RAS M-321

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	EN-DC-315	REV. 0
		INFORMATIONAL USE	PAGE 1 OF 34	
Flow Accelerated Corrosion Program				

Procedure Contains NMM REFLIB Forms: YES ☐ NO ☒

Effective Date	Procedure Owner:	W. A. Eaton	Executive Sponsor:	W. A. Eaton
12/1/2006	Title:	VP Engineering	Title:	VP Engineering
	Site:	Echelon	Site:	Echelon

Exception Date*	Site	Site Procedure Champion	Title
	ANO	William G. Smith	Technical Specialist III
	GGNS	Bruce Lee	Technical Specialist IV
	IPEC	Richard Burroni	Manager, P&CE
	JAF	Joe Pechacek	Manager, P&CE
	PNPS	Gearld Bechen	Senior Engineer
	RBS	Reggie Jackson	Technical Specialist IV
	VY	Larry Lukens	Engineering Supervisor
	W3	Paul Stanton	Engineering Supervisor
	ECH	Charles Turk	Manager, Design Engineering
	WPO	Robert Penny	Manager, Engineering Programs

Site and NMM Procedures Canceled or Superseded By This Revision

- **ENN DC-315**
- **ENS-DC-315**

Process Applicability Exclusion)

All Sites: ☐ Specific Sites: ANO ☐ GGNS ☐ IPEC ☐ JAF ☐ PNPS ☐ RBS ☐ VY ☐ W3 ☐

Change Statement

Initial issue of fleet procedure which replaces ENN-DC-315 and ENS-DC-315.

*Requires justification for the exception

Template Secy-028

DS-03

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1.0 PURPOSE

[P-33641 - P-33643], [P-33645], [P-33714 – P-33719], [P-33730], [P-35351], [JAFP-87-0737], [JPN-89-051], [IP3-87-055Z], [IPN-89-044], [BECo-89-107], [FVY-89-66], [FVY-87-94], [FVY-87-121], [P-1079], [P-35269], [P-24444], [P-15802], [P-15803], [P-16557], [P-20303], [P-22888]

[1] The purpose of this procedure is to provide requirements for establishing and maintaining an effective Flow Accelerated Corrosion (FAC) Program that will standardize Entergy Nuclear Fleet's approach towards mitigating FAC damage.

[2] This procedure uses a systematic approach for long term monitoring to enhance the reliability of the affected FAC components by reducing the probability of failures and reduces maintenance costs associated with unplanned or unnecessary repairs.

[3] This procedure provides criteria and methodology for selecting components for inspection, performing inspections, evaluating inspection data, disposition of results, sample expansion requirements, piping repair /replacement criteria, program responsibilities and documentation requirements.

[4] This program is applicable to carbon steel plant piping systems and includes feed water heater and moisture separator re-heater (MSR) shells susceptible to FAC. It includes inspections of single-phase and two-phase piping components for both safety and non-safety related systems.

[5] This procedure may be used as a guide for evaluating systems and components that are not included in the FAC program.

2.0 REFERENCES

[1] NRC Generic Letter 89-08, Erosion/Corrosion Induced Pipe Wall Thinning.

[2] NUREG-1344, "Erosion/Corrosion-Induced Pipe Wall Thinning in U.S. Nuclear Power Plants."

[3] NSAC 202L, latest revision, EPRI Document, "Recommendations for an Effective Flow Accelerated Corrosion Program"

[4] EPRI Technical Report, TR-106611, "Flow-Accelerated Corrosion in Power Plants"

[5] NRC Bulletin No. 87-01, "Pipe Wall Thinning."

[6] EN-LI-102, "Corrective Action Process."

[7] Erosion/Corrosion in Nuclear Power Plant Steam Piping: Causes and inspection Program Guidelines. EPRI, April 1985. NP-3944.

2.0 cont.

[8] ENN-NDE-9.05,"Ultrasonic Thickness Examination"

[9] ANSI B31.1 "Power Piping", (For applicable code year see individual plant FSAR).

[10] ENN-DC-126, "Calculations".

[11] ENS-DC-126, "Engineering Calculation Process".

[12] ENS-DC-126-01, "Engineering Calculation Process".

[13] ENN-CS-S-008, "Pipe Wall Thinning Structural Evaluation".

[14] ENS-PS-S-001, "Pipe Wall Thinning and Crack-like Flaw Evaluation Standard".

[15] Site ASME XI Repair / Replacement Program as applicable.

[16] ENN-EP-S-005 "Flow Accelerated Corrosion Component Scanning and Gridding Standard".

[17] EPRI Paper, "Single-Phase Erosion/Corrosion of Carbon Steel Piping", February 1987.

[18] EPRI Paper - "Practical Consideration for the Repair of Piping Systems Damaged by Erosion/Corrosion", dated 10/5/87

[19] Acceptance Criteria for Structural Evaluation of Erosion/Corrosion Thinning in Carbon Steel Piping. EPRI, April 1988. NP-5911.

[20] NRC Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repairs of ASME Code Class 1, 2 &3 Piping".

[21] INPO SOER 87-3, "Piping Failures in High-Energy Systems Due to Erosion/Corrosion", March 1987.

[22] INPO Significant Operating Experience Report (SOER) 82-11, "Erosion of Steam Piping and Resulting Failure", February 1982.

[23] IN 93-21, Summary of NRC Staff Observations compiled during Engineering Audits on inspections of Licensee E/C Programs", dated March 25, 1993.

[24] EPRI CHUG Position Paper #3, "A Summary of Tasks and Resources Required to Implement an Effective Flow Accelerated Corrosion Program."

2.0 cont.

[25] EPRI CHUG Position Paper #4,"Recommendations for inspecting Feedwater Heater Shells for Flow-Accelerated Corrosion Damage", February 2000.

[26] CHECWORKS Steam /Feedwater Application, "Guidelines for Plant Modeling and Evaluation of Component Inspection Data", EPRI No. 1009599, Final Report, September 2004.

[27] Entergy Quality Assurance Manual

[28] ENN FAC Qualification Card ENN-TK-ESPG-042, "Implementing the Flow Accelerated Corrosion Program ".

