JAN 2 9 1992

Docket No. 50-336

Mr. John F. Opeka
Executive Vice President - Nuclear
Northeast Nuclear Energy Company
P. O. Box 270
Hartford, Connecticut 06141-0270

Dear Mr. Opeka:

Subject: Inspection 50-336/91-81

This refers to your letter dated January 3, 1992, in response to our letter dated December 12, 1991.

Thank you for informing us of the corrective actions you are taking in response to the erosion/corrosion induced failure of the moisture separator reheater drain line at Millstone Unit 2. The effectiveness of your erosion/corrosion inspection program including these corrective actions will be examined during a future NRC inspection.

Your cooperation with us is appreciated.

Sincerely,

Jacque P. Durr, Chief
Engineering Branch
Division of Reactor Safety

IE:01

cc:
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NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
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January 3, 1992

Docket Nos. 50-213
50-245
50-336
50-423
A10077

Mr. Thomas T. Martin
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Dear Mr. Martin:

Haddam Neck Plant
Millstone Nuclear Power Station, Unit Nos., 1, 2, and 3
Erosion/Corrosion Program Update
Response to NRC Region I Augmented Inspection Team Report

Introduction

Northeast Nuclear Energy Company (NNECO), on behalf of Millstone Unit No. 2, hereby submits information responsive to the NRC Region I Augmented Inspection Team (AIT) Report, dated December 12, 1991.(1) This letter will also confirm that NNECO has fulfilled its commitments, as stated in the November 18, 1991(2) Northeast Utilities (NU) erosion/corrosion program letter at Millstone Unit No. 2, prior to returning the unit to service on December 28, 1991. Additionally, NNECO and Connecticut Yankee Atomic Power Company (CYAPCO) are hereby providing selected erosion/corrosion (E/C) program information, as appropriate, to clarify and support related topical discussions between various NRC Staff and NNECO/CYAPCO personnel.

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(1) M. W. Hodges letter to J. F. Opeka, "NRC Region I Augmented Inspection Team Report (50-336/91-81)," dated December 12, 1991.

(2) J. F. Opeka letter to the U.S. Nuclear Regulatory Commission, "Haddam Neck Plant, Millstone Nuclear Power Station, Unit Nos. 1, 2, and 3, Erosion/Corrosion Programs," dated November 18, 1991.

Background

In a letter dated November 18, 1991,(3) NNECO and CYAPCO provided a brief overview of our erosion/corrosion program that evolved from the Millstone Unit No. 3 moisture separator drain line pipe rupture. As a result of the November 6, 1991 Millstone Unit No. 2 moisture separator reheater (MSR) drain line rupture event, the NU E/C program, then in the process of being upgraded, was accelerated and enhanced. We further stated that our units would not be returned to service until comprehensive component inspections had been completed, all indications of observed degradation had been evaluated and dispositioned as required, and where necessary, component/piping would be repaired or replaced.

On November 22, 1991 a contingent of Northeast Utilities personnel presented the restart erosion/corrosion program to the NRC Region I Staff. This comprehensive presentation included not only a discussion of the pipe rupture event, but more importantly it focused on the enhanced erosion/corrosion programmatic issues. A significant portion of the presentation covered NU's screening approach to identify locations susceptible to E/C. This was primarily based upon use of the CHECMATE computer program and broad industry experience. The explicit organizational structure delineating inspection, implementation, resolution/review, and acceptance responsibilities, was presented. Programmatic documentation (program manual) and control were also discussed.

Shortly following the presentation to Region I Staff, key NU corporate engineering management personnel relocated to the Millstone site, to coordinate and assist in the restart erosion/corrosion program. This organization provided focused and coordinated resource allocation, during all phases of program implementation.

Current Millstone Unit No. 2 Status

At Millstone Unit No. 2, all actions necessary to return the unit to service have been completed. Comprehensive inspections of susceptible components utilizing CHECMATE, current industry experience, and unit specific history have been completed, or exempted where appropriate, as explained later in this section. The corrective actions listed in Section 4.2, of the NRC Region I AIT Report, regarding numbers of inspections and analyses have either been met or exceeded. All indications of observed degradation have been evaluated and dispositioned per program requirements. The repair and replacement of components/piping have been completed.

The Millstone Unit No. 2 E/C restart program resulted in extensive inspections. The total number of inspection locations selected for the

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(3) Ibid.

Millstone Unit No. 2 E/C restart program was approximately 690. The number of required inspection locations consisted of 189 large bore (2" or greater) and 152 small bore (less than 2") locations based on the industry experience. A total of 102 large bore inspection locations were established based on the CHECMATE analysis. In addition, 57 large and small bore inspection locations were identified by walkdowns as well as 18 additional inspection locations from the plant-specific experience data base. Lastly, as a result of the inspection findings, a total of 175 additional large and small bore piping inspection locations were included into the E/C restart program using the sample expansion criteria.

The E/C restart program inspection requirements were implemented by completing approximately 530 new inspections during the current outage, by crediting prior applicable inspection results for 95 locations and by taking exemptions for 27 locations. A summary of the exemptions taken is provided in Attachment 2. It is noted that exemptions were taken based on component inaccessibility and/or inconsequential damage considerations. The remaining component inspections (approximately 40 locations) deal with the auxiliary steam system piping and will be completed in the very near future. The E/C restart inspection program identified 10 locations which required component repair or replacement. All repairs or replacements were completed prior to startup.

We believe that the E/C restart program was comprehensive and effective based on the scope of inspections, including the sample expansions, and the repairs and/or replacements completed prior to startup.

Additional E/C Program Information

The NU E/C program has already demonstrated itself to be comprehensive and effective, as all four NU units will be subjected to thorough and systematic piping/component inspections. A copy of the E/C Technical Requirements for Restart document, previously discussed (and requested by NRC Staff) during the November 22, 1991 Region I Staff meeting, is provided as Attachment 1. This E/C technical requirements document, applicable for our four nuclear units, was developed in conjunction with industry standards and in collaboration with Electric Power Research Institute (EPRI) personnel. It has undergone not only internal review and approval, but has also been independently reviewed by EPRI.

Briefly, these component inspection locations, in susceptible systems, are identified from the following four sources:

(1) CHECMATE--The computer code developed by EPRI to predict pipe wall thinning in systems without sufficient historical inspection data.

(2) Industry Experience Locations--Components which industry experience indicates are particularly susceptible to E/C (e.g., those

downstream of flow control valves, orifices/flow meters, exit nozzles, and feed pumps).

(3) Plant-Specific Experience Locations--Component locations within the specific plant where previous thinning has required repair or replacement.

(4) Engineering Based/Walkdown Selections--Certain systems and pipe segments have usage and flow rates which cannot be accurately quantified because demand greatly varies or are controlled by a remote level, pressure, or temperature signal and will not be analyzed in CHECMATE.

