

**MRP** Materials Reliability Program \_\_\_\_\_ MRP 2015-025

DATE: July 6, 2015

TO: Robert O. Hardies, Senior Level Advisor  
Division of Engineering, Office of Nuclear Reactor Regulation

FROM: Bernie Rudell, Exelon, MRP Integration Chairman  
Anne Demma, EPRI, MRP Program Manager

SUBJECT: EPRI-MRP Interim Guidance for Management of Thermal Fatigue

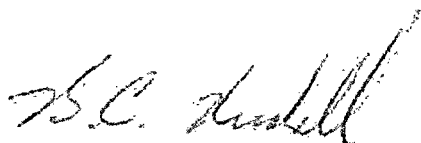
REFERENCES:

1. Materials Reliability Program: Management of Thermal Fatigue in Normally Stagnant Non-Isolable Reactor Coolant System Branch Lines (MRP-146, Revision 1, 1022564), June 2011
2. Materials Reliability Program: Management of Thermal Fatigue in Normally Stagnant Non-Isolable Reactor Coolant System Branch Lines – Supplemental Guidance (MRP-146S, 1018330, January 2009)
3. Materials Reliability Program: Assessment of Residual Heat Removal Mixing Tee Thermal Fatigue in PWR Plants (MRP-192, Revision 2, 1024994), August 2012

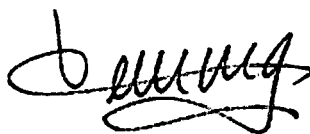
Dear Mr. Hardies

As discussed in the annual Industry / USNRC Materials Programs Technical Information Exchange Meeting on June 2, 2015, the Electric Power Research Institute (EPRI), Materials Reliability Program (MRP) recently published Interim Guidance that supplements existing thermal fatigue management guidelines in references 1, 2 and 3. During that discussion, you requested EPRI to provide a copy of the guidance changes for information. Attachment 1 is provided in response to your request.

Sincerely,



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MRP Chairman  
Exelon Generation



Anne Demma  
MRP Program Manager  
Electric Power Research Institute

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Cc: Joseph Holonich, NRC  
Joseph Golla, NRC

Attachment: NEI 03-08 Needed and Good Practice Interim Guidance for Management of Thermal Fatigue

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## Attachment 1

### NEI 03-08 Needed and Good Practice Interim Guidance for Management of Thermal Fatigue

#### 1. Good Practice Interim Guidance

##### 1.1. Validation of Thermal Fatigue Management Assumptions

Thermal fatigue is a dynamic aging mechanism that is sensitive to plant configuration and operating history. Key assumptions made in determining component life and inspection requirements may be subject to design and operational changes and may warrant periodic monitoring to ensure analysis validity. Assumptions may include insulation, piping supports and operational practices.

###### 1.1.1. Good Practice:

###### *Validation of Thermal Fatigue Management Assumptions*

Analyses performed in support of MRP-146 and MRP-192 examination plans should be reviewed to identify key assumptions. This may include plant screening evaluations and corrective action documents related to thermal fatigue. Key assumptions should be evaluated to determine if periodic inspections or monitoring is appropriate to ensure analysis integrity.

##### 1.2. Expanded MRP-192 Examination Volume Requirement

MRP-192 Section 3 specifies examination volumes that include the mixing Tee downstream weld, and all other welds within 4 pipe diameters downstream of the mixing Tee weld. Non-destructive and destructive examinations performed following recent OE identified cracking in the perpendicular branch inlet pipe to the mixing Tee. Computational simulations of thermal transients in mixing Tees have also observed relatively large magnitude thermal cycles in the upstream pipe inner surface. The extent to which thermally stratified eddies penetrate upstream piping is dependent on flow velocities and Mixing Tee geometry. It is possible that under low branch flow conditions, cracking could initiate at upstream piping welds. Based on these observations, the recommended MRP-192 examination volume specified in Section 3 is being expanded to include areas of observed and potential cracking.

1.2.1. Good Practice:

*Expanded MRP-192 Examination Volume Requirement*

In addition to the examination volumes specified in Section 3 of MRP-192, Revision 2, it is recommended that future MRP-192 examinations also include the Mixing Tee weld to the upstream piping as shown in Figure 1.