[29] ENN/ENS-DC-115, "Engineering Response Development".

[30] EN-DC-115, Engineering Change Development"

[31] EOI-C-QC-ESPP-PFAC- "Qualification card for Flow Accelerated Corrosion Engineers".

[32] EN-DC-202, "NEI 03-08 Materials Initiative".

[33] JAF-SPEC-MISC-03290 Rev.0, "Specification for Evaluation and Acceptance of Local Areas of material, parts and components that are less than the specified thickness." By REEDY Engineering.

[34] IP3-SPEC-UNSPEC-02996 Rev.0, "Specification for Evaluation and Acceptance of Local Areas of material, parts and components that are less than the specified thickness." By REEDY Engineering.

[35] CHECWORKS Steam /Feedwater Application, Version 2.1, EPRI No. 1009600, Final Report, October 2004.

[36] CHECWORKS Steam /Feedwater Application, latest version.

[37] Institute of Nuclear Plant Operations, "Engineering Program Guide, Flow Accelerated Corrosion", EPG-06 (Pending).

3.0 DEFINITIONS

[1] Base Line Inspection – An initial wall thickness measurement of a component taken prior to being placed in service.

[2] Basis Document - Program documents that define the scope, attributes, commitments, evaluation reports and predictive models that forms the basis of the FAC program (i.e., System Susceptibility Evaluation reports). These documents contain the basis for the plant piping in the CHECWORKS model, the susceptible-not-modeled (SNM) piping and those that are non-susceptible.

[3] Code Minimum Thickness (t_{min}, $t_{codemin}$) – The minimum required global wall thickness based on hoop stress.

[4] Critical Thickness ($t_{crit,}$) -The minimum required wall thickness per code of construction required to meet all design-loading conditions.

[5] Deficient Component - A component identified by examination to be below t_{accpt} wall thickness or projected to be below t_{accpt} wall thickness by the next refueling outage.

[6] Degraded component – A component identified as being below the screening criteria that is acceptable for continued operation.

[7] EPRI CHUG – EPRI CHECWORKS USERS GROUP.

[8] Examination - Denotes the performance of all visual observation and nondestructive testing, such as radiography, ultrasonic, eddy current, liquid penetrant and magnetic particle methods.

[9] Examination Checklist/ Traveler – A data sheet developed for the components being inspected and may contain but is not limited to the following: t_{nom}, t_{meas}, Tmin, Screening criteria, components name, system number, previous data, inspection datasheet number, grid size, examination extent, work order and affiliated minimum wall calculation.

[10] Flow Accelerated Corrosion (FAC) - Degradation and consequent wall thinning of a component by a dissolution phenomenon, which is affected by variables such as temperature, steam quality, steam/fluid velocity, water chemistry, component material composition and component geometry. Previously known as Erosion/Corrosion.

3.0 cont.

[11] Grid - A pattern of points or lines on a piping component, where UT thickness measurements will be made. Grid may be permanently marked with circumferential and longitudinal grid lines.

[12] Grid Point – A Specific location on a piping component, where a UT thickness measurement will be made. Grid points are at the intersections of the circumferential and longitudinal grid lines.

[13] Grid Point Reading – UT reading taken at the intersection of the grid location.

[14] Grid Scan– 100% scans of the area between the grid lines. The lowest measurement in each area to be recorded as the measured thickness.

[15] Full Scan – scans of 100% of an area, circumference, nozzle, heater segments etc, measuring minimum, maximum and averages thicknesses and approximate location of minimum measured thickness.

[16] Grid Size - The distance between grid points in the circumferential or longitudinal direction. Also called grid space or grid spacing.

[17] Initial Thickness (t_{init}): The thickness determined by ultrasonic examination prior to the component being placed into service (baseline) or the first ultrasonic examination during its service life. If an examination has not previously been performed on the component, the initial thickness shall be determined by reviewing the initial ultrasonic data for that component. The area of maximum wall thickness within the same region as the worn area (based on the method selected for evaluating wear) shall be identified and compared to t_{nom}. If the thickness is greater than t_{nom}, the maximum wall thickness within that region shall be used as t_{init}. If that thickness is less than t_{nom}, t_{nom} shall be used as t_{init}.

[18] Inspection Location - A specific component (i.e., elbow, tee, reducer, straight pipe section).

[19] Inspection Outage - the outage during which the component was inspected.

[20] Large-bore Piping - Piping generally greater than 2" nominal pipe size with butt-weld fittings.

[21] Line Scans– piping segments broken into one-foot lengths (Small-Bore pipe).

3.0 cont.

[22] Minimum acceptable wall thickness (t_{accpt}) – Maximum value of axial stress, hoop stress, and or critical thickness and the piping replacement values of 0.3 t_{nom} for Class1 piping or 0.2 t_{nom} for Class 2, Class 3 and non-safety related piping.

[23] Minimum Measured Thickness - (t_{meas} or t_{mm}) as identified by ultrasonic thickness examination, the present thickness at the thinnest point on a component.

[24] Local minimum required thickness – (t_{aloc}) Minimum acceptable local wall thickness as calculated by ENN-CS-S-008 or ENS-PS-S-001.

[25] Minimum required thickness – (t^{a}_{min}) Minimum required pipe wall thickness based on axial stress (See ENN-CS-S-008) .

[26] Next Scheduled Inspection (NSI) -The outage at which an inspection will be performed on a given component.

[27] Nominal Thickness (t_{nom}) - Wall thickness equal to ANSI standard thickness.

[28] PASS 1 Analysis - Runs modeled in CHECWORKS that either have no inspection data, an insufficient number of inspections to provide a proper calibration, or where there is no expectation of ever developing a proper calibration.

[29] PASS 2 Analysis - The process of utilizing UT inspection data thickness measurements in CHECWORKS to predict wear and wear rates for components.

[30] Piping Segment - A run of piping that consists of inspection locations which have common operating parameters (i.e., temperature, pressure, flow rate, Oxygen content and pH level).

