# Independent Review of the Indian Point Energy Center Flow-Accelerated Corrosion Program

Jeffrey S. Horowitz, ScD

March 22, 2012

# Contents

## Overview

This Report documents an independent review of the programmatic features of the flow-accelerated corrosion (FAC) program at Indian Point Units 2 and 3 (collectively IPEC). This review was based primarily on a review of program documentation.

## Purpose

This review was done in support of Entergy's testimony in the IPEC license renewal proceedings. It was performed to:

- Establish an independent baseline of knowledge for the testifying expert on the specifics of the IPEC FAC program, and
- Establish a record of the features of the IPEC FAC program based on a direct review of related documentation and the CHECWORKS[1] models.

This review focused on programmatic issues rather than a detailed technical review of specific component evaluations or structural calculations.

## Executive Summary

A review of the FAC program at Indian Point Units 2 and 3 was conducted using the available program documentation. The main findings of this review were:

- The IPEC FAC program is consistent with recommendations of the EPRI document NSAC-202L Revision 3[2] {reference 1} and the general requirements of INPO engineering program guide EPG-06 {reference 2}.
- The IPEC FAC program is also consistent with the more general guidance of the "GALL Report" (i.e. NUREG-1801, Revision 1 {reference 3}).[3]
- Both IPEC units are using excellent water chemistry with the pH of the final feedwater systems greater than 9.8 with ethanolamine used as the pH control agent.
- While some specific comments are offered, none of these are significant enough to require immediate action. Additionally, several good practices are noted.

## Review Process Used

The review was based on an examination of relevant IPEC program documentation, in comparison to standard industry guidance and practices. To do this, the program was divided into a number of

[1] CHECWORKS™ is a product of the Electric Power Research Institute, Inc.

[2] For convenience, the term "NSAC-202L" will be used to represent "NSAC-202L, Revision 3" throughout this document.

[3] Entergy has taken an exception to the GALL Report, Revision 1, because the IPEC FAC program is based on NSAC-202L, Revision 3, rather than NSAC-202L, Revision 2.

program elements. Each element is presented as a self-contained section with each section consisting of an introduction defining the relevant specifications, a summary of the IPEC documents, and an assessment of how well these documents satisfy the specifications.

A complete list of the documents reviewed is presented in Appendix A of this document.

# Review of the FAC Program Elements

## Corporate FAC Procedure

### Introduction

Procedures are used to define the organization and the conduct of the FAC program. In Section 3.1 of NSAC-202L (Rev 3) {reference 1}, the recommended contents for a corporate procedure are defined. More general requirements are described in Section 2.1 of EPG-06 {reference 2}.

Quoting from NSAC-202L (rev. 3), the recommendations consist of:

- *A corporate commitment to monitor and mitigate FAC.*
- *Identification of the tasks to be performed (including implementing procedures) and associated responsibilities.*
- *Identification of the position that has overall responsibility for the FAC program at each plant.*
- *Communication requirements between the lead position and other departments that have responsibility for performing support tasks.*
- *Quality assurance requirements.*
- *Identification of long-term goals and strategies for reducing high FAC wear rates.*
- *A method for evaluating plant performance against long-term goals.*

### IPEC Documentation

The flow-accelerated corrosion (FAC) program at all Entergy nuclear sites is described and defined by EN-DC-315, Revision 6 [A-1].[4] The contents of EN-DC-315 were reviewed against the NSAC-202L recommendations.

### Assessment

EN-DC-315 contains the items described above. Care is taken to delineate the roles and responsibilities from management down through the FAC engineer. The importance of this item is emphasized in EPG-06. Additionally, the other sub-elements of the program are also described.

In general, the document is consistent with NSAC-202L Revision 3 {reference 1} although the following items are noted:

[4] Numbers in square brackets refer to the list of documents reviewed presented in Appendix A of this document.

