue

C. The Erosion Corrosion Engineer shall assign the inspection points to an inspection category according to Attachment 3, Categorization of Inspection Points.

EXAMPLE 5.2 C. Categorization of Inspection Points

If an inspection point has a high susceptibility to pipe wall thinning but the consequences of a pipe rupture are low then that inspection point would be placed in Category B.

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1. The Principal Engineer - Secondary Systems shall review and approve the selection and categorization of the inspection points.

2. Changing an inspection point categorization shall require the following:

   a. The Erosion/Corrosion Engineer shall make a written evaluation and justification of the proposed change.

5.2 Inspection Point Identification and Categorization (Continued)

b. The Principal Engineer - Secondary Systems shall review the evaluation and justification and approve the change.

5.3 Inspection Point Examination Selection

A. The Erosion/Corrosion Engineer shall select, and prioritize, inspection points to be examined during a refueling outage from the following groups of inspection points:

1. Inspection point EB-01-1005-05:
#12 Main Steam Line, adjacent to the second elbow, downstream of the steam generator, inside Containment, shall be inspected during every Unit 1 refueling outage. **[B-3] [B-4]**

   a. The USNRC shall be notified prior to any change in the inspection frequency of inspection point EB-01-1005-05 according to CCI-154, NRC Correspondence. **[B-3] [B-4]**

2. Red Alert Inspection Points:
Inspection points previously classified Red Alert and similar components in all trains.

3. High Risk Inspection Points:
Inspection points added after the start of the current outage because of a high potential for wall thinning.

4. Yellow Alert Inspection Points:
Inspection points previously classified as Yellow Alert and similar components in all trains.

5. Erosion/Corrosion Inspection Point List:
Previously unexamined inspection points on the Erosion/Corrosion Inspection Point List.

   a. Category A inspection points will be selected first until all have been inspected at least once.

6. Previously Repaired Components:
Baseline thickness measurements of all inspection points repaired or replaced since the last refueling outage.

7. Newly Repaired or Replaced Components:
Baseline thickness measurements of all inspection points repaired or replaced during the current outage.

8. Previously Examined Inspection Points:
Inspection points that have not been examined during the past four planned refueling outages.

B. Inspection points included in components scheduled for replacement during the current refueling outage shall not be scheduled for examination.

5.3 Inspection Point Examination Selection (Continued)

C. When any inspection point scheduled for examination cannot be examined during that outage the Erosion/Corrosion Engineer shall:

1. Notify the Principal Engineer - Secondary Systems and the responsible System Engineer immediately.

    a. Notification shall contain any technical justification made by the Erosion/Corrosion Engineer for omitting the inspection and an estimation of risk of failure.

5.4 Inspection Techniques

A. The Erosion/Corrosion Engineer shall initiate an Issue Report according to QL-2-100, Issue Reporting and Assessment, requesting the grid marking and nondestructive examination of components selected for inspection during a scheduled refueling outage.

1. The Erosion/Corrosion Engineer should provide the Principal Engineer - Materials Engineering and Inspection with a list of the points selected for inspection during a refueling outage and their priority no later than six months prior to the start of that outage.

B. Craft personnel shall mark the appropriate grid pattern and grid size from Attachment 6, Grid Patterns, or an alternate grid pattern provided by the Erosion/Corrosion Engineer, on the components of interest at each inspection point prior to nondestructive examination.

1. The grid should start at least two grid spacings upstream of the upstream weld, cover the component of interest and extend at least two diameters downstream of the downstream weld. See Attachment 6, Grid Patterns, for grid patterns of different types of components.

2. The grid pattern shall be made finer or extended further if field conditions prohibit normal gridding. See Attachment 7, Fittings Requiring Special Consideration, for conventions controlling gridding of specialized components.

3. The locations of the grid lines shall be as near the same for each successive inspection of a given component as possible.

C. The Principal Engineer - Materials Engineering and Inspection shall ensure the pre-selected inspection points are examined by the Nondestructive Examiner during the first one-half of the refueling outage.

D. The Nondestructive Examiner should use ultrasonic nondestructive examination to inspect for pipe wall thinning unless the pipe geometry prevents it.

1. The Nondestructive Examiner shall ensure the correct grid pattern is marked on the component before beginning examination.