[31] Predicted /Projected Thickness (t_p, t_{pred}) -The calculated thickness of a component based upon a rate of wear to some point in time (e.g., next refueling, next scheduled examination).

[32] Quadrant Scan– Piping segments divided in quadrants A, B, C, D that are 90 degrees apart and broken into one-foot lengths, or as specified by the FAC engineer.

3.0 cont.

[33] Qualified FAC Engineer- Individual who has completed the FAC Qualification Card, who participates in the Engineering Support Personnel (ESP) training program and demonstrates knowledge required for the use of the CHECWORKS computer program.

[34] Reference Point - The point on a piping component where the longitudinal and circumferential grid lines originate.

[35] Remaining Service Life (RSL) - The amount of time remaining based upon an established rate of wear at which the component is anticipated to thin to t_{accpt}.

[36] Safety Factor – A Margin of Safety used to account for inaccuracies in wear rate evaluation.

[37] Sample Expansion - The addition of inspection locations based on significant or unexpected wall thinning during planned inspection(s).

[38] Significant wall thinning - Wall thinning to a thickness which is the largest of:

(a) a thickness less than 60% of pipe nominal wall thickness

(b) Wall thinning to a thickness that is half the remaining margin of the piping/ component which is above t_{accpt}. [½ (0.875 t_{nom} + t_{accpt})]

(c) (t_{accpt} + 0.020) inch.

[39] Small-bore Piping - Piping that is generally 2" or less nominal diameter and that typically uses socket welded fittings.

[40] Subsequent Inspection - Inspection of components that have had a baseline inspection and/or an initial operational inspection.

[41] Susceptible Line - Piping determined to be susceptible to FAC using the EPRI susceptibility criteria in NSAC 202L, industry experience and as documented in the System Susceptible Evaluation.

[42] Susceptible Non-Modeled (SNM) Piping - A subset of the FAC susceptible lines that cannot be modeled using the EPRI CHECWORKS software.

[43] Time - Time in service shall be actual hours on line or of operation and/ or hours critical. Calendar hours may be used for conservatism.

3.0 cont.

[44] Train – Loops within subsystems that have similar geometries, flow rates and temperatures and which have similar FAC risk.

[45] UT Datasheets - Paperwork that documents the results of the ultrasonic thickness inspections.

[46] Wear (W) - The amount of material removed or lost from a components wall thickness since baseline or subsequent to being placed in service.

[47] Wear Rate (WR) - Wall loss per unit time.

4.0 RESPONSIBILITIES

4.1 MANAGER, ENGINEERING PROGRAMS

[1] Providing a single point of accountability and is responsible for the overall health and direction of the FAC programs.

[2] Ensuring that the FAC programs are effectively developed and implemented.

[3] Providing oversight for implementing the FAC programs.

[4] Co-ordinate ENN or ENS FAC working group meetings.

[5] Co-ordinate ENN or ENS FAC Self-Assessments.

4.2 SUPERVISOR, CODE PROGRAMS

[1] Designate responsible engineer/Personnel from the Code Programs Engineering Group for the implementation and maintenance of the Flow Accelerated Corrosion Program.

[2] Ensure that the Flow Accelerated Corrosion Program activities are conducted in accordance with this procedure.

[3] Shall ensure that repair procedures are in place to support any planned repairs or replacements.

[4] Ensure audits and surveillance of selected Flow Accelerated Corrosion (FAC) activities is performed to verify compliance with applicable codes, procedures and drawings.

4.2 cont.

[5] Provides personnel to perform NDE during normal plant operation and unscheduled outages.

[6] Shall provide qualified Non-Destructive Examination personnel to perform flow accelerated corrosion inspections during scheduled refueling and maintenance outages.

[7] Provides personnel to perform reviews of all final FAC UT data sheets.

[8] Provides personnel to review vendor procedures, personnel certifications and equipment certifications.

[9] Assuring adequate technical personnel are available to provide required support services prior to the outage.

[10] Allocation of resources to execute the requirements of the program.

[11] Provide funding and resources to address control and configuration requirements for FAC drawings.

[12] Having bench strength and back up personnel for the FAC program.

4.3 NDE LEVEL III OR DESIGNEE

[1] Reviews and approves FAC personnel and equipment certifications, and NDE procedures including revisions.

[2] NDE Level II or Level III reviews and signs all final NDE/UT data sheets to ensure appropriate NDE examinations have been completed in accordance with the FAC program. The NDE level III review of Risk Informed examination shall be performed in accordance with the site ISI program requirements.

[3] Resolution of anomalies found in inspection data.

[4] Identify discrepancies or deficiencies and initiates condition report in accordance with FAC program or site protocols as appropriate.

[5] Performs oversight of selected FAC examinations to verify vendor procedure compliance.

[6] Performs functions in accordance with applicable procedures including the Entergy Quality Assurance Program.

4.4 FLOW ACCELERATED CORROSION ENGINEER

[1] Shall determine scope of inspections. The FAC Engineer shall develop a list of components/piping segments to be inspected prior to each outage using the criteria of NSAC-202L and CHECWORKS Pass1 and Pass 2 output as a guide. Previous outage inspection results shall be reviewed prior to development of the inspection list. This list shall be based on the susceptibility to flow accelerated corrosion and the severities of wear identified from previous inspection results.

[2] Review and/or perform an engineering evaluation for all Flow Accelerated Corrosion inspections where pipe wall thinning has been identified and concur on any recommended action. Calculations shall be done in accordance with applicable procedures.

[3] Shall ensure that appropriate inspections are performed in accordance with the scope of the Flow Accelerated Corrosion Program.

[4] Shall review and may sign all inspection data and make recommendations for repair/replacement of piping materials in accordance with applicable site protocols.

[5] Shall provide NDE data for review and signature to the ANII, if requested by the ANII.

[6] Shall provide Risk Informed Inspection data sheet (s) to the ANII for review and signature, if applicable.

[7] Develops or reviews program basis documents.

[8] Shall revise and/or expand the scope of the Flow Accelerated Corrosion inspection program to incorporate industry and in-house operating experiences and track/trend inspection results.