- Although CHECWORKS analysis and interpretation are discussed in EN-DC-315, the topic of line calibration as part of the Pass 2 analysis was not directly discussed. However, the subject of line calibration is discussed in the CHECWORKS reports (e.g. [A-11]) and the calibration status of each analysis line is presented in Appendix B of such reports. As the treatment of calibrated versus non-calibrated lines is an important subject, the next revision of this document should treat the subject.[5]
- Alloy sampling of piping materials for the detection of trace Chromium has been found by the FAC community as an important factor in the identification of potential non-susceptible components. It has been recognized as a valuable part of an effective FAC program (e.g., § 4.5.7 of NSAC-202L) and is used widely in the industry. Judging from this procedure, Entergy has not yet incorporated alloy sampling into their FAC program inspection process. As a result, the scope of Entergy's FAC inspections at IPEC may be somewhat larger than necessary.

Additionally, the definition of flow-accelerated corrosion in the document should be revised to state that the degradation mechanism is limited to carbon and low alloy steels. This is to distinguish the mechanism from other, similar degradation mechanisms that attack other alloys and are covered by other programs. It would also match the intent of NSAC-202L and the actual purpose of the Entergy FAC program.

## Other FAC Related Procedures

### Introduction

In addition to the corporate procedure, EN-DC-315, other procedures are used by the FAC Program at IPEC. These procedures define and describe tasks related to the FAC program and are generally part of the inspection and evaluation process.

### IPEC Documentation

The FAC-related procedures reviewed were:

- the procedure, CEP-FAC-001 [A-2], defines the requirements for gridding the piping components prior to inspection using the ultrasonic technique (UT),
- the procedure, CEP-NDE-0505 [A-3], specifies the conduct of UT inspection,
- an engineering standard, EN-CS-S-008 [A-4], describes the process used for evaluating the structural acceptance of FAC degraded piping,
- an engineering standard, EN-CS-S-009[A-5], defines the materials to be used to replace FAC degraded components.

The general guidance for, the need for and the use of procedures of this type are discussed in §3.2 of NSAC 202L.

### Assessment

Treating the procedures and standards individually:

[5] As will be discussed later in this section, the CHECWORKS Pass 2 results are examined to determine which lines are calibrated. The subject of calibrated lines is discussed under the documentation of the CHECWORKS models.

- CEP-FAC-001 is an Entergy corporate procedure defining the gridding of piping components prior to inspecting the components for degradation caused by FAC using UT. This subject is treated in Sections 4.5.2 and 4.5.3 of NSAC-202L. The requirements of the procedure closely follow NSAC-202L with regard to the grid size as a function of the pipe diameter (Table 4-1 of NSAC-202L and Table 1 of CEP-FAC-001), and other related issues, i.e., downstream coverage, grid layout, and grid marking.
- CEP-NDE-0505 is an Entergy corporate procedure specifically designed for FAC inspections using UT. It includes requirements for personnel qualifications, test equipment and couplant to be used, and surface preparation. Also included are requirements for calibration and record keeping.
- EN-CS-S-008 is a detailed corporate engineering standard for evaluating the structural acceptance of FAC degraded piping. It includes requirements for ASME Code evaluations of Safety Related (i.e., ASME Class 1, 2 and 3 piping) and Non-safety Related Piping. It references the appropriate documents – NSAC-202L, ASME Boiler and Pressure Vessel Code, ANSI B31.1 Power Piping Code, and the relevant ASME Code Cases.

  Included in this standard are methodologies for dealing with the different piping components (e.g., reducer) as well as for straight pipes. Uniform thinning and localized thinning cases as well as through wall flaws are considered.
- EN-CS-S-009 is a corporate engineering standard defining the material used to replace piping that has been degraded by FAC. This standard applies to large and small bore Class 2 and Class 3 as well as non-safety piping. Note that Class 1 piping is specifically excluded. However, at IPEC, there is no FAC susceptible, carbon steel Class 1 piping.