The results of these inspections for Millstone Unit Nos. 1 and 3 and the Haddam Neck Plant will be reported to the NRC Staff in subsequent correspondence. As of this writing, we anticipate that approximately 300, 600, and 680 inspections will be conducted at these units, respectively. One finding was of particular note during the current E/C program inspections at Millstone Unit No. 3. A component in a 16-inch, extraction steam line, immediately downstream of the high pressure turbine, was found to be worn significantly enough to require immediate replacement. This finding occurred on December 17, 1991, approximately one day before a pipe rupture in a 14-inch extraction steam line downstream from the high pressure turbine at a nuclear facility in Spain. Although the particular Millstone Unit No. 3 piping component was initially identified for inspection based on "industry experience," CHECMATE also correctly "flagged" the component for inspection. The wear rates predicted by CHECMATE and engineering predicted values for this particular component correlated favorably. The engineering predicted wear rate in this particular area was approximately 65 mils/year, and the CHECMATE initial prediction was approximately 58 mils/year. The actual inspection data were then fed back into CHECMATE, per the E/C program technical requirements, to further improve the wear rate correlation.

Information Sharing with Industry

Our recent E/C experience and findings have been and will continue to be shared with the industry utilizing the Nuclear Network system. On November 7, 1991 we communicated the Millstone Unit No. 2 MSR drain line rupture to the industry on the Nuclear Network System. On December 12, 1991 a supplemental notice was electronically transmitted as Technical Support Information Exchange (TI), describing the NU E/C efforts to comprehensively enhance and accelerate completion of our E/C program. On December 16, 1991, that message was reclassified as Operating Plant Experience (OE). We have since received several telephone follow up inquiries as a result of this information sharing. On December 30, 1991, another Nuclear Network electronic message was transmitted, in which the Millstone Unit No. 3 extraction steam line inspection finding was discussed. We will continue to share information with the industry, in the future, as appropriate.

Conclusion

We completed the NU erosion/corrosion program manual technical requirements for restart, at Millstone Unit No. 2, as described in Attachment 1, with the previously noted exceptions, prior to returning the unit to service.

NU believes the Erosion/Corrosion Restart Program provides a high degree of assurance that each unit will operate until the next refueling outage without experiencing an Erosion/Corrosion related piping rupture.

Our E/C program activities at the other units are in various stages of completion. We will remain in periodic contact with the NRC Staff and provide additional program updates as more information becomes available. Please do not hesitate to contact us if you have any questions.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

J. F. Opeka
Executive Vice President

cc: T. T. Martin, Region I Administrator
E. M. Kelly, Section Chief, Reactor Projects, Region I
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W. J. Raymond, Senior Resident Inspector, Millstone Unit Nos. 1, 2, and 3

Docket Nos. 50-213
50-245
50-336
50-423

Attachment No. 1

Haddam Neck Plant
Millstone Nuclear Power Station, Unit Nos. 1, 2, and 3
Erosion/Corrosion Program Update

Erosion/Corrosion Program Manual Technical Requirements for Restart
Northeast Utilities
Connecticut Yankee [Haddam Neck Plant] and
Millstone Units [Nos.] 1, 2, & 3

January 1992

EROSION/CORROSION PROGRAM MANUAL

TECHNICAL REQUIREMENTS FOR RESTART

NORTHEAST UTILITIES

CONNECTICUT YANKEE and
MILLSTONE UNITS 1, 2 & 3

NORTHEAST UTILITIES SERVICE COMPANY
107 Selden Street
Berlin, CT 06037

December 2, 1991

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1.0 RESTART PROGRAM OBJECTIVE

This "Restart Program Manual" will define the Erosion/Corrosion evaluation and inspection criteria which will be utilized at Connecticut Yankee and Millstone Units 1, 2 and 3 prior to restart of the units. The objective of the program is as follows:

> The Erosion/Corrosion Restart Program shall provide a high degree of assurance that each unit will operate until the next refueling outage without experiencing an Erosion/ Corrosion related piping rupture.

The program provides a methodical and systematic evaluation of erosion/corrosion wall thinning using the CHECMATE Code, plant specific experience, industry experience, and engineering experience. The program is designed to meet or exceed accepted industry practice and to ensure that the program is executed in a high quality, consistent, and uniform manner at all units. The program defined herein will be utilized until each of the units is restarted. An overall long-term E/C program document (in final preparation) will include details regarding inspection frequency, long term data retention, and other details which will be utilized in defining the long term NU corporate E/C program.

Based on the technical criteria and methodology presented herein, it is our position that this comprehensive approach with well written procedures, specified responsibilities, and specified quality criteria, will result in a program that will assure a high level of confidence that no pipe ruptures will occur during the next operational cycle in piping systems susceptible to erosion-corrosion degradation. The first line of defense in this comprehensive approach is to preclude pipe ruptures. Meeting that objective will ensure personnel safety and minimize challenges to plant safety in the short term.

2.0 E/C PROGRAM DESCRIPTION

This program defines inspection and related engineering activities required to predict, detect, and evaluate piping erosion/corrosion at Connecticut Yankee and Millstone Point Units 1, 2, and 3. Specified procedures and methods satisfy the requirements of USNRC Generic Letter 89-08, "Erosion/Corrosion - Induced Pipe Wall Thinning." Methods are based on the program guidelines developed by NUMARC, the Electric Power Research Institute (EPRI), and the ASME and provide for systematic measures to ensure that erosion/corrosion does not lead to unacceptable degradation (pipe wall thinning) of either single phase or two phase high-energy piping systems.

This program applies to the detection of pipe wall thinning due to erosion/corrosion (E/C) of safety related and non-safety related carbon and low alloy steel piping systems. Those systems selected for inclusion into the E/C monitoring program are defined and

evaluated. The most susceptible components are selected from these systems for inspection. The inspections performed provide protection against excessive wall thinning in both the inspected components and other less susceptible uninspected components.

The NU Erosion-Corrosion Restart Program has been enhanced by the following requirements:

1. The inspection scope for large bore piping has been expanded tc include additional susceptible components.

2. The Restart Program evaluates erosion/corrosion in small-bore piping (<2" in diameter).

3. The lessons learned from the Millstone Unit No. 2 reheater drain line failure have been integrated into the Restart Program.

4. The Restart Program Manual has been independently reviewed by EPRI. All applicable recommendations have been integrated.

The NU Erosion/Corrosion Restart Program has been developed to efficiently and effectively meet the objective outlined in Section 1.0. Major technical requirements and data management aspects of the program are specified in this document. Implementation procedures will be utilized to define responsibilities, technical implementation, documentation records, and interdepartment communication.

The following activities are identified for program implementation. Figure 1 provides a flow chart for these activities for a unit during this Restart Program.