[9] Shall maintain records of all inspection results and inspection database.

[10] Develop a FAC examination checklist/traveler that contains t_{nom}, screening criteria, t_{accpt}, line number, etc. for the components being inspected.

[11] Shall initiate request for engineering services in accordance with the MAXIMO/Indus Asset Suite or site specific work control system for piping replacement or engineering evaluations as required. This request should include recommended materials for replacement and configuration changes, if applicable, to reduce the effects of flow accelerated corrosion.

[12] Shall periodically review completed plant modifications to assess their effect on the scope of the flow accelerated corrosion program.

4.4 cont.

[13] Shall assist in vendor oversight as required.

[14] Maintaining control of the predictive models (e.g. CHECWORKS), which includes any development, updates or revisions to the models.

[15] Developing, revising, and issuing FAC program documents.

[16] Initiating and/or responding to Condition Reports and Engineering Requests for evaluating degraded and deficient components or other discrepancies or deficiencies within the scope of the FAC program.

[17] Developing post outage inspection summary reports.

[18] Review and disposition Operating Event (OE) notices for applicability to the FAC program.

[19] Analyzing inspection data to determine component acceptability for continued service and to determine the need for sample expansion.

[20] Prioritizing and ranking inspection in terms of susceptibility and consequence of failure.

[21] Develop and maintain the System Susceptibility Evaluation report.

4.5 DESIGN ENGINEERING/RESPONSIBLE ENGINEER

[1] Provide minimum acceptable wall thickness (t_{accpt}) to the FAC Engineer. Responsibility may be delegated to another department or qualified personnel.

[2] Perform local wall thinning evaluations for components having UT measurements that are below or are projected to go below the minimum acceptable wall thickness (t_{accpt}) or administrative wall thickness requirement. Responsibility may be delegated to another department or qualified personnel.

[3] Prepare and issue engineering response packages for component requiring replacement. Responsibility may be delegated to another department or qualified personnel.

[4] Perform remaining service life evaluation for components in the FAC program as required. Responsibility may be delegated to another department or qualified personnel.

4.6 MAINTENANCE SUPERVISOR/DESIGNEE

[1] The maintenance supervisor or designee will ensure that adequate craft personnel are available to support the FAC program. The supervisor shall ensure that scaffolding is erected, when needed, and insulation removed from components/piping segments that will be inspected and that the piping is prepared for inspection. Scaffolding erection in safety related areas should be in accordance with site procedures.

[2] The maintenance supervisor or designee shall inform the FAC engineer when it is necessary to remove a pipe support for inspection. An engineering evaluation is required if a pipe support requires removal.

[3] The maintenance supervisor must ensure that surfaces to be inspected are free from all foreign materials that would interfere with the inspections, i.e., dirt, rust, paint, etc. If cleaning is required, this may be accomplished by power sanding, flapper wheel only) hand wire brushing, or hand sanding in accordance with site procedures/protocols.

[4] The maintenance supervisor shall ensure restoration of lines, i.e. insulation replaced, scaffolding removed, upon completion of the FAC inspection.

4.7 FAC/ISI PROJECT COORDINATOR

[1] A FAC/ISI project coordinator may be chosen to Implement the activities of the inspection plan, the duties, if applicable, may include but is not limited to the following activities:

(a) Performing component walk downs

(b) Generating NDE inspection packages

(c) Defining NDE staffing as required

(d) Scheduling of inspections

(e) Acquiring data as required

(f) Providing field coordination to ensure timely inspection are accomplished

(g) Tracking progress of the FAC inspection project

(h) Transmitting inspection results to the FAC Engineer

5.0 DETAILS

5.1 PRECAUTIONS AND LIMITATIONS

None.

5.2 ANALYSIS/PRE-EXAMINATION

[1] The criteria contained in NSAC-202L, latest revision, shall be used to perform the System Susceptibility Evaluation (SSE).

[2] The System Susceptibility Evaluation report shall be developed and peer checked in accordance with ENN or ENS procedures.

[3] Non-typical operation of systems should be taken into consideration and if necessary factored into the FAC program.

[4] The susceptible small-bore piping inspection priority ranking should consider personnel safety, consequence of failure and plant unavailability.

[5] Industry and plant experiences relating to FAC will be factored into the program.

[6] The CHECWORKS model should be used for guidance in determining inspection priority based on relative ranking for specific locations to be examined for FAC damage.

5.3 PREPARATION OF OUTAGE INSPECTION PLAN

[1] The FAC Program Engineer shall prepare an Outage Inspection Plan prior to the outage to meet site milestones.

[2] The Outage Inspection Plan should consider the cost of repair/replacement versus inspection.

[3] The Outage Inspection Plan should consider inspection priority based on relative ranking for specific locations to be examined for FAC damage.

[4] Each identified location shall be documented in the inspection plan, along with the component number and reason for selection.

[5] The inspection plan shall be reviewed by qualified FAC personnel.

5.3 cont.

[6] Component Selection

(a) The FAC engineer shall prepare a FAC Outage Inspection scope as directed by plant milestones or as directed by Station management.

(b) Inspection selections shall be made in accordance with the requirements of this procedure and shall be identified based on CHECWORKS results, industry/station/utility experience, required re-inspections, the non- modeled program piping and engineering judgment.

(c) If a selected inspection location is determined to be excessively difficult, impractical or costly to examine due to inaccessibility, temperature, ALARA concerns, scaffolding requirements, or other factors, then an equivalent alternate inspection location may be selected.

(d) Components selected shall be formally documented.

(e) The criteria for component selection should consider the following:

(1) Components selected from measured or apparent wear found in previous inspection results.

(2) Components ranked high for susceptibility from current CHECWORKS evaluation.

(3) Components identified by industry events/experience via the Nuclear Network or through the EPRI CHUG.

(4) Components selected to calibrate the CHECWORKS models.

(5) Components subjected to off normal flow conditions. Primarily isolated lines to the condenser in which leakage is indicated from the turbine performance monitoring system.