  Included in this standard are interface requirements with the various functional groups involved with piping replacements, e.g., welding or design. The replacement material of choice is chromium-molybdenum steel with a nominal chromium concentration of either 1 ¼ or 2 ¼ % (i.e., – ASTM A335-P11 or P-22; or ASME SA335 Gr. P11 or P22; or equivalent). These materials are included in the NSAC-202L list of recommended materials (see §5.2).

All of these four procedures and standards meet the letter and spirit of NSAC-202L and the ASME Code requirements.

## System Susceptibility Evaluation

### Introduction

As described in Section 4.2 of NSAC-202L Rev. 3, the system susceptibility evaluation is an important element of an effective FAC program. The objective of this evaluation is to define the portions of the plant piping that is susceptible to FAC. Criteria for making this determination are presented in that section of NSAC-202L.

### IPEC Documentation

The system susceptibility analyses for the IPEC units are presented in [A-6, A-7]. These documents, together with their color coded flow diagrams [A-8, A-9] define the system susceptibility for IPEC.

### Assessment

The susceptibility evaluations follow the approach outlined in NSAC-202L. The use of color coded flow diagrams is a good practice that is becoming more common in the industry. Another good practice demonstrated is the fact that these documents are updated periodically to reflect changes in system configuration, materials and operation. This requirement is stated in §4.2.1 of NSAC, *"… this evaluation should be periodically reviewed to ensure that it is kept current with plant design changes and ways that systems are being operated …".* This observation was made by noting the release dates of these documents.

## CHECWORKS Models and their Documentation

### Introduction

The EPRI computer program CHECWORKS Steam Feedwater Application {reference 4} is used at IPEC to rank all of the modeled components in order to assist in preparing the list of components to be inspected during each refueling outage. The use of such a predictive program is recommended by NSAC-202L (§2.2 and §4.2) and by EPG-06 (§2.1.2.3). CHECWORKS is in use at all U.S. nuclear units.

### CHECWORKS Models

The CHECWORKS models for the two IPEC units each contain over 2,800 components. Due to the large size of the databases, the review of the current CHECWORKS models was based on a sample of the database. The models contain information describing the operating history, the water chemistry used, and a description of the piping components. Also included are the results of the water chemistry and wear rate analyses.

The water chemistry practices at both units are excellent. They both use ethanolamine (ETA) as the pH control agent with the calculated room temperature pH in the final feedwater of 9.8 for Unit 2 and 9.86 for Unit 3.

Appropriate power levels for the measurement uncertainty recapture (MUR) and the stretch power uprate (SPU) were included in the models for both units.

### IPEC Documentation

The CHECWORKS models for the IPEC units have been recently documented in two reports [A-10, A-11]. These reports are quite voluminous being over 1,500 pages long. They contain a description of the modeling assumptions and decisions used; the naming conventions used, a tabulation of the global input variables, such as operating times and water chemistry history; and a discussion of results. Also included, as appendices, are supporting information including change history of the model, tables of

program results notably the Pass 1 and Pass 2 results of the wear rate analysis as well as wear plots for the Pass 2 analyses.[6]

Of special interest was the discussion of the Pass 2 wear rate results found in §6.4 of both reports. This section included a discussion of line calibration – a topic discussed in §4.4.1 of NSAC, and a discussion of the components with a predicted "negative time to *Tcrit*."[7] Both of these topics have become important issues with INPO in recent years.

### Assessment

#### *CHECWORKS Models*

The CHECWORKS models for both IPEC units were reviewed. The currently released version of CHECWORKS is Version 3.0 Service Patch 2.0. This is the version at use at IPEC. The models appeared to be complete with regard to the global information, the component data, and the inspection data.

#### *IPEC Documentation of CHECWORKS Models*

The reports documenting the CHECWORKS models provide a very detailed look at the models and the underlying assumptions used. There also are detailed assessments of line calibration and components with negative times to *Tcrit*. These assessments are considered good practices and go beyond what is often seen in program documentation.