2.1 NU Engineering Activities

Engineering activities required by this program include:

1) Identification of E/C susceptible systems.
2) Ranking of E/C susceptible systems and locations.
3) Selection of piping locations for examination.
4) Establishment of examination sample expansion criteria.
5) Establishment of acceptance criteria.
6) Evaluation and disposition of piping locations which do not satisfy the acceptance criteria.
7) Assistance as required in the development of repair/replacement procedures.

2.2 Plant Inspection Activities

Plant inspection activities required by this specification include:

1) Inspection scheduling.
2) Preparation of locations for inspection.
3) Performing inspections.

4) Recording all inspection results and transmittal to Engineering.
5) Generation of immediate reports during the inspection for locations which do not satisfy acceptance or screening criteria.

2.3 CHECMATE Analysis

CHECMATE, developed by the Electric Power Research Institute (EPRI)[1], is used to predict pipe wall thinning. The CHECMATE code models the susceptible piping systems by breaking the system down into discrete components -- locations where wall thinning may occur. The modelling is performed for segments of the identified system. For similar segment groups, operating hours and water chemistry are identified. For each segment, the design conditions, operating pressure, flow conditions, component types, materials, pipe diameter, and pipe thickness are identified. A CHECMATE analysis is performed. The modelling and analyses are performed by engineers qualified and experienced in CHECMATE.

The analysis ranks the specific components in a segment with respect to the susceptibility to erosion/corrosion wall thinning. If no previous thickness data has been taken on a line, these rankings are utilized to select the locations for examination of components.

Following the initial inspections, or by utilizing previous inspections, the measured thickness data is input into the CHECMATE model. An adjustment of the predicted erosion/corrosion rates is made so that the predicted rates are correlated to the measured rates. This analysis also provides the time required until the minimum acceptable wall thickness for internal pressure is reached. This time is used to select additional components for examination.

3.0 SYSTEM SELECTION CRITERIA

In order to select candidate piping systems for inclusion into the E/C program, each system in the plant is screened as indicated in Figure 2. All systems in the plant are considered to be candidates for inclusion in the program. The P&IDs for the systems are each individually evaluated to assure that all susceptible systems are included. The system screening criteria defined in this section are utilized to determine the susceptible portions of each of the systems. The results of the system screening are reviewed with Plant Maintenance personnel and a Senior Reactor Operator to assure complete understanding of the system operation and previous problem areas. This process results in a marked-up set of P&IDs which define all the susceptible portions of the plant systems.

These piping in these systems are reordered for purposes of analysis in CHECMATE. Portions of the systems with common operating characteristics are grouped. These are further broken

down into pipe lines which are modeled in one CHECMATE analysis package. For the purposes of the erosion/corrosion evaluation, the plant systems are redefined into recognizable susceptible piping systems. These systems are tabulated for each unit in Appendix A. For the purposes of sample expansion, consistency shall be maintained with the ranking lists and system boundaries utilized for initial component selection.

In general, all the plant systems are considered to be susceptible to erosion/corrosion unless excluded by the criteria defined below:

3.1 Primary System

Plant primary systems in PWRs and the Reactor Vessel and Recirculation Piping in BWRs are not considered to have significant susceptibility to E/C. These are stainless steel or stainless clad low alloy steel operating at approximately 300°C (≈600°F). Studies indicate essentially zero attack on the material typical of these systems. Plant primary side piping in PWRs and the Vessel and Recirculation Piping in BWRs are therefore excluded from the program.

3.2 Material

The percentage of chrome present in alloy steel has been found to significantly lower erosion rates. Therefore, systems which are made of stainless steel are not included in the program. Systems constructed of carbon and chrome-moly steel piping with below 5% chromium content shall be included in the program.

3.3 Content

Superheated or "Dry" steam conditions have been shown not to cause erosion/corrosion and are excluded from the program. Due to industry performance without erosion/corrosion wall thinning, main steam line conditions that exist in the main steam line between the steam generator and the turbine are included in this definition and are excluded from the Restart Program.

3.4 Energy Level

All systems with operating pressure greater than 275 psi or operating temperatures greater than 200°F shall be included in the program. Cold condensate returns from heating systems are low pressure (approximately 15 psi) and have very limited portions of the line that exceed 200°F but are not greater than 212°F. The condensate cools quickly. These lines are excluded from the program.

Systems below these temperature and pressure criteria have been considered for potential susceptibility and included when appropriate (Industry Experience in Section 3.6).

3.5 Use

Portions of susceptible piping systems with normally closed valves will be evaluated to determine whether to include them or not in the list of susceptible piping systems. The following criteria will be used to categorize the portions of piping systems with normally closed valves:

3.5.1 Portions of piping systems with greater than 2% usage shall be included. Portions with less than 2% usage are considered to be "low usage" lines.

3.5.2 When the usage is indeterminate, the portion shall be included.

3.5.3 When a current low usage area has seen more frequent use in the past, the portion of the piping system shall be included.

3.5.4 Portions of piping systems with low usage but with flashing flow conditions when used, such that rapid wear may occur, shall be included.

3.5.5 Portions of piping systems with low usage but where industry or plant experience indicates that problems may occur shall be included. The "experience base" is obtained from historical performance as noted by the cognizant engineers, plant operation and maintenance personnel, and EPRI.

3.5.6 Portion of piping systems with greater than nominal valve leakage and flashing flow conditions or a history of leaking valves shall be included. (In general, valve leakage will be checked by a plant thermography program - the valves which are to be checked to verify lack of valve leakage shall be tabulated and provided to each of the units.)

Plant specific P&IDs are utilized for the review of susceptible systems and "low usage" areas. The P&IDs, once reviewed, are re-reviewed with a Senior Operator and Plant Engineer at each unit. Adjustments to the selection are made as appropriate based on input from the units operating and maintenance personnel.

3.6 Industry/Plant Experience

Systems known to be E/C susceptible based on industry or plant experience are included in the program. These include, for instance, low energy steam extraction lines which operate under vacuum conditions but are susceptible to erosion/corrosion. The industry experience systems are based on input from EPRI and the CHECMATE Users Group (CHUG), and review of industry literature [1,2]. Meetings and

communication with each units engineering staff and Plant Operators is also utilized to provide required input.

3.7 Pipe Size

Pipe with a nominal 2" diameter and above is included in the Large Bore Program. Piping with a nominal diameter less than 2" is included in the Small Bore Program. Both of these programs will be defined in detail in the following sections.

Appendix A lists the systems which resulted from the above evaluation and are included within this program for each plant as susceptible systems.

4.0 PIPING 2" AND GREATER

The following sections will describe criteria for component selection for inspection, for component evaluation, and for inspections to be performed on piping which is 2" and greater in diameter. The criteria defined in Section 3 is utilized to determine the system susceptibility.

4.1 Selection of Components for Examination

A component in a susceptible piping system is selected for inspection for any one of three reasons:

1. It is demonstrated to have a high erosion rate or low predicted remaining life (time to t_{min}), relative to the other components, by CHECMATE analysis.