(6) Engineering judgment / Other

(7) Piping identified from Work Orders (malfunctioning equipment, downstream of leaking valves, etc.).

(8) Susceptible piping locations (groups of components) contained in the Small Bore Piping database, which have not received an initial inspection.

5.3[6](e) cont.

(9) Piping identified from Condition Reports/ Corrective action, Work Orders (malfunctioning equip, downstream of leaking valves, etc.).

(10) Vessel Shells – Feed-water heaters, moisture separator re-heaters, drain tanks etc.

[7] Inspection schedule

(a) Inspection sequence and schedule should be developed based on priority established by the FAC engineer considering repair/scope expansion potential. Consideration will also be incorporated based on other outage work priorities, job conflict and system window duration.

(b) The FAC outage schedule should contain sufficient time for analysis and evaluations of the components being inspected.

[8] Drawing Preparation

(a) For each component scheduled for inspection, an isometric or other acceptable location drawing should be prepared prior to the outage that identifies the component to be examined. When applicable ensure the component number is shown on the drawing.

[9] Obtain Minimum Acceptable Wall Thickness (t_{accpt})

(a) Obtain t_{accpt} values for each component to be inspected.

(b) The minimum acceptable wall thickness, t_{accpt}, values should be obtained from ENN-CS-S-008 or ENS-PS-S-001 as applicable or from an approved site method <u>(e.g. FAC Manager).</u>

(c) Values for t_{accpt} should be obtained from design engineering or it may be delegated to another department or qualified personnel. These values may be ascertained prior to or during an outage.

5.3 cont.

[10] Component Identification

(a) Inspected components should have a unique identifier to allow for the tracking of inspection data.

(b) Component identifiers may allow for the identification of the Unit, system, sub-system, line number and corresponding location of that component within a sub-system.

(c) Components in the CHECWORKS non-modeled piping may be identified by using line numbers.

[11] Pre-inspection Activities

(a) Review inspection schedule, inspection requirements and sequence with appropriate plant personnel to ensure requirements for the completion of the FAC inspection are understood.

(b) The FAC engineer should participate in the preparation of FAC inspection work packages as required.

5.4 GRIDDING

[1] Gridding of components shall be performed in accordance with recommendation of NSAC 202L, ENN-EP-S-005 (for ENN plants only), and applicable site approved procedures or as specified by the FAC engineer.

[2] Gridding information shall be documented on the appropriate NDE UT data sheet either by a sketch or digital photo.

5.5 NDE TEST METHODS AND DOCUMENTATION

[1] Components can be inspected for FAC wear using ultrasonic testing (UT), radiography testing (RT), visual observation or other approved methods. The inspection technique used shall be at the discretion of the FAC engineer.

5.5 cont.

[2] UT thickness measurement is the primary method of determining pipe wall thickness.

(a) Inspections will be performed by using one of the following techniques:

(1) Grid Point Reading

(2) Grid Scan

(3) Quadrant Scan

(4) Line Scan

(5) Full Scan

(b) Ultrasonic Thickness measurement shall be performed in accordance with approved NDE, site or vendor procedures.

(c) A data sheet for components inspected shall be prepared. The information included in the sheet should contain but is not limited to the following:

(1) Plant's name/unit

(2) Components name

(3) Component sketch

(4) NDE technician signature/ date

(5) Grid size

(6) Axial and radial grid boundaries

(7) Calibration information

(8) Level II or Level III signature/date

(9) Work order information

(10) Nominal & Measured thickness

(11) 87.5% nominal thickness screening criteria

(12) Scanning method

5.5 cont.

[3] Radiograph Testing

(a) RT (digital or conventional) is the preferred method for inspecting socket welded fittings. The method used is at the discretion of the FAC engineer.

(b) RT can be performed during plant operations without removing insulation

[4] Visual Observation

(a) Visual observation/techniques may be used for examination of large components such as tanks, cross-around piping, cross-under piping, pump casings, shell walls, valves etc. (visual techniques is only applicable to two phase flow).

(b) Follow-up UT examinations, at the discretion of the FAC engineer, may be required of areas where significant damage is observed or suspected.

5.6 EVALUATION OF UT INSPECTION DATA

NOTE
Historically, typical manufacturing practice has been to supply fittings (especially tees, elbows and reducers) with wall thickness significantly larger than the piping nominal thickness.

[1] The data review should consider screening for further evaluation. Factors that should be considered when reviewing the inspection data include unknown initial thickness (especially fittings), counter-bore, obstructions, and manufacturing wall thickness variations.

[2] For each component that is examined and is below the screening criteria of 87.5% of nominal wall, the wear, wear rate, remaining service life shall be calculated.

[3] The FAC Program Engineer or designee shall review the UT data to ensure that the data is complete and corresponds to the requirements specified on the inspection data sheet (i.e., grid size, spacing, flow direction, starting and ending locations, obstructions, missing data, suspect readings and orientation).

[4] If low readings are encountered from repeat inspections that are due to counter-bore, then those areas shall be noted and additional inspections are not required.

5.6 cont.

[5] Grid Refinement

(a) A grid reduction / refinement may be used if the minimum measured thickness is less than the minimum required wall thickness, severe wall thinning is detected, engineering judgment, or the projected thickness is less than the minimum required wall thickness or as directed by the FAC engineer.

(b) The results of the grid refinement or scan shall be documented on an inspection data sheet.

[6] Grid Extension

(a) If measurement indicates wall loss at any edge of the grid, then the grid should be extended until the entire wear pattern is mapped.

[7] Determination of Initial Wall Thickness

(a) Initial Thickness (t_{init}): The thickness determined by ultrasonic examination prior to the component being placed into service (baseline) or the first ultrasonic examination during its service life. If an examination has not previously been performed on the component, the initial thickness shall be determined by reviewing the initial ultrasonic data for that component. The area of maximum wall thickness within the same region as the worn area (based on the method selected for evaluating wear) shall be identified and compared to t_{nom}. If the thickness is greater than t_{nom}, the maximum wall thickness within that region shall be used as t_{init}. If that thickness is less than t_{nom}, t_{nom} shall be used as t_{init}.