## Susceptible, Non-Modeled Systems

### Introduction

Not all lines are amenable to analysis by CHECWORKS. Lines that are susceptible to FAC, but are not suitable for analysis are considered to be susceptible, non-modeled (SNM). SNM lines are treated differently for the purposes of inspection planning then the modeled lines as no analytical results are available. This is the approach recommended by §4.2 of NSAC-202L.

In the system susceptibility evaluations [A-6, A-7] and the associated color coded flow diagrams [A-8, A-9], the SNM lines were identified.

### IPEC Documentation

The SNM program at IPEC is described in two reports [A-12, A-13]. These reports contain a prioritized ranking of all of the SNM piping at IPEC. They also contain a description of the methodology used, the assumptions used in performing the analysis, and the prioritization scheme employed. Industry experience, maintenance history, and operating conditions were considered in determining the

---

[6] Pass 1 analyses are the predictions of the program without using component inspection data. Pass 2 calculations are the Pass 1 predictions refined by the use of the line correction factor (LCF). Generally, the Pass 2 results are used for inspection planning.

[7] "Tcrit" is a user defined CHECWORKS variable. For the IPEC models, *Tcrit* was defined as the largest of three values: the thickness necessary to withstand the hoop (i.e. circumferential) stress, the thickness necessary to withstand an assumed longitudinal stress, and an administrative minimum of 0.100 inches. See §5.3.2 of IPEC 3 report [A-11] for more details.

susceptibility. Based on these factors, each line was evaluated as having: High susceptibility, Moderate susceptibility, or Low susceptibility. Appendices contain lists of line sorted by the degree of susceptibility.

### Assessment

The two SNM reports provide a comprehensive view of the non-modeled lines in the plant. Further, the reports provide a description of the methodology used to determine the susceptibility classes. Note that while there is no standard methodology used in the nuclear industry for making this classification, the methodology used in these evaluations appears to be logical and reasonable for the purpose.

## Inspection Planning

### Introduction

The components to be inspected are defined in advance of each refueling outage. The selection of components for inspection is discussed in §4.4 of NSAC-202L. Good practice is to document the inspection location as well as the reason that the location was selected (e.g., trending, CHECWORKS analysis).

### IPEC Documentation

The inspection scope is defined prior to each outage and is documented in a scoping report in the form of a Microsoft EXCEL spreadsheet. For this assessment, five scoping spreadsheets were available [A-14 through A-18]. These spreadsheets are working documents that contain a list of the components to be inspected together with information describing the location of the component and any additional information. Tracking of crafts tasks (e.g., scaffolding) is also provided. Of note is the "Remarks" column that provides the reason why the component was selected for inspection at this time. Some of the reasons for including an inspection location were: CHECWORKS results, trending, few inspections in the piping segment, re-inspection called for by FAC Manager[8], and operating experience.

### Assessment

In my experience reviewing FAC programs at nuclear utilities, there is no set format for the inspection planning document. Rather, each utility has its own way of documenting the inspection list. The spreadsheets reviewed seemed complete and the inclusion of the reason why the components were selected for inspection is considered a good practice.

Looking at all of the spreadsheets, a table was constructed (see below) of the number of components scheduled for inspection, and the number of the inspections that were repeat inspections. Looking at the last column in this table, the percentage of new inspections varied from 43% to 52%. This is in line with the recommendation of §4.4 of NSAC-202L that, "*The inspection list generated from the categories above should be a reasonable mix of locations that have not been previously inspected and re-inspections.*" In fact it is in very good agreement with the industry rule of thumb that the half the inspection locations should be new ones.

[8] FAC Manager™ is a product of CSI Technologies, Inc.

| *Outage* | *Inspections Planned* | *Number of Re-Inspections* | *% New Inspections* |
|---|---|---|---|
| 2R19 | 125 | 63 | 50% |
| 2R20 | 128 | 68 | 47% |
| 3R15 | 128 | 64 | 50% |
| 3R16 | 154 | 88 | 43% |
| 3R17 | 147 | 76 | 52% |

Also the number of locations inspected in an outage is comparable with other similar U.S. PWRs.