5.4 **Inspection Techniques** (continued)

a. The Nondestructive Examiner shall notify the Erosion/Corrosion Engineer immediately if the grid pattern is missing or incorrectly marked on a component scheduled for examination.

2. The Nondestructive Examiner shall establish the origins for each nondestructive examination.

a. Each component or part of a component shall be designated as a separate zone and have its own origin. See Figure 5, Attachment 6, Grid Patterns for sample origin locations.

b. The grid shall emanate from an origin (x=0, y=0) with x being the circumference and y the longitude of the component.

3. If the origin of any zone at an inspection point is not permanently marked with a low stress metal V stamp, the Nondestructive Examiner shall mark it accordingly. **[B-5]**

E. The Nondestructive Examiner shall complete an ultrasonic thickness measurement record, approved according to MN-3-101, Nondestructive Examination for each ultrasonic examination completed.

1. Any obstruction or other interference with a grid pattern should be clearly noted on this record.

2. Thickness measurements shall be taken and recorded, or a limitation noted, for each intersection of the grid lines.

3. The following information shall be recorded on the ultrasonic thickness measurement record: **[B-6]**

a. Type of couplant

b. Size of transducer

c. Frequency of transducer

d. Ultrasonic instrument model and serial number

4. The following information shall be recorded on a geometric sketch on the ultrasonic thickness measurement record:

a. Origins of the grid system used

b. Number sequence of inspection points

c. Component orientation (i.e., looking up, down, north, south, etc.)

d. Direction of flow

e. Grid size

5.4 **Inspection Techniques** (Continued)

5. The ultrasonic thickness measurement record shall be reviewed according to MN-3-101, Nondestructive Examination.

    a. The ultrasonic thickness measurement record shall be forwarded to the Erosion/Corrosion Engineer within two working days of completion of physical measurements. **[B-6]**

5.5 **Inspection Results Classification and Disposition**

A. Within 48 hours of receipt of the ultrasonic thickness measurement report the Erosion/Corrosion Engineer shall: **[B-6]**

1. Calculate the erosion/corrosion rate for each component of each inspection point by determining the difference between the measured wall thickness and the reference thickness using the formulas in Attachment 4, Calculating Erosion/Corrosion Rate.

    a. If there is evidence of erosion/corrosion in tees, laterals or crosses initiate an Issue Report according to QL-2-100, Issue Reporting and Assessment, requesting a Design Engineering evaluation unless the component will be replaced during the current outage.

2. Project the number of months remaining until the component has eroded/corroded to the code minimum wall.

3. Classify each inspection point based on the projected number of months remaining for each component, using the criteria of Attachment 5, Classification Criteria.

    a. Piping components shall not be classified satisfactory based on satisfactory examination data acquired from a similar train or parallel service line.

B. If any inspection point is classified as Unsatisfactory the Erosion/Corrosion Engineer shall:

1. Determine if the component should be repaired or replaced, or if a Design engineering evaluation should be made to determine if the component can remain in the as found condition.

    a. Initiate an Issue Report according to QL-2-100, Issue Reporting and Assessment within 24 hours of determining the unsatisfactory status, requesting the desired action. **[B-6]**

2. Notify the Principal Engineer - Mechanical Engineering or the Principal Engineer - Plant Design Support verbally if an engineering evaluation will be requested.

3. Request additional nondestructive examinations according to MN-3-101, Nondestructive Examination, of four adjacent components and of similar points in other trains of the system.

5.5 Inspection Results Classification and Disposition (Continued)

a. Two of the adjacent components examined shall be upstream and two downstream from the Unsatisfactory inspection point.

4. Confer with the Piping Replacement Project Engineer if a number of components in a pipe run are classified as Unsatisfactory to determine if the piping system should be replaced.

5. Notify the Principal Engineer - Secondary Systems and the Outage Coordinator of any problem or delay that might affect the scheduled implementation of secondary piping inspection according to CCI-142, Outage Management, and initiate a scope change request as necessary.

C. If any inspection point is classified as Red Alert the Erosion/Corrosion Engineer should:

1. Request additional nondestructive examinations according to MN-3-101, Nondestructive Examination, of four adjacent components and of similar points in other trains of the system.

   a. Two of the adjacent components examined should be upstream and two downstream from the Red Alert inspection point.

2. Schedule the component(s) for inspection during the next refueling outage and, if possible, during any unscheduled outage.