[8] Determination of Wear

(a) Wear of piping components may be evaluated using the band, area, and blanket or point-to-point method as defined in NSAC-202 L, latest revision or any other approved method.

(b) Evaluation of inspection data that is determined to require wear evaluation shall be documented and reviewed.

5.6 cont.

[9] Wear rate Determination

(a) Wear rate is determined by wear/ unit time (Units to be consistent with thickness evaluation).

(b) A reasonable safety factor should be applied to the wear rates to account for inaccuracies in the FAC wear rate calculations.

(c) Wear rate evaluation should be evaluated on a component evaluation sheet.

[10] Predicted Thickness (t_p , t_{pred})

(a) The projected or predicted thickness to the next schedule refueling outage.

$$t_{pred} = t_{meas} - \text{Safety factor x Wear Rate x Time}$$

A safety factor of 1.1 should be applied to all Entergy nuclear plants. If a value less than 1.1 is used the reason shall be documented.

[11] Determination of Remaining Service Life (RSL)

(a) Remaining service life (RSL) shall be evaluated as follows, units to be consistent with thickness evaluation:

$$RSL = (t_{meas} - t_{accpt}) / (\text{Safety Factor x Wear Rate})$$

5.7 EVALUATION OF RT INSPECTION DATA

[1] Qualified NDE personnel shall interpret the film and report the examination result to the FAC engineer.

[2] Appropriate conservatism should be used to determine if a component requires replacement or re-inspection as a consequence of qualitative nature of RT.

[3] RT inspection shall be recorded on a data sheet.

5.8 EVALUATION OF VISUAL INSPECTION DATA

[1] Where accessible, visual inspections may be performed on two-phase flow lines.

[2] Follow-up UT inspection is required for locations where significant damage is observed or suspected.

[3] Due to the qualitative nature of visual inspections, appropriate conservatism should be used when determining whether a component is acceptable to return to service and when establishing a re-inspection frequency.

5.9 DISPOSITION OF INSPECTION RESULTS

[1] The following are used to disposition component inspection results. Reference attachment 9.3 for logic diagram

NOTE
Certain components may have very little margin remaining as a consequence of high stresses in the line even though $t_{pred} \geq 0.875\ t_{nom}$ and therefore may require evaluation, for example Feedwater, Condensate, RHR, etc.

[2] If t_{pred} is $\geq 0.875\ t_{nom}$, the component is acceptable as is and may be returned to service.

[3] If t_{pred} is $< 0.875\ t_{nom}$, evaluate for sample expansion (Reference section 5.12).

[4] If t_{pred} is $\leq 0.3\ t_{nom}$, for ISI Class 1 piping repair or replacement is required in accordance with the requirements of ASME Section XI Repair and Replacement Program.

[5] If t_{pred} is $\leq 0.2\ t_{nom}$, for ISI Class 2, Class 3 and non-safety related, repair, replace or evaluate as warranted in accordance with applicable site programs or as directed by the FAC engineer.

[6] If t_{pred} is $\geq t_{accpt}$, the component is acceptable for continued operations, however monitoring is required in accordance with program requirements.

5.9 cont.

[7] If t_{pred} is < t_{accpt}, a structural evaluation is required in accordance with site approved procedures or engineering standards. Also a sample expansion evaluation is required. Repair or replacement in accordance with the requirements of ASME Section XI Repair and Replacement Program or other site approved process may also be required.

[8] If t_{meas} is < t_{accpt}, **generate a condition report**. A structural evaluation is also required in accordance with applicable site procedures or engineering standards.

5.10 RE-INSPECTION REQUIREMENT

[1] If the remaining service life (RSL) of a component is greater than or equal to the number of hours in the next operating cycle, then the component may be returned to service.

[2] If the component's remaining service life (RSL) is greater than the number of hours in the next operating cycle but is less than the number of hours in the next two operating cycles, then the component should be considered for re-inspection, repair or replacement during the next scheduled outage.

[3] If the component is acceptable for continued service, then it shall be re-examined before or during the outage immediately prior to the cycle during which it is projected to wear to the minimum allowable wall thickness.

5.11 COMPONENTS FAILING TO MEET INITIAL SCREENING CRITERIA

[1] If the results of the remaining life evaluation are shorter than the amount of time until the next scheduled inspection, there are several options for disposition of the component, as follows:

(a) Shorten the inspection interval (for components that can be inspected online)

(b) Refine the t_{accpt} value through a detailed stress analysis, which should be provided by Design Engineering or designee.

(c) Repair or replace the component

(d) ISI Class1 components that are less than or equal to 0.3 t_{nom} must be repaired or replaced unless further structural evaluation permits continued service.

[2] Wall thinning resulting in less than t_{accpt} shall be reported immediately to the FAC engineer by verbal or written communications.

5.11 cont.

[3] A condition report shall be generated when significant wall thinning or unexpected wear is detected in a system or component.

[4] A condition report shall be generated for wall thinning below t_{accpt} or other site established limit and a subsequent structural evaluation performed to disposition the line for continued service.

[5] If a previous condition report was generated for a component with wall thinning then no new condition report is required provided that the associated structural evaluation is current and applicable.

5.12 SAMPLE EXPANSION

[1] If a component is discovered that has a current or projected wall thickness less than the minimum acceptable wall thickness (t_{accpt}), then additional inspections of identical or similar piping components in a parallel or alternate train shall be performed to bound the extent of thinning except as provided below. Reference section 5.12.2.

[2] When inspections of components detects significant wall thinning and it is determined that sample expansion is required, the sample size for that line should be increased to include the following:

(a) Components within two diameters downstream of the component displaying significant wear or within two diameters upstream if the component is an expander or expanding elbow.

(b) A minimum of the next two most susceptible components from the relative wear ranking in the same train as the piping component displaying significant wall thinning.

(c) Corresponding components in each other train of a multi-train line with a configuration similar to that of the piping component displaying significant wall thinning.

[3] If the expanded inspection scope detects additional degradation, the sample expansion should continue until no additional components with significant wear are detected.