Finally, some of the spreadsheets there were components that were marked as removed from the inspection list without a reason given. The lack of documentation for deferrals of inspections has been an INPO area of attention. As stated in §2.3.1 of EPG-06 {reference 2}, the FAC engineer, *"Ensure there is sufficient technical justification for the proposed change or deferral."*

The rationale for deferrals for each outage appears on another spreadsheet (e.g., [A-19]). Reviewing [A-19], the explanations were given for each deferral. These changes are subject to supervisory review if they are made before the outage scope is frozen, and to formal management signoff if made after the outage scope is frozen.

## Evaluation of Inspection Data

### Introduction

The inspection data taken during an outage is first evaluated by a qualified engineer and later the evaluations are reviewed by another qualified engineer. This evaluation is performed for two main reasons. Namely to:

- demonstrate the structural adequacy of the inspected component, and
- use as a basis for determining how much degradation has occurred. This value is fed back into CHECWORKS for comparison with the predicted degradation as well as in determining the line correction factor in the Pass 2 analysis.

These topics are discussed in §§4.6 and 4.7 of NSAC-202L. They are also discussed in §§5.6 through 5.11 of the Entergy corporate FAC procedure EN-DC-315 [A-1]. Additionally, the structural acceptance portion of this evaluation is described in detail in the Engineering Standard EN-CS-S-008-Multi [A-4].

### IPEC Documentation

The component evaluations are documented as formal, signed engineering calculations. Because of different procedural and Code requirements, the documentation of the component evaluation process is divided into two parts – for Safety Related Components (e.g., [A-20]) and for Non-safety Related Components (e.g., [A-21], [A-22]).

The evaluation of the Safety Related Component was performed according to the Engineering Standard [A-4]. This document, i.e. [A-20], contains, for the Safety Related components: an inspection list and a detailed calculation for each component of the minimum required thickness of the component two

years in the future.  Having this value in advance of the outage streamlines the inspection and evaluation process.

The evaluation of the Non-Safety Related Components was performed using the FAC Manager software. The evaluation reports, e.g., [A-21] contain a summary of the component inspections and calculations of the minimum required thickness and the projected lifetime of the component.

Note that for both cases, the amount of FAC-caused degradation (conventionally known as "wear") was determined using the FAC Manager computer program.

### Assessment

#### *Safety Related Components*

The evaluations of the Safety Related components are documented in a thorough manner.  The determination of the minimum acceptable thicknesses in advance of the outage is a good practice as it avoids the possible schedule impact of waiting for the structural results.

#### *Non-safety Related Components*

The evaluations of the Non-safety Related components are thoroughly documented through the use of FAC Manager reports.  This program and approach are commonly used in the industry.

## Outage Reports

### Introduction

The results of the inspections performed during each outage should be documented in an outage report. The recommendations for the content of outage reports are presented in §3.3 of NSAC-202L.  Briefly, the outage report should describe:  the components inspected, the reasons for their selection, and the evaluation and disposition of the inspected components.

### IPEC Documentation

The two most recent outage reports were reviewed for this assessment [A-23, A-24] covering the 2R19 and the 3R16 refueling outages.  These reports and their associated attachments are lengthy and contain detailed information about the inspections performed including the components inspected, the inspection packages for each inspection, and tables containing cross-reference information.  Also included is information detailing the inspection personnel, the equipment used and the equipment certifications.

Of the two outage reports available, [A-23] is the more complete one and will be the one discussed here.[9]  This report contains both high level as well as detailed information.

[9] Document [A-24], documenting the very recent 3R16 outage, consisted only of the inspection report and has not yet been completed to include all of the material contained in [A-23].

The high level information includes an overall summary of the outage work as well as a system by system summary of the inspection results. Also included is a list of the condition reports generated and their disposition.