3. Confer with the Piping Replacement Project Engineer to determine if the piping system should be replaced during the current outage if a number of components in the system are classified as Red Alert.

D. If any inspection point is classified as Yellow Alert the Erosion/Corrosion Engineer should:

1. Request additional nondestructive examinations according to MN-3-101, Nondestructive Examination, of two immediately adjacent components and of similar points in other trains of the system.

   a. One of the adjacent components examined should be upstream and one downstream from the Yellow Alert inspection point.

2. Schedule the component(s) for inspection no later than the second subsequent refueling outage.

3. Determine if the piping system should be reclassified Red Alert if a number of components in a system are classified as Yellow Alert.

E. If any inspection point is classified as Satisfactory, the Erosion/Corrosion Engineer shall:

1. Schedule the inspection point for normal re-examination.

5.5 **Inspection Results Classification and Disposition** (Continued)

2. Monitor changes in plant operating conditions which would affect erosion/corrosion control parameters listed in Attachment 1, Inspection Point Selection.

F. The Erosion Corrosion Engineer shall provide the Outage Manager with written status reports according to CCI-142, Outage Management.

5.6 Secondary Pipe Replacement

A. At the conclusion of each scheduled refueling outage the Erosion/Corrosion Engineer shall provide the Pipe Replacement Project Engineer with a list of all inspection points identified as Red or Yellow Alert.

B. Following each scheduled refueling outage the Pipe Replacement Project Engineer shall develop a Secondary Pipe Replacement List of components and/or portions of piping systems to be replaced during the next scheduled refueling outage.

1. All components or portions of piping systems projected to reach Unsatisfactory status following the next scheduled refueling outage will be added to the Replacement List.

2. Additional components or portions of piping systems shall be added based on an evaluation of the following:

a. The number of inspection points classified Red or Yellow Alert.

b. The number of carbon steel components in a pipe system or pipe run.

c. The cost effectiveness of replacing all versus part of a pipe system or pipe run.

d. Design Engineering evaluation

C. The Pipe Replacement Project Engineer shall submit the Pipe Replacement List for a scheduled refueling outage to the Principal Engineer - Secondary Systems for approval nine months prior to the start of the outage.

1. The Pipe Replacement Project Engineer shall provide the Erosion/Corrosion Engineer with a copy of the Pipe Replacement List as soon as it is approved by the Principal Engineer - Secondary Systems.

D. The Pipe Replacement Project Engineer shall initiate Issue Reports requesting replacement of the approved components and pipe runs according to QL-2-100, Issue Reporting and Assessment, no later than six months prior to the start of the scheduled refueling outage.

E. During each scheduled refueling outage the Pipe Replacement Project Engineer shall conduct a visual inspection, to the maximum extent practical, of components adjacent to components being replaced.

5.6 **Secondary Pipe Replacement** (Continued)

1. If additional pipe wall thinning is noted beyond the components to be replaced, the Pipe Replacement Project Engineer shall notify the Erosion/Corrosion Engineer.

   a. The Erosion/Corrosion Engineer shall request an ultrasonic examination be performed to determine thickness of these areas.

   b. The Erosion/Corrosion Engineer should also request ultrasonic examination of adjacent locations inaccessible for visual examination of inside surfaces.

2. The Pipe Replacement Project Engineer shall determine if:

   a. The pipe replacement work should be expanded to include the adjacent pipe and components.

   b. A design engineering evaluation to accept the component should be requested by completing an Issue Report according to QL-2-100, Issue Reporting and Assessment.

F. The Pipe Replacement Project Engineer shall provide the Outage Manager with written status reports according to CCI-142, Outage Management.

G. The Superintendent - Nuclear Maintenance shall ensure the Principal Engineer - Secondary Systems is informed of all repairs or replacements on secondary system components as implemented by Mechanical Maintenance, Contractor Administration or Mobile Maintenance.

5.7 **Erosion/Corrosion Data Base**

The Erosion/Corrosion Engineer shall maintain an Erosion/Corrosion data base.

A. The data base shall consist of the following:

1. List of active inspection points.

2. The data listed in Attachment 7, Inspection Point Data, for each component of an inspection point.

   a. Except for subsequent thickness measurements, this data shall be established at the first inspection of each inspection point.

B. If any datum for an inspection point has not been previously recorded in the Erosion/Corrosion Data Base, it shall be recorded when the point is next inspected.