2. It is E/C susceptible based on previous plant experience, industry experience, or E/C judgment.

3. It is the result of sample expansion based on the inspection of other locations.

4.1.1 CHECMATE Locations

For systems without sufficient historical inspection data, the CHECMATE analysis will be utilized to select components for initial examination based on E/C susceptibility. The initial examination will include the highest ranked components and other components of various types ranked among the most susceptible. These inspection results will be utilized to populate the analysis model with actual inspection data for analysis calibration purposes.

Prior inspections will be evaluated to determine the acceptability and usefulness of the inspection data. In general, the data will be utilized to

provide the inspection data required for CHECMATE calibration purposes.

Once an analysis model is calibrated by the initial examination data or by acceptable data taken in previous inspections, CHECMATE results shall be utilized to select inspection locations based on predicted component remaining life (time to t_{min}). The inspection data is inserted into CHECMATE and any required additional points identified prior to the startup of each unit.

4.1.2 Industry Experience Locations

The components which industry experience indicates are particularly susceptible are downstream of flow control valves, orifices/flow meters, exit nozzles, and feed pumps. The following examinations will be performed:

- downstream of all flow control valves.
- downstream of orifices/flow meters, exit nozzles, and feed pumps. At least one of these components from parallel trains will be selected for examination. If one parallel train can be shown to have a larger flow velocity or higher usage, it shall be selected for examination. A CHECMATE analysis will be utilized to demonstrate that the condition in the line selected for analysis is similar to the condition in the other line or lines. Significantly different flow conditions or geometries in parallel trains shall require that all trains be examined.

The "industry experience" components are those components identified by EPRI and the CHECMATE Users Group (CHUG), and review of industry literature is also utilized [1,2].

4.1.3 Plant Specific Experience Locations

The plant maintenance staff is consulted to determine the locations of previous thinning which has required repair or replacement. These locations will be integrated into the Restart Program.

4.1.4 Engineering Based Selections

Certain systems and pipe segments have usage and flow rates which cannot be accurately quantified because demand greatly varies or are controlled by a remote level, pressure, or temperature signal and

will not be analyzed in CHECMATE. The Aux Steam systems are an example of this in each of th. units. An approach to these lines will be utilized which bounds the susceptibility of the line to erosion/corrosion wear and identifies locations for examination.

Industry experience based inspections are performed on these lines. Additional locations will be specified. The additional locations will be specified in a manner to assure that significant variations in susceptibility due to usage, steam quality, velocity, or materials are represented and bounded. These selections will be based on CHECMATE experience.

4.2 Component Examinations

Ultrasonic testing by qualified and certified inspection personnel shall be utilized to detect wall thinning. Plant specific ISI procedures govern details of the inspection procedure and shall be reviewed by a qualified Level III UT inspector. The NU corporate procedure NU-UT-30 will be the required procedure for ultrasonic inspections.

Appendix B provides inspection requirements for inspections to be performed as a result of this program.

4.3 Engineering Evaluation of UT Data

All inspected components are to be evaluated for continued service and ultimately dispositioned as either "acceptable" or "repair/replace". The evaluation shall consider the projected wear rate, system design pressures, primary bending moments, material code allowable stresses, and percent of nominal pipe wall thickness remaining. This data will also be used to assure that acceptability of the uninspected components. The evaluations will meet NU Procedures NE&O 5.05 and 5.06.

The evaluations performed are necessary in order to determine if the component must be repaired or if it is acceptable to operate for the remainder of the current operating cycle. The evaluation method required is a function of the minimum measured component wall thickness and the minimum thickness which is predicted to exist at the end of the upcoming service period (t_{pred}). A 10% safety factor is added to the time to the next outage in the calculation of the predicted thickness at the time of the next outage. A flow chart of the evaluations is provided in Figure 3. The following evaluations shall be performed:

For $t_{pred} > 0.875\ t_{nom}$,

no further evaluation is required. The component is qualified for continued service.

For $t_{pred} < 0.300\ t_{nom}$,

these components shall be repaired or replaced and that component qualification through further analysis is not permissible.

For $0.3\ t_{nom} \leq t_{pred} \leq 0.875\ t_{nom}$,

analyses will be performed as required to assess wall degradation. Engineering guidelines will be utilized to assure consistency in the evaluation.

Component structural evaluations shall be performed to assure component qualification up to the next RFO. This qualification will assure that code minimum pipe wall requirements (t_{min}) are satisfied.

In addition to pressure stresses, the evaluation of components shall include consideration of pipe primary bending moments in accordance with the applicable construction code.

The initial evaluation shall assume that the minimum wall thickness extends uniformly over the entire component. If the wear region is localized, as demonstrated by inspection, a local stress evaluation may be performed in accordance with accepted structural mechanics methods.

All minimum wall thickness evaluations performed shall be consistent with the stress limit requirements of ANSI B31.1 or ASME Section III requirements as applicable to a specific unit and system. Meeting the required Code applicable to each unit provides inherent margin to failure, which provides protection against occasional unanalyzed loads, such as waterhammer.

Failure to meet the structural acceptance criteria specified requires component repair or replacement in accordance with an approved repair plan.

4.4 Sample Expansion

4.4.1 Measured Thickness Less Than 70% of Nominal Thickness

The examination sample shall be expanded if wall thinning due to erosion/corrosion results in a measured thickness (t_{meas}) less than 70% of the nominal thickness (t_{nom}). The sample expansion shall require examination of the next two susceptible locations in the same train and the equivalent location in a parallel train, if any. CHECMATE analysis, observed thinning trends, and prior test data will be utilized to identify the next two locations for sample expansion in the same train.

4.4.2 Predicted Thickness Less Than Minimum Thickness

The examination sample shall be expanded if wall thinning due to erosion/corrosion results in a predicted wall thickness (t_{pred}) at the next refueling outage less than the calculated minimum acceptable wall thickness (t_{min}). The sample expansion shall require examination of the next two susceptible locations in the same train and the equivalent location in a parallel train, if any. CHECMATE analysis, observed thinning trends, and prior test data will be utilized to identify the next two locations for sample expansion in the same train.

The sample expansions shall continue until either the measured thicknesses are greater than 70% t_{nom} or the predicted thicknesses are greater than t_{min}. Previous data, if taken at a location of a required sample expansion location, will be evaluated as a sample expansion inspection.

4.4.3 CHECMATE Locations

As a result of inspections, additional CHECMATE inspection locations may be specified as described in Sections 2.3 and 4.1.1.

4.5 Documentation

The documentation for the evaluation will be prepared following normal quality assurance related documentation procedures. The following records will be developed and maintained.