As to the detailed component level information, of particular interest are the documents that define the inspection location and record the results. These are normally known as "inspection packages." At IPEC they are typically five pages long and are signed by the inspector and three reviewers. The inspection package also includes the equipment used and calibration data, a sketch and photograph of the area inspected, and color coded tables showing the inspection results. Packages for each inspection performed, sorted by system are included in the outage report.

### Assessment

The outage reports reviewed provide a detailed report of the outage work performed and the results found. In particular, based on my experience, I view these as very complete inspection packages.

## Treatment of the Stretch Power Uprate

### Introduction

The general treatment of power uprates by a FAC program is described in Section 4.3.1 of NSAC-202L. This section provides some general recommendations for dealing with the change of operating conditions that occur with a power uprate. Specifically, the relevant portions of this section are:

> *When power uprates are being considered, it is recommended that the proposed changes to operating conditions and any possible changes to the plant heat balance diagram be fully reviewed and evaluated using the Predictive Plant Model.*[10] *Potential changes to the Susceptible-Not-Modeled lines should also be considered. This should include identification of any piping areas and equipment where FAC rates are predicted to significantly increase…*

### IPEC Documentation

Two reports were issued [A-25, A-26] describing the CHECWORKS analyses performed in advance of the stretch power uprates (SPU). These reports contain a description of the modeling used and the results obtained by using CHECWORKS at the post SPU conditions and then comparing these results with the pre-SPU results. Tables in the reports showed the pre- and post-SPU values of the global variables. Also included are tables showing the predicted change of wear rates as a result of the SPU.

### Assessment

The CHECWORKS reports are complete and cover the lines modeled with CHECWORKS. These reports contain sufficient information to plan for the post-uprate inspections.

[10] That is the CHECWORKS model.

# Program Assessments

## Introduction

Assessments of the FAC programs are done by external evaluators (e.g., INPO) and internal personnel. The importance of program assessments is discussed in Sections 2 and 3 of EPG-06, and mentioned briefly in §2.1 of NSAC-202L.

## IPEC Documentation

Two sets of internal assessments were available to this review. Three recent, quarterly program health reports and three "snapshot assessments."

The program heath reports are quarterly reports which are designed to show management the health of the program [A-27 through A-29]. As is the usual practice in the nuclear industry a four color scale is used to rate the program with the colors ranging from green (the best) through white, yellow and red (the worst).

The snapshot assessments were conducted by a team of internal personnel with experience with FAC. In all cases, the team reviewed the inspection lists prior to refueling outages [A-30, A-31, A-32]. Note that the independent review of inspection lists is recommended in §3.3 of NSAC-202L. As part of this review process, non-conformance reports are issued if any actions are determined. These non-conformance reports are then put into the corrective action system to ensure that the appropriate actions are taken.

For the 3R17 assessment [A-32], there were two additional sets of objectives. One was to review the IPEC FAC program against the FAC programs at two other Entergy stations. The other was to review the state of the IPEC documentation against industry standards. These additional objectives were prompted by the negative findings of a recent EPRI assessment of the FAC program at another Entergy station.

## Assessment

### *Program Health Reports*

At IPEC, the Program Health Reports are standardized, eleven page documents designed to show the program status to station management. These reports divide the program performance into four major areas – Program Personnel, Program Infrastructure, Program Implementation, and Equipment Related Plant Performance. These main areas are further subdivided into a total of 24 sub-areas. For all of the three reports available, the IPEC FAC program was assessed overall as "Green" – the highest rating. The main negative finding – a "Red" score – was for not having of a qualified backup FAC engineer in place. The previous backup FAC engineer had left the company and although a replacement had been identified, a fully qualified backup was not yet in place. Further, although the qualified backup engineer was not in place, there were other qualified personnel locally available to assist the program if necessary.

### *Snapshot Assessments*

Treating the reviews of the inspection lists first, the three documents available provide a thorough examination of the projected inspection lists on a system by system basis. The inspections lists were reviewed and challenged to ensure that the inspections were properly focused. In my judgment, the comments and challenges shown in these assessments reflects good practices at work and should not reflect negatively on the program.