C. The data base shall be updated following each refueling outage.

D. A predictive model of erosion/corrosion should be used in conjunction with the data base to determine additional inspection points and to adjust inspection point priority. [B-6]

6.0 BASES

B-1 USNRC Generic Letter 89-08, Erosion/Corrosion-Induced Pipe Wall Thinning, requires an Erosion/Corrosion program be implemented.

B-2 G.C. Creel reply to NRC Generic Letter 89-08, February 26, 1990, affirming Materials Engineering and Analysis (ME&A) Implementing Procedure (IP) 5.05, Secondary System Piping Erosion/Corrosion Inspection Program, was fully implemented.

B-3 Letter from G.C. Creel to USNRC, Subject: CCNPP Unit No. 1; Docket No. 50-317, Main Steam Thin Wall, committing CCNPP to perform NDE of EB-01-1005-05 each Unit 1 refueling outage and notifying the USNRC of any change in inspection frequency.

B-4 Letter from D.G. McDonald (NRC) to G.C. Creel, Subject: Justification of Non-Repair of a Main Steam Line Flaw at CCNPP, Unit No. 1, agreeing repair or replacement of #12 Main Steam Line not required. Acknowledges commitment to perform NDE each Unit 1 refueling outage and to notify the USNRC of any change in inspection frequency.

B-5 G.C. Creel Reply to Notice of Violation Inspection Report 50-317/90-01; 50-318/90-01, dated May 15, 1990, requires permanent weld zero and center line identification prior to any ASME XI surface or volumetric examination of piping welds.

B-6 AIT item #CT9300001 requires time constraints be set on E/C inspection information transfer and recommends incorporation of comments from USNRC Inspection Report 50-317-92-28 & 50-318-92-28, as feasible.

7.0 RECORDS

The following records are generated by this procedure:

- Ultrasonic Thickness Measurement Record
- Erosion/Corrosion Inspection Point List
- Erosion/Corrosion Data Base

The responsible Procedure Sponsor shall ensure records are controlled according to PR-3-100, Records Management.

ATTACHMENT 1, INSPECTION POINT SELECTION

E/C Control Parameter	Condition resulting in selection as potential E/C Inspection Point
Fluid Flow	Complex flow path High local turbulence Flow restrictions (open valves, flow control valves, reducers, orifices, etc.) Flow perturbations caused by weld configurations (counterbore, backing strap, build up, grinding, etc.) Flow perturbation caused by adjacent components with different thickness but matching OD.
Piping Geometry	One inch or greater Piping downstream of control valves and reducer Direction and/or velocity changing fittings Closely coupled fittings (less than ten diameters separation)
Piping Materials	Carbon Steel Replacement piping, other than carbon steel, until it is established that no further thickness measurements are required
Operating Conditions	High moisture content (wet steam) Possible flashing (especially downstream of valves, reducers, etc.) Possible cavitation
High Energy	Temperature greater than 200° F Pressure greater than 250 psia
Water Chemistry	Low pH value
History	Similar inspection points classified Yellow Alert Similar inspection points classified Red Alert Similar inspection points classified Unsatisfactory
Consequences of failure	Personnel injury Damage to plant safety systems (direct or consequential) Plant revenue

ATTACHMENT 2, SYSTEMS INCLUDED IN EROSION/CORROSION MONITORING

For information only.

Main steam to high pressure turbine stop valves

Main steam to second stage reheater

Main steam turbine bypass to condenser

Main steam to steam generator feed pump turbine

Main steam to auxiliary feed pump turbine

High pressure turbine exhaust to Moisture Separator Reheaters (MSRs)

Reheated steam to low pressure turbines

Reheated steam to steam generator feed pump turbine and auxiliary boiler

Condensate booster pump discharge to steam generator feed pump suction

Feedwater pump discharge to steam generator

Feedwater pump recirculation to condenser

Auxiliary Feedwater from the Auxiliary Feedwater pumps

Steam generator blowdown

Heater 6A and 6B extractions, vents, dumps, and drains, excluding atmospheric vents and drains

Heater 5A and 5B extractions, vents, dumps, and drains, excluding atmospheric vents and drains

Heater 4A and 4B extractions, vents, dumps, and drains, excluding atmospheric vents and drains

Heater 3A and 3B extractions, vents dumps, and drains, excluding atmospheric vents and drains