- Evaluations to identify system susceptibility
- CHECMATE packages
- Ranking of components
- Selection of Inspection Locations
- Evaluations of wall thickness
- Sample expansion inspection location selection
- NDE inspection records

The screening and analysis packages shall be signed by the originator and checker. CHECMATE packages shall include a printout of the CHECMATE input file, a marked P&ID to show the system boundaries, the applicable isometric drawing or sketch to show component locations, a description of assumptions, and any telecons, data transmittals, or other documentation used to create the model. The inspection data and the resolution of the inspection data shall be included in a UT Data Folder.

All records will be submitted to the NU Nuclear Plant Records Facility (NPRF) for retention.

5.0 PIPING LESS THAN 2" IN DIAMETER

The following sections will describe the specific evaluations and inspections to be performed on piping which is less than 2" in diameter. The small bore piping will be evaluated on a sample basis for the Restart Evaluation. The objective of the small bore piping evaluation is to provide a high degree of confidence that a small bore pipe rupture will not occur to compromise plant operation or personnel safety. A methodical and systematic review of small bore piping shall be conducted to satisfy this objective.

The inspection and the sample expansion utilized will form a baseline for additional examination at future outages.

Plant maintenance history will be utilized to provide additional assurance that small bore piping is satisfactory. Thermography, for example, on traps to determine leakage is an effective tool to minimize the extent of erosion-corrosion damage. Previously performed inspections on small bore piping will also be fully utilized in this Restart Program.

5.1 Small Bore Screening

The Small Bore Program will evaluate piping with diameters of 3/4" to 1 1/2". The same criteria as utilized in Section 3 for screening large bore systems shall be used for small bore systems.

5.2 Component Selection

Components to be examined will be selected from the systems selected in Section 5.1 above. The component selections will include components in areas known to have erosion/corrosion susceptibility. This will include the following locations:

Downstream of flow control valves

Downstream of orifices

Upstream and downstream of steam traps

Large Bore or component take-offs in two phase flow areas

Last two changes in direction prior to condenser

Downstream of all flow control valves will be inspected. Inspections of one parallel train will be utilized for the other locations identified.

These locations shall be selected by detailed review of the P&IDs. Elbows and other fittings, at locations of potentially

high erosion-corrosion susceptibility, will also be selected for examination either from isometrics or during walkdowns of the susceptible systems at each unit.

5.3 Component Examinations

The procedure for component examination is identical to that specified for large bore piping in Section 4.2. Appendix B provides inspection requirements for inspections to be performed as a result of this program. As stated in Appendix B, 100% scanning may be utilized in small bore piping when the component size precludes the use of grids.

5.4 Engineering Evaluation of UT Data

The approach for evaluation of UT data is similar to that specified for large bore piping in Section 4.3.

5.5 Sample Expansion

The approach for sample expansion is similar to that specified for large bore piping in Section 4.4.

5.6 Documentation

The requirements for documentation is similar to that specified for large bore piping in Section 4.5.

6.0 QUALITY CRITERIA/INDEPENDENT REVIEWS/EXEMPTIONS

6.1 Quality Criteria

6.1.1 All CHECMATE analyses will be performed by trained and experienced personnel.

6.1.2 All NDE inspections will be performed by trained personnel certified with the use of qualified procedures.

6.1.3 All structural evaluations will be performed by qualified and experienced personnel in accordance with the intent of NE&O procedures 5.05 and 5.06.

6.1.4 All records and documentation specified in Sections 4.5 and 5.6 will be maintained and submitted to NFRP within six months after start-up.

6.2 Independent Reviews

The following tasks and/or evaluations will be independently reviewed to assure high quality and success of the Restart Program. The objective of the independent reviews is to ensure (1) that all inspection locations have been correctly identified, (2) that all identified locations have been

inspected and properly dispositioned, and (3) that all repairs/replacements have been completed prior to start-up.

6.2.1 Summary list of all inspection locations and supporting evaluations.

6.2.2 Summary list of all inspections conducted as well as prior inspections credited.

6.2.3 Summary list of all DRF's, NCR's and PDCR's and supporting documentation.

In addition, an independent review and/or surveillance of specific tasks and activities will be performed to ensure procedural compliance.

6.3 Exemptions

All exemptions and/or exceptions to the technical criteria imposed on the Restart Program must be documented and receive Station Management or Engineering Management approval.

The exception/exemption evaluation and review and approval should be per the intent of NE&O Procedure 5.11, "Design Change Notices for Design Documents" except that the proposed disposition must receive approval from Station Management or Engineering Management. Figure 4 is a form for requesting an inspection exemption or an alternate inspection location.