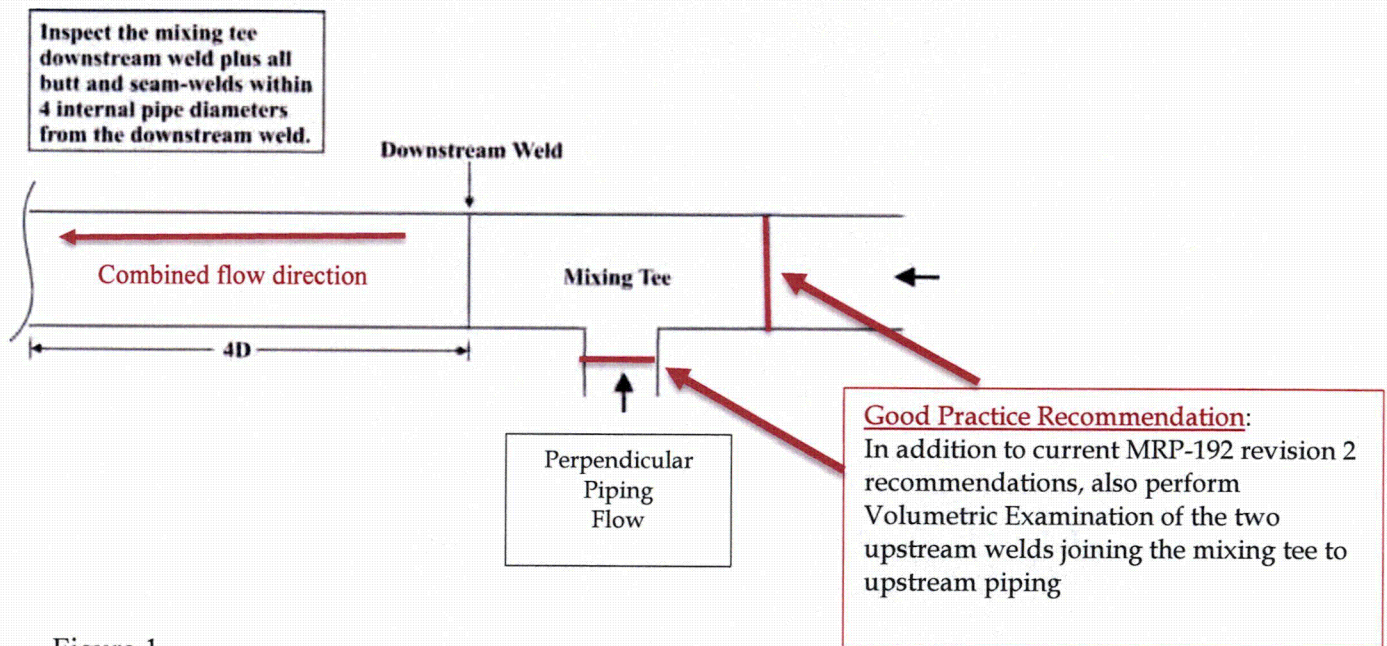


Figure 1

Revised volumetric examination recommendations.

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## 2. Needed Interim Guidance

### 2.1. Down Horizontal (DH) Branch Lines subject to cyclic operational out-flow

The introduction to Section 2 of MRP-146 identifies that the analytical models used for identification of thermal fatigue susceptibility are not applicable to DH lines where in-leakage or out-leakage is present. Recent operating experience has identified at least one through wall cracking event involving a 2-inch Nominal Pipe Size (NPS) drain line where fatigue failure was likely to have been accelerated by thermally stratified, cyclic chemistry sampling in the DH branch line. This OE identifies the need for near term actions to limit the potential of unacceptable cracking.

Continuous or slowly varying leakage through closed valves or other fixed mechanical boundaries does not constitute cyclic outflow for purposes of this concern.

#### 2.1.1. Needed Requirement:

*One Time Examination of Down Horizontal (DH) Branch Lines >1-inch NPS to <4-inches NPS that have had a prior history of cyclic operational out-flow.*

Normally stagnant DH branch lines where cyclic out flow operations have occurred in the past, shall be examined in accordance with requirements and examination volumes specified in MRP-146 to ensure acceptable elbow and piping condition. This one-time examination requirement shall be performed no later than the first refueling outage starting after June 1, 2016.

Examinations meeting the requirements of MRP-146, and performed after June 1, 2013 may be credited for meeting this Needed requirement, if determined to be acceptable by the responsible engineer. This determination should consider the adequacy of volumetric coverage consistent with the intent of section 2.4.3 in this letter.

This one time examination is not required if the incremental fatigue usage of piping due to thermally stratified outflow has been conservatively analyzed and shown to be negligible.

These examinations ensure piping integrity subsequent to previous cyclic out-flow operations. Results of these examinations do not require EPRI-MRP review for Guideline management purposes and may be reported in the annual MRP-219 outage surveys.

#### 2.1.2. Needed Requirement:

*Periodic Examination of Down Horizontal (DH) Branch Lines >1-inch NPS and <4-inches NPS that have a continuing potential for cyclic operational out-flow*

Normally stagnant DH branch lines where cyclic out flow operations are expected to occur in the future, shall be examined every other refueling outage

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subsequent to cyclic out flow operation and the first refueling outage starting after June 1, 2016. Examinations shall conform to the requirements and volumes specified in MRP-146.

If the fatigue contribution due to outflow is evaluated with all other usage, including MRP-146 effects, and shown to remain within acceptable limits, this examination schedule may be relaxed by the owner. Examinations may be deferred following operating cycles where cyclic operational out-flow does not occur.