MSR second stage reheater drains to reheater drain tank and to heaters 6A and 6B and condenser

MSR first stage reheater drains to reheater drain tank and to heater 5A and 5B and condenser

Heater drain pump discharge

High pressure extraction steam drains

Miscellaneous steam line drains

ATTACHMENT 3, CATEGORIZATION OF INSPECTION POINTS

E/C SUSCEPTIBILITY	FAILURE CONSEQUENCES	INSPECTION CATEGORY
High	High	A
High	Medium	A
High	Low	B
Medium	High	A
Medium	Medium	B
Medium	Low	C
Low	High	B
Low	Medium	C
Low	Low	D

ATTACHMENT 4, CALCULATING EROSION/CORROSION RATE (Page 1 of 3)

The informatio:a listed below is used to determine the acceptability of each component at each inspection poin The acceptance criteria of Attachment 5, Acceptance Criteria, are used to determine the cl assification of each component.

1. Calculate Minimum Thickness

T_M = Minimum Thickness, in inches, required by original Construction code.

$$= \frac{PD_O}{2(SE+PY)} + A$$

A = 0.0625 inches or any other value specified by GS-DES.

d = Inside diameter.

D_O = Outside diameter of pipe, in inches.

P = Design Pressure (psig) from M-601, Piping Class Summary.

S_E = Maximum allowable stress due to internal pressure and joint efficiency in psi.

Y = 0.4 unless $D_O/T_{MIN} < 6$ then $Y = \frac{d}{d + D_O}$

2. Calculate Erosion/Corrosion Rate

E/C Rate = Maximum calculated erosion/corrosion rate of a component (inches per month).

$= \frac{T_{REF}-T_A}{M}$ (If T_A is greater than T_{REF}, E/C Rate = 0 Use alternate evaluations to confirm.)

C = The circumferential cross section containing the minimum measured thickness.

L = The longitudinal cross section containing the minimum measured thickness.

L & C = The longitudinal or circumferential cross section containing the minimum measured thickness.

M = Months in service between the time when T_{REF} and T_A were established.

T_A = Smallest thickness measured in a component of an inspection point. Note: If T_A is greater than T_{REF} than request alternative evaluation.

T_{INIT} = Initial thickness. Defined in Table 2.

T_{MAX} = The maximum measured thickness in the longitudinal or circumferential cross section.

T_{NOM} = Nominal wall thickness as determined by the original pipe size and schedule.

T_{REF} = Reference thickness. Defined in Table 1.

ATTACHMENT 4, CALCULATING EROSION/CORROSION RATE (Page 3 of 3)

TABLE 1

Definition of TREF

Condition 1	Condition 2	Value of TREF
Inspection point with no thickness measurement	Not Applicable	TINIT as defined in Table 2
Inspection point with previous thickness measurement	Thickness NOT measured at the same grid points for two consecutive measurements	TINIT as defined in Table 2
Inspection point with previous thickness measurement	Thickness measured at the same grid points for two consecutive measurements	Thickness at the same location as TA from most recent measurement

TABLE 2

Definition of TINIT

Group	Components Included	Inspection Area	Value of TINIT
1	Tee, Laterals, Crosses	N/A	See Note 1
2	Valves, Orifices	N/A	1.125 TNOM
3	Elbow, Return	C	TMAX
4	Reducing Elbow, Eccentric Reducer/Expander	L & C	TMAX
5	Pipe, Reducer/Expander Weld, Half Coupling	C	TMAX

Note 1: TINIT can only be obtained by taking baseline readings or by using a previous reading. E/C rates may not be available until the next scheduled refueling outage. If there is evidence of E/C then an evaluation by Design Engineering shall be requested.

ATTACHMENT 5, CLASSIFICATION CRITERIA

Inspection Point Classification	**Acceptance Criteria**
Unsatisfactory	Smallest measured thickness less than or equal to minimum thickness or Approximate thickness in 24 months less than or equal to minimum thickness.
Red Alert	Approximate thickness in 24 to 48 months less than or equal to minimum thickness.
Yellow Alert	Approximate thickness in 48 to 72 months less than or equal to minimum thickness.
Satisfactory	Approximate thickness 72 months or more greater than minimum thickness.