Considering now the additional parts of the 3R17 assessment [A-32], these parts represent a much more detailed review of the some of the technical aspects of the program. In addition to the corporate FAC engineer and a site engineer familiar with FAC – the normal team for a snapshot assessment, a peer from another Entergy site was also part of the review team. The fact that this additional review was performed reflects favorably on the FAC program as another was made to ensure that deficiencies seen at another Entergy site were not present at IPEC.

The findings of the review team were quite favorable as seen by their conclusion, presented below:

> *The IPEC's FAC program is well organized, well documented and there is a firm management commitment to the program. Program documents are updated frequently and in a timely manner. All documents were confirmed to be processed in accordance with site protocols and all drawings are controlled. Documents can be found in the records management system and they are easily retrievable.*

## Summary and Recommendations

Based on this assessment, the FAC program at IPEC closely follows NSAC-202L, the industry standard that describes FAC program in nuclear plants as well as the relevant INPO guidance (e.g., EPG-06). It also meets the general requirements of the GALL Report.

### Program Strengths

The following program strengths are noted:

- There is an experience site FAC engineer. He has been at IPEC for 4 years and has a total of 16 years experience with FAC programs in nuclear utilities.
- The program documentation including the System Susceptibility Evaluations are updated periodically and kept up to date.
- Excellent water chemistry practices are being used in both units.
- The CHECWORKS models are complete and up to date with the inspection results fed back into the manner to run Pass 2 in a timely manner.
- An analysis of the Pass 2 results is made to determine which lines are calibrated. This information is included in the CHECWORKS reports.
- Additionally, any predicted negative times to *Tcrit* are identified and if possible explained. This analysis is also documented in the CHECWORKS reports.

## Suggestions for Improvement

Based on the review of this program, the following suggestions for improvement of the FAC program at IPEC are offered.

- The industry standard definition of FAC being a degradation mechanism that only affects carbon and low alloy steels should be used in the Entergy Corporate Procedure [A-1].
- The procedure used to determine whether Pass 2 analysis lines are calibration should be documented in the Entergy Corporate Procedure [A-1], rather than simply relying on the reference to NSAC-202L in [A-1].
- The use of alloy sampling to detect trace chromium in piping components is recommended. This has become as standard practice in the nuclear industry and its use helps focus inspection programs and improve Pass 2 results. Note that adding alloy measurements to a FAC program, tends to make a program more efficient in that it will eliminate the need to inspect fitting containing a significant amount of trace chromium.

## References


1. *Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R3).* EPRI, Palo Alto, CA: 2006. 1011838.
2. *Engineering Program Guide, Good Practice,* EPG-06, Institute of Nuclear Power Operations, Atlanta, December 2006.
3. *Generic Aging Lessons Learned (GALL) Report,* NUREG-1801, Revision 2, U.S. Nuclear Regulatory Commission, December 2010.
4. *CHECWORKS™ Steam/Feedwater Application Version 3.0 SP-2 User Guide,* EPRI, Palo Alto, CA: 2010. EPRI Product 1021383.

## Appendix A – List of Documents Reviewed

This appendix presents a list of the documents reviewed in the course of this assessment. Unless otherwise noted, these documents were produced by Entergy.

A-1. EN-DC-315, Revision 6, *Flow Accelerated Corrosion Program*, (October 26, 2011).

A-2. CEP-FAC-001, Revision 0*, Flow Accelerated Corrosion Program Component Scanning and Gridding Standard,* August 19, 2010.

A-3. CEP-NDE-0505, Revision 4, *Ultrasonic Thickness Examination,* July 29, 2009.