7.0 REFERENCES

1. CHECMATE User's Manual, EPRI, "Two-Phase Erosion-Corrosion Analysis Package", NSAC/145L, April 1989.

2. CHECMATE User's Group (CUG) Newsletters, Various.

3. NE&O 5.05, "Design Input and Verification."

4. NE&O 5.06, "Engineering Analysis and Design."

5. NE&O 5.11, "Design Change Notices for Design Documents."

PROGRAM RESTART ACTIVITIES

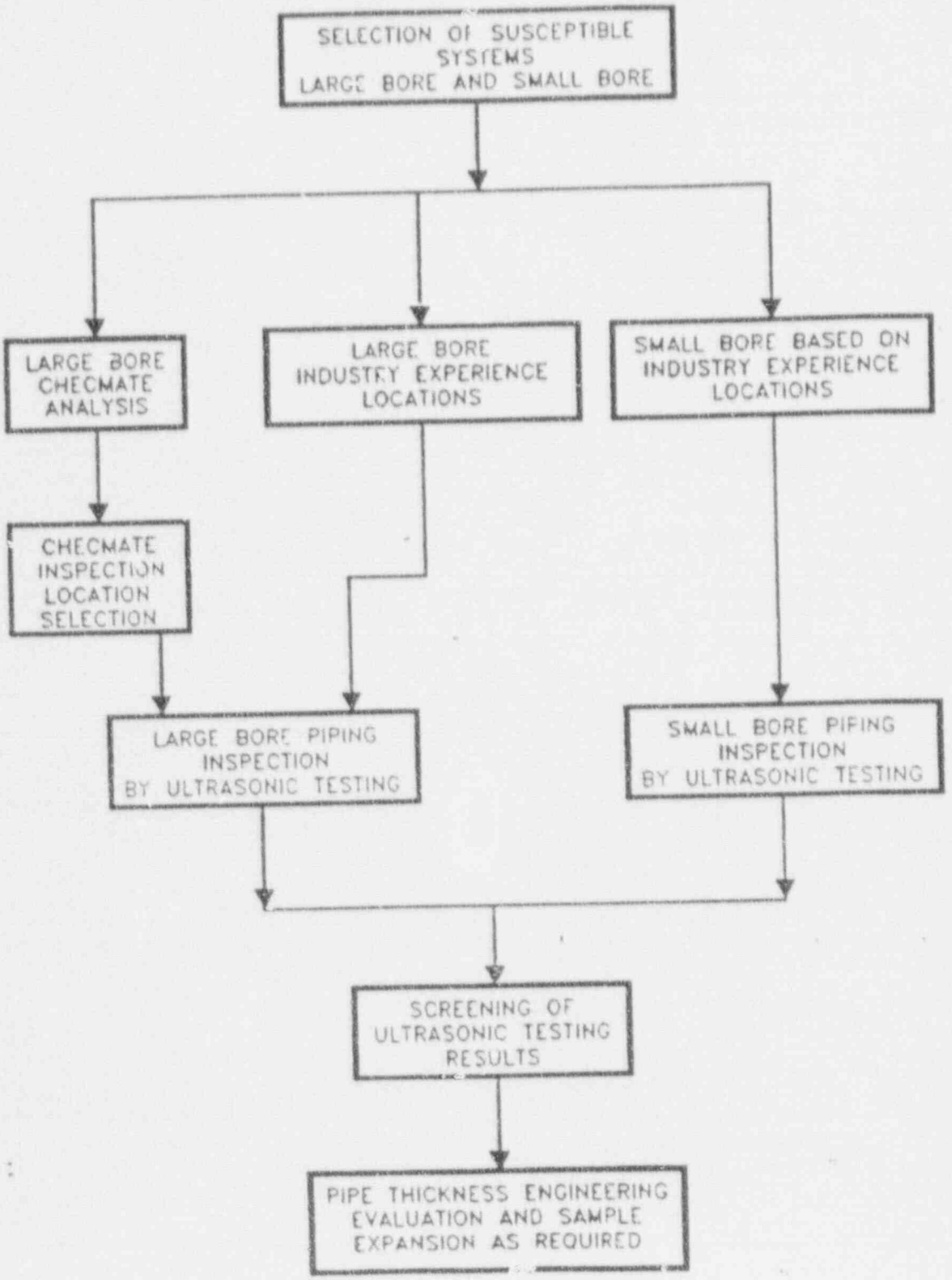

FIGURE 1

FILE NO. 91155A/FIG-1

PLANT SYSTEM SCREENING

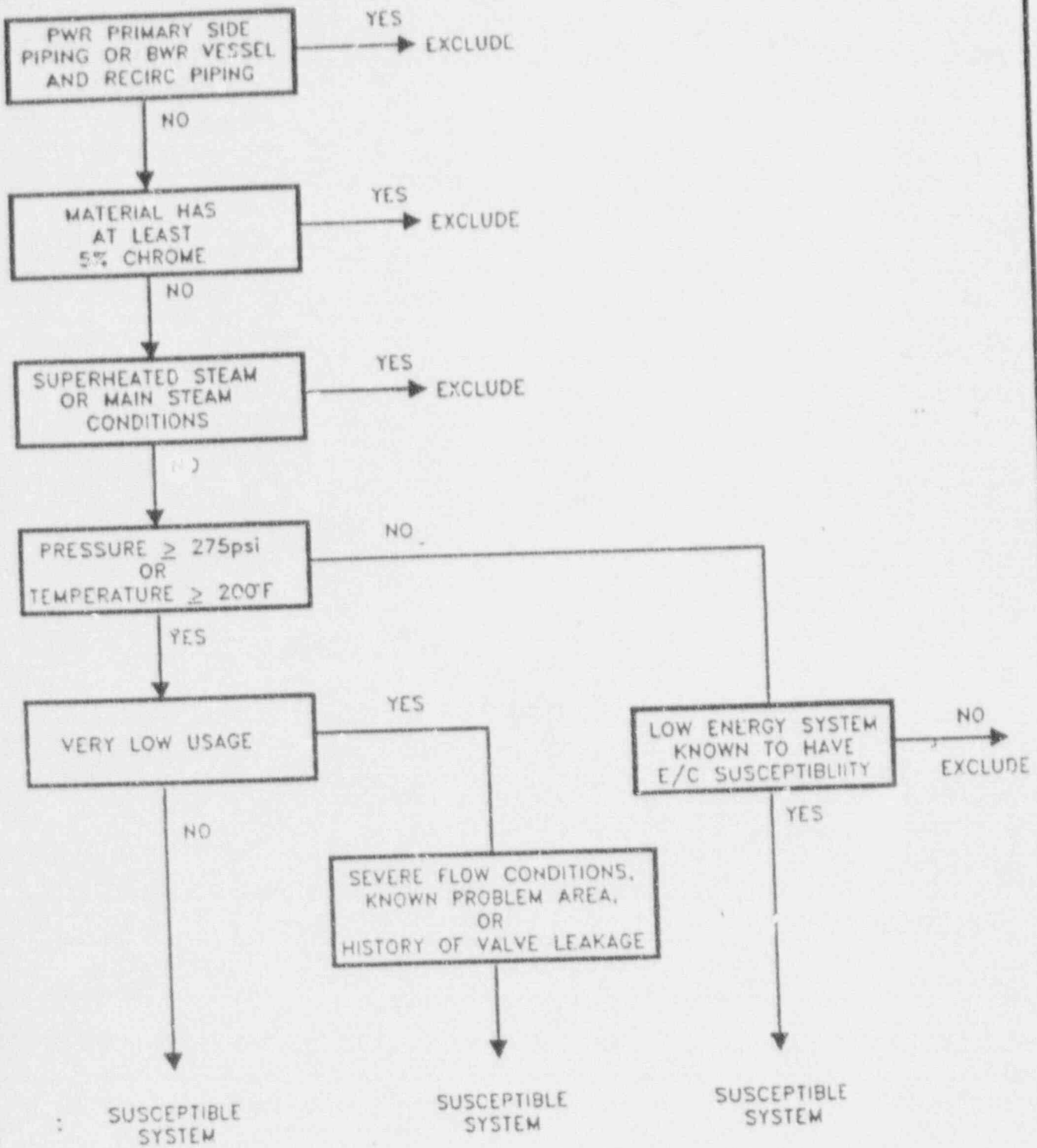

FIGURE 2

FILE NO: 91135A/FIG-2

PIPE WALL EVALUATION

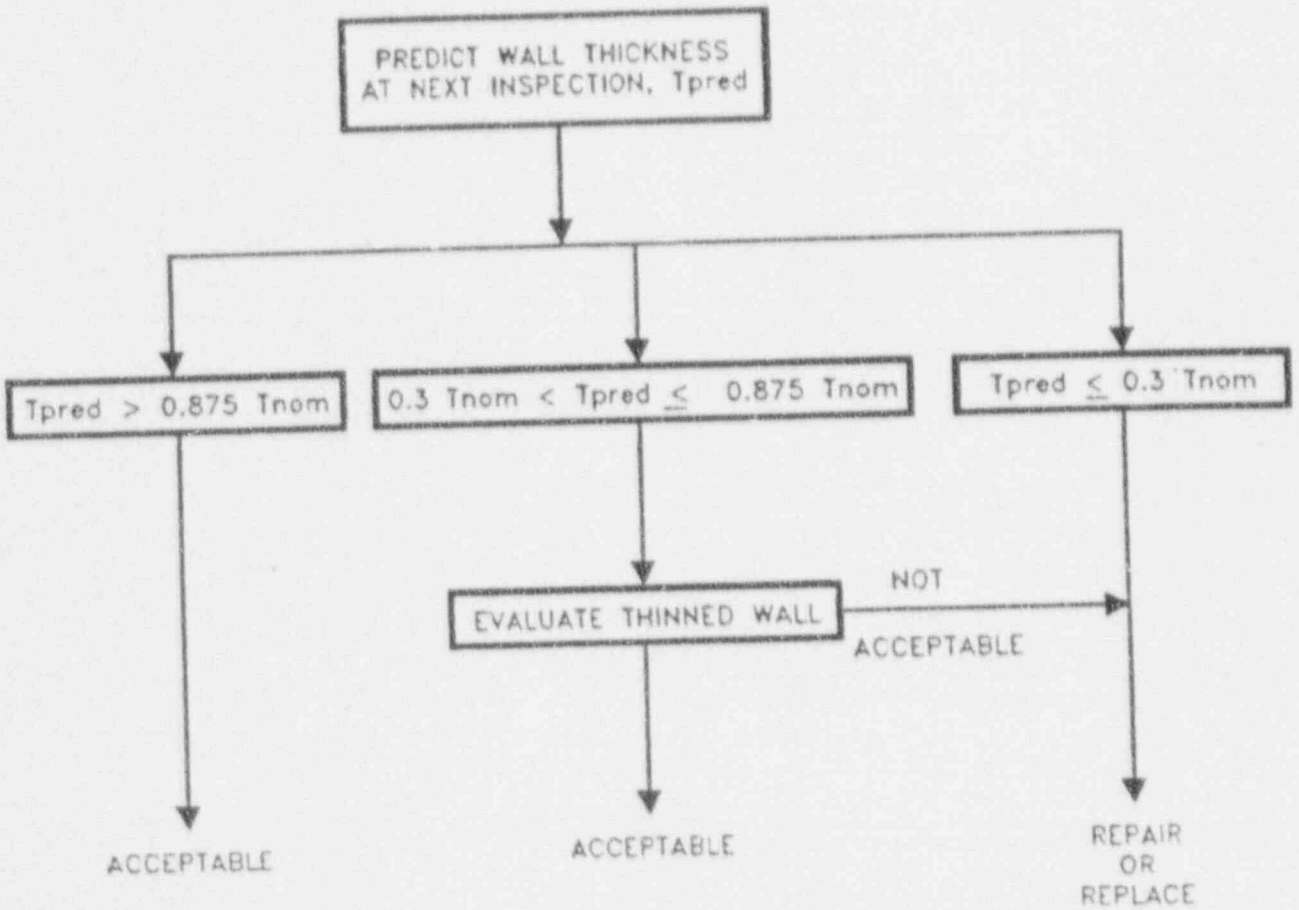

FIGURE 3

FILE NO. 91155A/FIG-3

Figure 4

EROSION/CORROSION RESTART PROGRAM
REQUEST FOR INSPECTION EXEMPTION OR ALTERNATE INSPECTION LOCATION

I. Request

Review of the following identified item is requested.

Plant: MP1 ___ MP2 ___ MP3 ___ CT ___

Item Identifier: _____

Basis for Request: _____

_____ _____

ISI Supervisor/Date

II. Resolution

A. Inspection of specified location required. Yes ___

Basis for above determination. _____

B. Other Options ___ If "Other Options" is checked, please select one of the following:

1. Alternate Inspection is required. Yes ___ No ___

Location: _____

Basis for Selection: _____

2. Consequences Tolerable, inspection to be deferred. Yes ___ N/A ___

Selection of this option requires the location to: a)not represent a potential source of personnel injury, and b) not challenge plant operation.

Basis for Selection: _____

_____

3. Waiver with Compensatory Measures, inspection to be deferred.Yes ___ N/A ___

Compensatory Measures being taken: _____

_____

Prepared By: _____ Approved By: _____
Engineering/Date NU Engineering Manager/Date

Reviewed By: _____ Approved By: _____
NU Engineering/Date Unit Director/Date

If yes to Items 2 or 3 above, Executive Approval Is Required:

_____
Vice President/Date