ATTACHMENT 6, GRID PATTERNS (Page 1 of 5)

Table 1. Required Grid Spacing

PIPE SIZE	GRID SIZE
Less than or equal to 3"	No grid. Scan the area of interest
Greater than 3" Less than or equal to 6"	1" X 1"
Greater than 6" Less than or equal 18"	2" X 2"
Greater than 18"	3" X 3"

The location of the origin (x=y=0) should placed according to the following conventions:

1. The coordinate y=0 is always at the upstream end of the grid.

2. The circumference coordinate x will increase from zero in accordance with the right hand rule (thumb in the direction of flow and x increasing in the direction of the fingers).

3. The origins should be located so the coordinate x=0 is continuous from one component to the next in a given pipe line. See Figure 6.

4. The origin should be located on the upstream end of an elbow on the centerline of the outside arch. It should be located so that the area to be gridded extends from 0 at the origin to 360 degrees in a clockwise manner around the pipe. See Figure 7.

5. The origin on a tee should be on the side, 90 degrees from the symmetry plane that contains the branch and pipe run centerlines. Step 2 should be given consideration when selecting a side but either side can be selected at the Nondestructive Examiner's discretion.

6. The origin on a branch pipe is at the branch-to-pipe weld and on the same side of the tee as the run pipe origin.

7. If the origin cannot be located as required above due to configuration, geometry or accessibility, other origins are acceptable if described and documented on the Ultrasonic Thickness Measurement Record.

ATTACHMENT 6, GRID PATTERNS (Page 2 of 5)

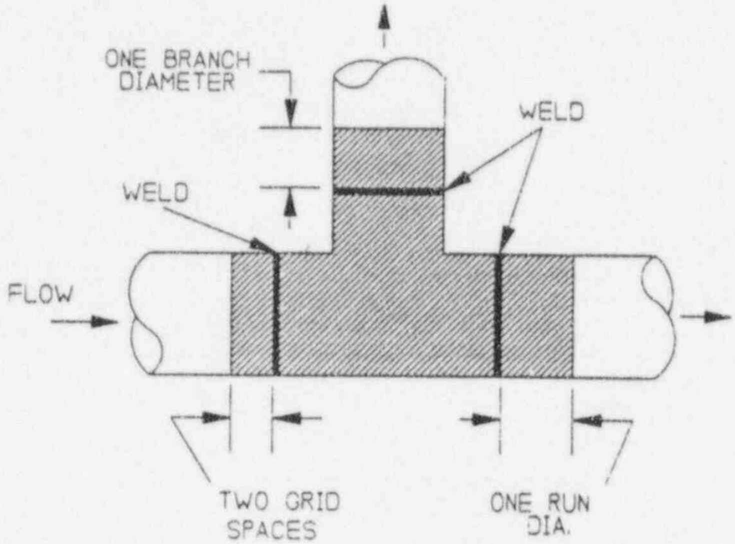

Figure 1. Tee (Single and Two Phase)

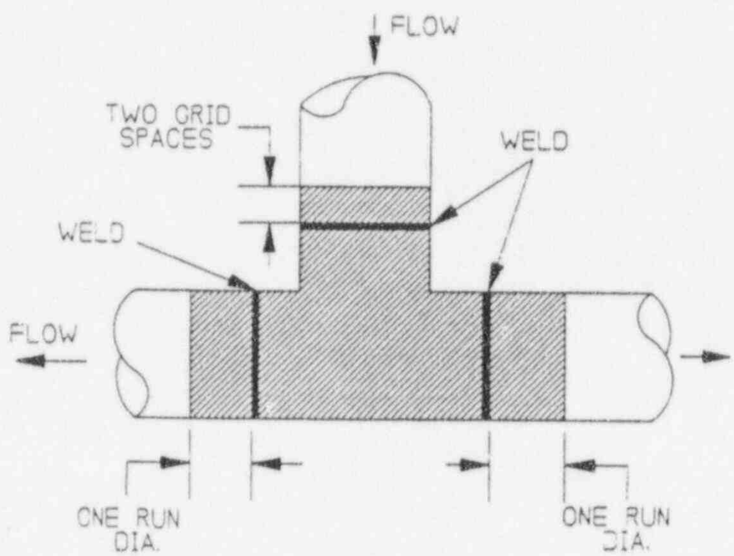

Figure 2. Tee (Single and Two Phase)

ATTACHMENT 6. GRID PATTERNS (Page 3 of 5)