A-4. EN-CS-S-008-Multi, Revision 0, *Pipe Wall Thinning Structural Evaluation,* January 1, 2010

A-5. EN-CS-S-009-Multi, Revision 1, *Replacement Material for Flow Accelerated Corrosion (FAC) Degraded Carbon Steel Piping, August 17, 2011*

A-6. "Indian Point Energy Center Unit 2 FAC System Susceptibility Evaluation (SSE)," CSI Technologies, Report No. 0700.104-02, Revision 2, October 14, 2011

A-7. "Indian Point Energy Center Unit 3 FAC System Susceptibility Evaluation (SSE)," CSI Technologies, Report No. 0700.104-17, Revision 2, October 14, 2011

A-8. "Indian Point Energy Center Unit 2 SSE/SNM Evaluation Color-Coded Flow Diagrams," CSI Technologies Document No. 0700.104-04, Revision 2, October 14, 2011

A-9. "Indian Point Energy Center Unit 3 SSE/SNM Evaluation Color-Coded Flow Diagrams," CSI Technologies Document No. 0700.104-19, Revision 2, October 14, 2011

A-10. "Indian Point Unit 2 CHECWORKS SFA Model," CSI Technologies, Calculation Number 0705.101-01, Revision 2, July 8, 2010.

A-11. "Indian Point Unit 3 CHECWORKS SFA Model," CSI Technologies, Calculation Number 0705.100-01, Revision 2, August 2, 2011.

A-12. "Indian Point Energy Center Unit 2 FAC Susceptible Non-Modeled Program, CSI Technologies, Document Number 0700.104-03, October 14, 2011.

A-13. "Indian Point Energy Center Unit 3 FAC Susceptible Non-Modeled Program, CSI Technologies, Document Number 0700.104-18, October 14, 2011.

A-14. "2R19_FAC_Inspection_scope_R2," MS EXCEL Spreadsheet

A-15. "2R20_FAC_Inspection_scope_R1," MS EXCEL Spreadsheet

A-16. "3R15_FAC_Inspection_scope_R0," MS EXCEL Spreadsheet

A-17. "3R16_FAC_Inspection_scope_R1," MS EXCEL Spreadsheet

A-18. "3R17_FAC_Inspection_scope_R1," MS EXCEL Spreadsheet

A-19. "2R19_FAC_Scope_Reduction_R1," MS EXCEL Spreadsheet

A-20. “Minimum Wall Thickness for 3R15 Outage Safety Related System FAC Inspection,” Engineering Calculation # 12843, March 31, 2009.

A-21. “3R15 FAC Minimum Wall Calculation for Various Components,” Engineering Calculation # 13840, April 6, 2009.

A-22. “3R16 FAC Minimum Wall Calculation for Various Systems,” Engineering Calculation No. IP-CALC-11-00016, April 5, 2011.

A-23. Mew, Ian, “IPEC Flow Accelerated Corrosion Inspection Summary for 2R19,” IPEC Memorandum to Distribution, IP-PCE-10-006, April 15, 2010.

A-24. “Entergy Nuclear Corporation 3R16 Refueling Outage 2011 Flow Accelerated Corrosion Inspection Summary Indian Point Unit 3,” URS-Inspection.

A-25. “Indian Point Unit 2, CHECWORKS Power Uprate Analysis,” CSI Technologies Calculation No. 040711-02 Revision 0, March 23,2005

A-26. “Indian Point Unit 3, CHECWORKS Power Uprate Analysis,” CSI Technologies Calculation No. 040711-01 Revision 0, March 23,2005

A-27. “Program Health Report, FAC – Flow Accelerated Corrosion Program,” Q2-2011.

A-28. “Program Health Report, FAC – Flow Accelerated Corrosion Program,” Q3-2011.

A-29. “Program Health Report, FAC – Flow Accelerated Corrosion Program,” Q4-2011.

A-30. “IPEC 3R16 FAC Scope Review,” IPEC Snapshot Self-Assessment Report, January 11, 2010.

A-31. “IPEC 2R20 FAC Scope Review,” IPEC Snapshot Self-Assessment Report, March 11, 2011.

A-32. “IPEC 3R17 FAC Scope Review,” IPEC Snapshot Self-Assessment Report, October 26, 2011.