Appendix A

SYSTEMS INCLUDED IN THE E/C EVALUATION

MILLSTONE UNIT 1

E/C SYSTEM INCLUSION LIST

1. Condensate
2. Feedwater
3. Feedwater Heater Drains
4. Moisture Separator Drains
5. Extraction Steam
6. Crossunder
7. Feedwater Heater Vents
8. Gland Steam
9. Auxiliary Steam
10. Feedwater Recirc
11. Main Steam Drains
12. Auxiliary Steam Drains
13. MSIV & Turbine Valve Drains & Leakoff
14. Cross Around Drains
15. Turbine Bypass Valve Drains
16. Steam Seal System Drains
17. Extraction Steam Drains
18. Feed Pump Seal Piping
19. CRD Pump Seal
20. CRD Return

MILLSTONE UNIT 2

E/C SYSTEM INCLUSION LIST

1. Condensate
2. Feedwater
3. Feedwater Heater Drains
4. Moisture Separator Drains
5. Reheater Drains
6. Steam Generator Blowdown
7. Extraction Steam
8. Cold Reheat (cross under)
9. Reheater Vents
10. Feedwater Heater Vents
11. Feedwater Recirc
12. Gland Steam
13. Auxiliary Steam
14. Main Steam Drains
15. Auxiliary Steam Drains
16. MSIV & Turbine Valve Drains & Leakoff
17. Cross Around Drains
18. MSR Vents & Drains
19. Turbine Bypass Valve Drains
20. Steam Seal System Drains
21. Feed Pump Turbine Supply Drains
22. Extraction Steam Drains
23. Heating Steam
24. MSR Shell Drains

MILLSTONE UNIT 3

E/C SYSTEM INCLUSION LIST

1. Condensate
2. Feedwater
3. Feedwater Heater Drains
4. Moisture Separator Drains
5. Reheater Drains
6. Reheater Vents
7. Extraction Steam
8. Cold Reheat (cross under)
9. Steam Generator Blowdown
10. Feedwater Heater Vents
11. Feedwater Recirc
12. Gland Steam
13. Auxiliary Steam
14. Main Steam Drains
15. Auxiliary Steam Drains
16. MSR Shell Drains
17. MSIV & Turbine Valve Drains & Leakoff
18. Cross Around Drains
19. MSR Vents & Drains
20. Turbine Bypass Valve Drains
21. Steam Seal System Drains
22. Feedwater Pump Turbine Supply Drains
23. Extraction Steam Drains
24. Feed Pump Seal Piping
25. Hot Water Heating