[4] Sample expansion is not required if the thinning was expected or if the thinning is unique to that component (e.g., degradation downstream of a leaking valve).

5.12 cont.

[5] Inspections of components from the current or past outages may satisfy the sample expansion criteria, therefore, some of the sample expansion requirements can be met without performing additional inspections.

[6] Sample expansion is not required for components that are being re-inspected if normal or expected wear is detected or wear unique to that component. All other wear patterns encountered shall be evaluated by the FAC Engineer to determine if sample expansion is required.

5.13 REPAIR / REPLACEMENT OF DEGRADED COMPONENTS
[NRC Generic Letter 90-05]

[1] The FAC engineer shall generate applicable documents to facilitate repair or replacement of degraded or deficient components.

[2] Components experiencing severe or unacceptable wear should be replaced with corrosion resistant material. However like in kind replacement may be appropriate if procurement of a resistant material would delay plant restart.

[3] Replacing components or fitting-by-fitting that have experienced significant wear is a satisfactory approach to reducing wear if the wear is very localized (i.e., wear is concentrated downstream of a flow control valve or orifice).

[4] Repairs and replacements to piping and components within the scope of Class 1, 2, 3 shall be performed in accordance with the requirements of ASME Section XI Repair and Replacement Program.

[5] All temporary non-code repairs to ISI Class 1, 2, 3 shall comply with NRC Generic Letter 90-05.

5.14 COMPONENT EVALUATION PACKAGES

[1] The FAC Engineer or designee shall assemble a component evaluation package for each examined component which may contain some of, but is not limited to the following:

(a) UT DATA Sheet

(b) Isometric drawing(s), sketches, flow diagram and digital photo.

(c) Reference to Structural /Minimum wall evaluation

(d) Component evaluation data sheet.

5.15 POST- INSPECTION ACTIVITIES

[1] The FAC Program Engineer shall prepare an Outage Summary report to document the outage FAC activities and submit to Records for retention in accordance with applicable procedures.

[2] Update CHECWORKS models with inspection data.

[3] Update small bore susceptible report as applicable

[4] Update all applicable FAC reports.

[5] Update FAC System Susceptible Report as required.

5.16 LONG TERM STRATEGY

[1] Entergy's fleet long-term strategy shall focus on reducing the plants FAC susceptibility. Optimization of the inspection planning process is an important factor. However, the reduction of FAC wear rates is necessary if both the number of inspections and the probability of failure are to be reduced. Subsequently the fleet's long term strategy will include the following elements:

(a) The use of improved materials for replaced components or proactive replacement of piping with corrosion resistant material.

(b) Utilization of improved water chemistry

(c) Incorporation of local design changes.

(d) Optimization of the inspection planning process,

(e) Industry participation in meetings for technology and information transfer (e.g. EPRI CHUG).

(f) Maintaining up-to-date predictive software and incorporating the latest inspection data in the models.

5.17 METHODS OF DETERMINING PLANT PERFORMANCE

[1] Program performance indicators, self- assessments and bench marking are utilized as methods for monitoring program and plant performance.

6.0 INTERFACES

[1] ENN-CS-S-008, “Pipe Wall Thinning Structural Evaluation”.

[2] ENN-EP-S-005 "Flow Accelerated Corrosion Component Scanning and Gridding Standard".

[3] ENS-PS-S-001, “Pipe Wall Thinning and Crack-like Flaw Evaluation Standard”.

[4] EN-DC-202, “NEI 03-08 Materials Initiative”.

7.0 RECORDS

[1] Record retention shall be in accordance with site procedures.

8.0 OBLIGATION AND COMMITMENTS IMPLEMENTED BY THIS PROCEDURE

8.1 OBLIGATIONS AND COMMITMENTS IMPLEMENTED OVERALL

None

8.2 SECTION/STEP SPECIFIC OBLIGATIONS AND COMMITMENTS

Step	Document	Document Section/Step	Commitment Number
[1]	QAPM	A.6a, A.6b, A.6c, A.6e	P33641–P33643, P-33645
[2]	QAPM	B.12a, B.12b, B.12c, B.12d, B.12e, B12f	P-33714 – P-33719
[3]	QAPM	B.15a, B.15c	P-33730, P-35351
[4]	NRC Generic Letter 90-05		None

8.3 SITE SPECIFIC COMMITMENTS

Step	Site	Document	Commitment Number or Reference
[1]	JAF	Response to NRC IE Bulletin 87-01	JAFP 87-0737
[2]	JAF	Response to NRC Generic Letter 89-08	JPN-89-051
[3]	IPEC Unit 3	Response to NRC IE Bulletin 87-01	IP3-87-055Z
[4]	IPEC Unit 3	Response to NRC Generic Letter 89-08	IPN-89-044
[5]	IPEC Unit 2	Response to NRC IE Bulletin 87-01	Mr. Murray Selman (Con Edison) to Mr. William Russell (NRC), Letter dated September 11, 1987.

8.3 cont.

[6]	Pilgrim	Response to NRC Generic Letter 89-08	BECo 89-107
[7]	VY	Response to NRC Generic Letter 89-08	Vermont Yankee letter to USNRC, FVY-89-66
[8]	VY	Response to NRC IE Bulletin 87-01	Vermont Yankee letter to USNRC, FVY-87-94
[9]	VY	Supplemental Response to NRC IE Bulletin 87-01	Vermont Yankee letter to USNRC, FVY-87-121
[10]	ANO	OCAN108914	P-1079
[11]	GGNS	GGNS Appendix K, Power Uprate	P-35269
[12]	GGNS	Response to NRC Generic Letter 89-08	P-24444
[13]	RBS	Response to NRC IE Bulletin 93-02	P-15802
[14]	RBS	Response to NRC IE Bulletin 93-02, Supp. 1	P-15803
[15]	WF3	Response to INPO SOER 87-03	P-16557
[16]	WF3	Response to IEN 89-001	P-20303
[17]	WF3	Response to IEN 93-021	P-22888

(a)

9.0 ATTACHMENTS

9.1 Guidance on Parameters affecting FAC.

9.2 Flow Accelerated Corrosion Program Attributes.

9.3 Wall Thinning Evaluation Process Map.

GUIDANCE ON PARAMETERS AFFECTING FAC

Listed below are factors to be considered when reviewing work requests, component replacements and modification packages for possible impact on the content of the FAC Program governed by DC-315. All Design Change Packages (DCP's) are required to be evaluated for impact to the FAC Program. This list is not intended to be all-inclusive or to limit the number of items an individual would consider when performing this impact assessment. It is intended as a reasonable list of items to consider for potential program content updates.