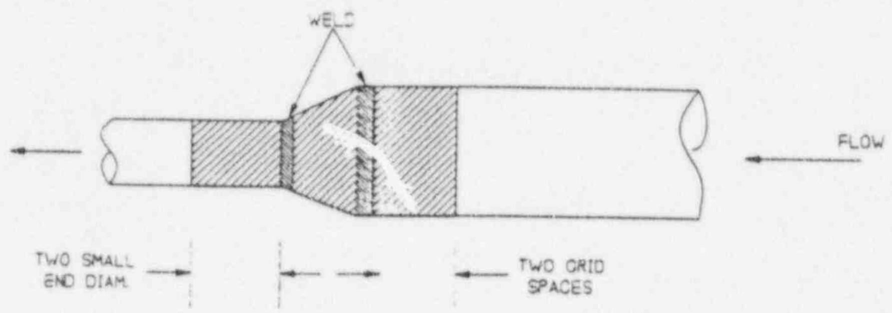

Figure 3. Reducer

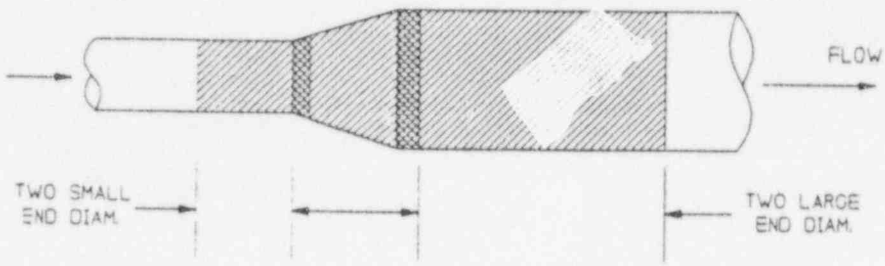

Figure 4. Expander

ATTACHMENT 6, GRID PATTERNS (Page 4 of 5)