CONNECTICUT YANKEE

E/C SYSTEM INCLUSION LIST

1. Condensate
2. Feedwater
3. Feedwater Heater Drains
4. Moisture Separator Drains
5. Reheater Drains
6. Reheater Vents
7. Extraction Steam
8. Cold Reheat (cross under)
9. Steam Generator Blowdown
10. Heater Vents
11. Turbine Plant Misc. Drains
12. Feedwater Recirc
13. Gland Steam
14. Auxiliary Steam
15. Main Steam Drains
16. Auxiliary Steam Drains
17. MSR Shell Drains
18. MSIV & Turbine Valve Drains & Leakoff
19. Cross Around Drains
20. MSR Vents & Drains
21. Turbine Bypass Valve Drains
22. Steam Seal System Drains
23. Feed Pump Turbine Supply Drains
24. Extraction Steam Drains
25. Feed Pump Seal Piping
26. Hot Water Heating

Appendix B

INSPECTION REQUIREMENTS

1. Grid size = π(OD)/12 or less but no greater than 6" and no smaller than 1", both in the circumferential and axial directions, along the neutral axis.

2. Circumferential grid lines shall be normal to flow.

3. Coverage: 2 Grid Bands upstream to 2 DIAMETERS downstream. (Minimum of 6")

4. Diffusers and expanding elbows: 2 Diameters upstream to 2 Diameters downstream (Minimum of 6").

5. Branch pipe welded to main pipe: 2 Branch Pipe Diameters plus 1 Main Pipe Diameter downstream in the branch pipe from the centerline of the main pipe (minimum of 6"), 3 Main Pipe Diameters downstream from the centerline of the branch along the main pipe (minimum of 6"), 2 Grid Bands plus 1 Main Pipe Diameter upstream of the centerline of the branch pipe along the main pipe.

6. If a component other than a valve is encountered within the required 2 diameter inspection region of the original component, the inspection region shall be extended to include that component. For valves, the inspection region shall extend up to the valve.

7. For control valves, inspect downstream weld prep region and attached contiguous fittings (e.g. reducer and elbow) plus 2 Diameters downstream. If there is a change in direction within 5 Diameters, that component shall also be inspected.

8. Accuracy of Equipment and Technique to be qualified:

   for $t_{nom} \geq 0.25$ inch, $\pm$ 5% of t_{nom}
   for $t_{nom} < 0.25$ inch, $\pm$ 0.005 inch

9. Record readings at grid intersections.

10. If grid size is greater than 2 inches and the measured wall thickness at a grid intersection is less than 87.5% t_{nom}, scan the area of the four adjacent grids and record the minimum thickness.

11. Data logger recording requirements shall be consistent with EPRI CHEC-NDE software requirements in order to expedite engineering review.

12. For piping less than 2" in diameter, 100% scanning may be utilized if a component size limitation prevents the utilization of a grid layout.

13. When the t_{meas} for piping or components downstream of pumps, valves and nozzles is such that piping or component replacement is required, perform a visual examination of the inside surface of the pump, valve, or nozzle during pipe repair/replacement. If there is significant wear evident in the component pressure boundary, a UT examination shall be performed on the component.

Docket Nos. 50-213
50-245
50-336
50-423

Attachment No. 2

Haddam Neck Plant
Millstone Nuclear Power Station, Unit Nos. 1, 2, and 3
Erosion/Corrosion Program Update

Millstone Unit No. 2 Erosion/Corrosion Program Exemptions

January 1992

MILLSTONE UNIT NO. 2 E/C PROGRAM INSPECTION EXEMPTIONS

NONHEATUP
Group*/Item

Aux Steam System--2-week deferment (from start-up) based on:

-- No E/C identified by inspections to date.
-- Visual inspection of similar piping at Millstone 1 showed piping was designed with large margins of safety.
-- Max operating conditions 50 psig and 298°F.
-- Normal operating conditions 35 psig and 298°F.

CM 53/61 — Extraction steam inside condenser:

-- 5th PT extraction steam to LP FW heaters 5A & B.
-- 20" HBD 281--horizontal straight run.
-- No personal safety consequences since inside condenser.
-- Leak would result in decreasing vacuum and turbine performance.

CM 53/18 -- 20" HBD 281--same as CM 53/61 except location in an elbow.

CM 54/10A -- LP Turbine 12th stage to LP heater 6A & B--same consequence evaluation as CM 53/18 & 61.

CM 54/20A -- Same as CM 54/10A.

EXPN/109 — 3/4" HBD 228--vacuum line from SGFP turbine to condenser penetration.

-- Leak detected by increase in CPD oxygen and SJAE flow rates--20120 Sh. 1.

137/200 — 12th stage LP 1A extraction steam to LP FW heaters 6A & B.

-- Within condenser--no personal safety consequences.
-- Same as CM 53/18.

138/201 — Same as 137/200.

EXPN/
(Ref. Request M2-91-76) — 1 1/2" HBD 275 miscellaneous turbine drains to condenser

-- Under vacuum.
-- Alternate downstream inspection data shows adequate margins.

17/32 — Reheater drain to 2nd stage drain tank 1A.

-- Line was cut and replaced last outage showing no thinning at fit-up.
-- Adjacent point shows little wear.

* CM designates CHECMATE isometric drawing and component number.

18/33	Same as 17/32 (12" GBD 32).
18/49	12" GBD 36 downstream of X31B. -- Other related inspection data showed minimal wear. -- Line was cut and rewelded at last outage. Fitup showed no thinning.
SSB/WD18	S/G feed pump turbine valve LP below seat drains. 3/4" HBD 226. -- Review of parallel line and upstream inspection data was substituted. -- Exempted a socket welding elbow and straight horizontal run.
001/003	18" GBD 13--20150 Sh. 121--Pump 2C--main feed--parallel line inspection.
CM 41/41	18" EBB 6--Main feedwater inside containment to S/G 1--Adequate coverage provided by 2/89 inspections of similar components.
SBIED/200	2" GBD 13--20119 Sh. 84--FO 5393 condensate--low usage.
SLBWD/LBW09	2" HBD 47--20119 Sh. 3--aux feed--low usage.
SSBWD/WD16	2" HBD 47--20119 Sh. 3--aux feed--low usage.
SSBWD/WD17	2" HBD 47-20119 Sh. 4--aux feed--low usage.
122/173	8" GE PPG--H2 (Gland Seal)--inaccessible/acceptable consequences.
123/177	4" GE PPG-H2 (Gland Seal)--inaccessible/acceptable consequences.

NOTE:

PT = Point

HBD = 150 pound, carbon steel, B31.1

CPD = Condensate pump discharge

GBD = 300 pound, carbon steel, B31.1

SJAE = Steam Jet Air Ejector

* CM designates CHECMATE isometric drawing and component number.