1. Water Chemistry. Many water chemistry parameters have been shown to contribute to FAC.

   a. pH Control Amine – pH is the primary chemistry parameter affecting FAC rates in PWRs. However, the amine used to control pH also plays an important role. Amines such as ammonia tend to separate more into the steam phase in two-phase flow conditions, and therefore provide less protection in the drains. Amines such as morpholine and especially ethanolamine have better partitioning characteristics for FAC.

   b. In a BWR, pH has much less of a role since the pH is stable and there are no amine's added to control the pH. FAC rates decrease as pH level increases. FAC rates seem to drop considerably at pH values of greater than 9.3 - 9.5.

   c. Oxygen Content - FAC rates decrease as oxygen concentration increases. Values that typically result in minimum FAC rates are approximately 15 to 20 ppb.

   d. Hydrogen Water Chemistry – BWR Plants that do not have hydrogen addition normally have a main steam oxygen content near 18 ppm. Plants with hydrogen water chemistry typically have an oxygen content from 3 to 12 ppm. This has a potential to impact the corrosion rates in the LP steam systems; mainly the first and second stage reheater drains based on industry experience.

   e. Hydrazine Injection - Hydrazine is added to the feed train of PWRs as an oxygen scavenger and to maintain a reducing environment in the steam generators. From zero to approximately 150 ppb,an increase in hydrazine concentrations seems to increase rates of FAC. Higher concentrations seem to result in no further increase in FAC rates. EPRI recommends the use of high levels of hydrazine (>100 ppb) to protect steam generator tubes; however, this can result in accelerated rates of FAC in the feed train. Although CHECWORKS does not currently model high hydrazine conditions, any model updates performed after the release of version 1.0F should carefully consider hydrazine concentrations.

   f. Zinc Injection - Industry experience has shown that zinc injection decreases corrosion and FAC wear rates due to the concentration of zinc at the oxide surface. The amount of reduction depends on the amount of zinc at the surface.

2. Piping Geometry - Piping geometry is one of the most important factors in FAC. Generally, geometries that produce the greatest turbulence also produce the highest FAC rates. Listed below are examples of obvious items that should be considered in any assessment:

   a. Addition or replacement of fittings, bends and branch connections.

   b. Like for like replacement of any fitting in a system that is susceptible to FAC damage or is part of system that is already part of the FAC Program.

   c. Alterations or repairs encountered in the nozzles or walls of FW heaters, MSR, Drain Tanks, FW Pumps, HD Pumps or CD/CB Pumps.

   d. Throttled Valves.

3. Piping Material Composition - Alloying elements improve the resistance of piping systems to FAC. In ascending order of resistance, the following table presents the degree of improvement over carbon steel:

Material	Nominal Composition	Rate (carbon steel) / Rate (alloy)
P11	1.25% Cr, 0.50% Mo	34
P22	2.25% Cr, 1.00% Mo	65
304	18% Cr	>250

4. In-Line Components - Addition or replacement of such components as thermowells, flow elements and pressure-reducing orifices should be evaluated. The local effects caused by these components can generate FAC damage in areas where overall conditions don't indicate the need for inspections.

5. Component Supports - Additions or deletions of components supports which could result in the need for a review of the existing code minimum wall value or a new code minimum wall calculation.

6. Operational Changes - System operational changes such as the normal operation of emergency heater drains, switching of spare components, extended use of normal start-up or by-pass lines, etc.

ATTACHMENT 9.1 **GUIDANCE ON PARAMETERS AFFECTING FAC**

Sheet 3 of 3

7. Component Replacements – Records should be updated for like for like replacement of fittings already in the program including new baseline data, changing next scheduled inspection due date, etc. Note and track whether the replacement components have had surface preparation and a UT grid applied for future outage planning.

8. External Sources – Information concerning FAC Inspection results from other stations and Nuclear Plants operated by others. General information distributed by EPRI Reports, INPO & NRC Bulletins, etc. should also be considered.

9. Maintenance History – A review of the maintenance performed on valves, orifices, steam traps, etc. should be considered. Valves that have had seat leakage can cause very localized wear in systems normally exempted. Plugged traps create water pockets in steam systems that accelerate metal loss. Eroded orifices can cause increased metal loss due to decrease in back pressure and increase in flow rates.

PROGRAM ATTRIBUTES

Attributes:

Program Infrastructure

(a) Program Structure: Roles & Responsibilities, Program Ownership, Organizational Interfaces, etc.
(b) Configuration management
(c) Program Bases
(d) Engineering Documentation
(e) Flow Accelerated Corrosion System Susceptibility Evaluation, Latest Revision.
(f) CHECWORKS models
(g) Change processes

Program Staffing and Experience

(a) Background and Expertise.
(b) Qualification and training.
(c) Bench Strength
(d) Time Allotment
(e) Industry Participation

Program Implementation

(a) Work control
(b) Inspections
(c) Maintenance and Repairs
(d) Control of Changes and Deferrals
(e) Review of INPO Operating Experience documents, CHUG operating experience, NRC notices.

Health Monitoring:

(a) System Engineering Health reports.
(b) FAC Quarterly Health Reports.

Effective Assessment:

(a) Perform FAC Self-Assessment on a periodic basis or as defined by applicable procedures.

Oversight:

(b) Effective assessment, Benchmarking or Audits.

ATTACHMENT 9.3 — WALL THINNING EVALUATION PROCESS MAP

Sheet 1 of 1

Logic Diagram - Evaluation of Pipe Wall Thinning