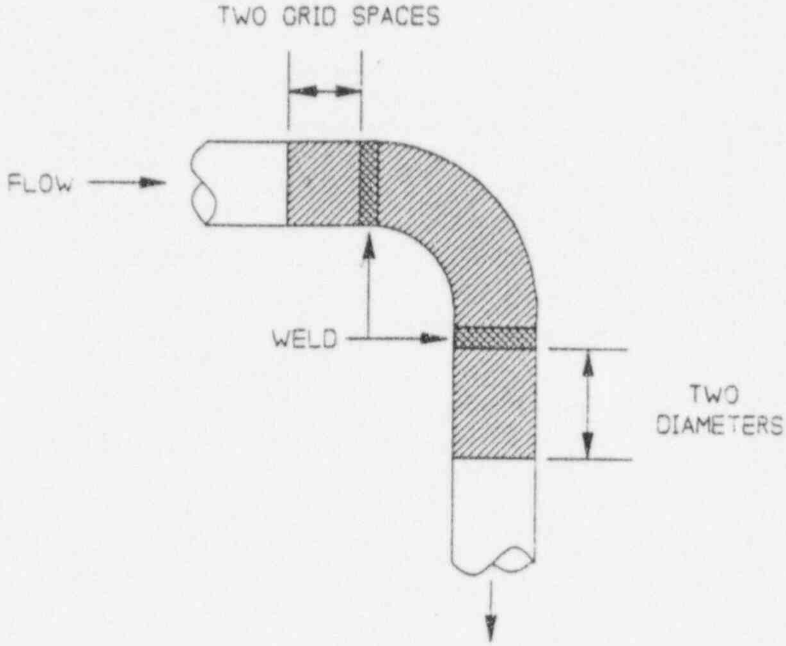

Figure 5. Elbow

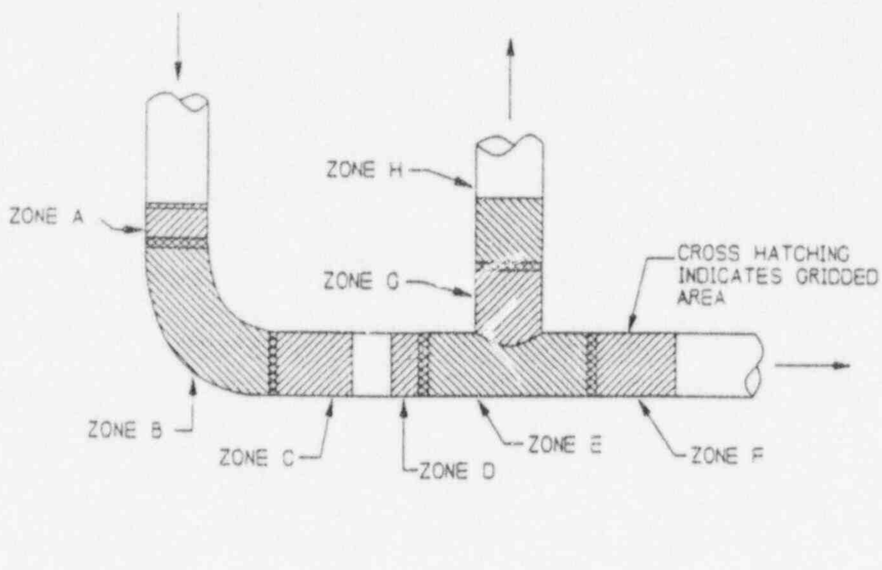

Figure 6. Sample Origin Locations

ATTACHMENT 6, GRID PATTERNS (Page 5 of 5)

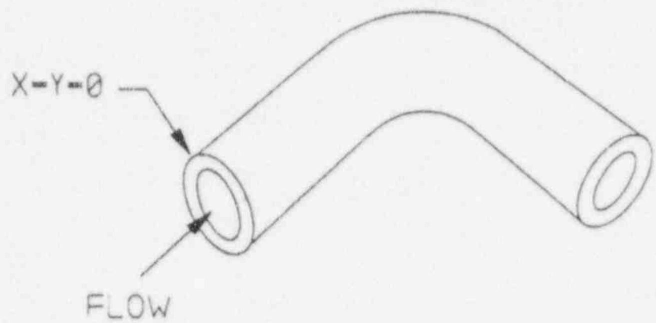

Figure 7, Origin on Elbow

ATTACHMENT 7, FITTINGS REQUIRING SPECIAL CONSIDERATION

A. Reducers/expanders and reducing/expanding elbows

Grid spacings on fittings with nonparallel (converging/diverging) grid lines should be set so the resulting spacing is less than that required in Table 1, Attachment 5, Grid Spacings.

1. Components with different size ends, both requiring the same grid size:

    a. Set circumferential grid spacings on the large end so the spacing on the small end will be less than required.

2. Components with different size ends, both requiring a different grid size:

    a. Use the longitudinal grid size and spacing of the small end for the entire length.

    b. Use the circumferential grid size and spacing of the small end for the entire component unless the resulting spacing exceeds that of Table 1, Attachment 5, Grid Spacings. If this happens re-establish the circumferential spacing on the large end equal to that required by Table 1, Attachment 5, Grid Spacings.

3. Reducing/expanding elbows:

    a. The longitudinal grid spacing should be set on the centerline of the upper or exterior curve.

B. Tees and laterals with different run and branch diameters

1. Grid size may be different for the run and branch pipes.

2. Grid size shall be based on the run and branch diameters.

C. Pipe less than 3 inches in diameter.

1. No grid is required

2. Thickness measurements should extend two inches upstream of the upstream weld and three inches downstream of the downstream weld.

ATTACHMENT 8, INSPECTION POINT DATA

The Erosion/Corrosion Data Base should include, but need not be limited, to the following information.

ACCESS	CONSTRUCTION MATERIAL
ACTIVE OR INACTIVE STATUS	CODE MINIMUM WALL
AREA LOCATION	NEXT SCHEDULED INSPECTION
CALCULATED E/C RATE	NOMINAL WALL
COMPONENT ID NUMBER	P&ID NUMBER
DATE OF EXAM	PIPE CIRCUMFERENCE
EXAM RESULTS	REMARKS
FLOOR ELEVATION	SMALLEST EXAM THICKNESS
PIPING GEOMETRY	SYSTEM DESCRIPTION
HEIGHT FROM FLOOR	PREDICTED TIME UNTIL FAILURE
INSTALLATION DATE	TRANSDUCER FREQUENCY
INSULATION TYPE	TRANSDUCER SIZE
ISO NUMBER	TYPE OF NONDESTRUCTIVE EXAM
LOCATION IN PLANT	