## 2.2. Down Horizontal (DH) Branch Lines Previously Exempted by MRP-146 Paragraph 2.1.5.4, MRP-146(S) Generic Analysis

Recent Operating Experience identified through wall cracking in Down Horizontally attached branch lines within 6-years of a previous examination where no cracks had been detected. The examination frequency for these branch lines had been relaxed under MRP-146 Paragraph 2.1.5.4 using MRP-146(S) paragraphs 2.2.2.4 and A.2.4. This experience draws into question the conservatism of extending examination schedules based on the analysis of MRP-146 Paragraph 2.1.5.4. Other factors may have contributed to this premature cracking event. In order to assess the extent of condition from a potentially non-conservative analysis method, a one-time examination will be necessary.

(Note: Branch lines with examination requirements based on MRP-170 software or other analysis alternatives under MRP-146 and MRP-146(S) are not subject to this one time examination requirement).

### 2.2.1. Needed Requirement:

*One Time Examination of Down Horizontal (DH) Branch Lines Previously Exempted by the Generic Analysis option described in MRP-146 paragraph 2.1.5.4.*

Down Horizontal (DH) branch lines that were determined not to have significant thermal fatigue based on generic analysis described in MRP-146 Paragraph 2.1.5.4 and MRP-146(S) Paragraphs 2.2.2.4 and A.2.4 shall undergo a one-time examination in accordance with the requirements specified in MRP-146 Paragraph 2.4.2.2 and the Needed NDE guidance contained in section 2.4 of this letter. This examination shall be performed no later than the first refueling outage commencing after June 1, 2016. Examinations meeting the requirements of MRP-146, and performed after June 1, 2013 may be credited for meeting this needed requirement, if determined to be acceptable by the responsible engineer. This determination should consider the adequacy of volumetric coverage consistent with the intent of section 2.4.3 of this letter.

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Plants may return to the current examination schedules after completion of this extent of condition examination.

Results from these examinations shall be communicated to the EPRI MRP Technical Support Advisory Committee for an assessment of whether the relaxation methodology under MRP-146 Paragraph 2.1.5.4 should be revised.

### 2.3. Up Horizontal (UH) Piping subject to Thermal Fatigue in the vertical pipe section

Up Horizontal (UH) piping with NPS of 2-inches and smaller was observed to be resistant to turbulent swirl penetration in mockup testing and simulations underlying the current MRP-146 guidance. This resistance to development of swirl penetration in the vertical pipe was assumed to result in resistance to thermal fatigue associated with cold in-leakage. MRP-146 Section 2.1.1 excludes examination requirements for vertical piping based on this presumption. However, in two recent operating events, cracking was discovered in 1 ½ inch NPS lines that had been excluded from examination requirements under MRP-146 Section 2.1.1 screening criteria. This recent OE has revealed an unanticipated mode of thermal cycling and cracking that also occurred at an unexpected location in the vertical pipe to RCS nozzle interface.

As a result of this experience, UH lines less than 2-inches NPS that may be subjected to cold in-leakage as defined in MRP-146 section 2.1 can no longer be exempted from examination on the basis of diameter alone. The required examination volume for these lines include vertical pipe sections where cracking was identified in the OE, in addition to the MRP-146 examination volume from which the line had previously been exempted.

It is not known if lines somewhat larger than 2-inches may be susceptible to vertical pipe cracking from this mode of thermal fatigue. Therefore, a one-time examination of vertical pipe for lines greater than 2-inches NPS and not larger than 4-inches NPS is needed to establish the extent of this thermal fatigue mode. This operating experience does not diminish the validity of other bases for exclusion of UH/H lines from examination in MRP-146 Section 2.1.1.

Branch piping of diameters 1-inch NPS and less remain exempted from examination based on engineering judgement that temperature differentials across small diameter pipe wall will be limited by conduction and as a result will suppress significant cyclic stresses.

#### 2.3.1. Needed Requirement:

*Periodic Examination of Up Horizontal (UH) configured Piping greater than 1-inch NPS and not larger than 2-inches NPS and having the potential of cold in-leakage.*

Normally stagnant UH piping, with nominal pipe sizes greater than 1-inch NPS and not larger than 2 -inches NPS and having a potential for cold in-leakage shall be examined every refueling outage commencing with the first refueling outage starting after June 1, 2016. Examinations shall conform to the requirements of MRP-146 as augmented in this Interim Guidance letter. The examination volume shall include the areas described in Section 2.4.2.1 of MRP-146, the pipe to nozzle (butt) weld and the vertical pipe base metal up to two pipe diameters above the weld or to the elbow if it is less than 2D from the weld as shown in figure 2. Examination of socket welds is not required.

2.3.2. Needed Requirement:

*One Time Examination of UH Configured Piping greater than 2-inches NPS and not larger than 4-inches NPS and having the potential of previous cold in-leakage.*

Up-Horizontal (UH) normally stagnant piping with nominal pipe sizes (NPS) of between 2 and 4 inches and having the potential for cold in-leakage, shall be examined using the examination requirements of MRP-146 as augmented in this Interim Guidance letter. This one-time examination shall include the pipe to nozzle (butt) weld, and the vertical pipe base metal up to 2 pipe diameters above the weld or to the elbow if it is less than 2D from the weld as shown in figure 2. Examination of socket welds is not required.

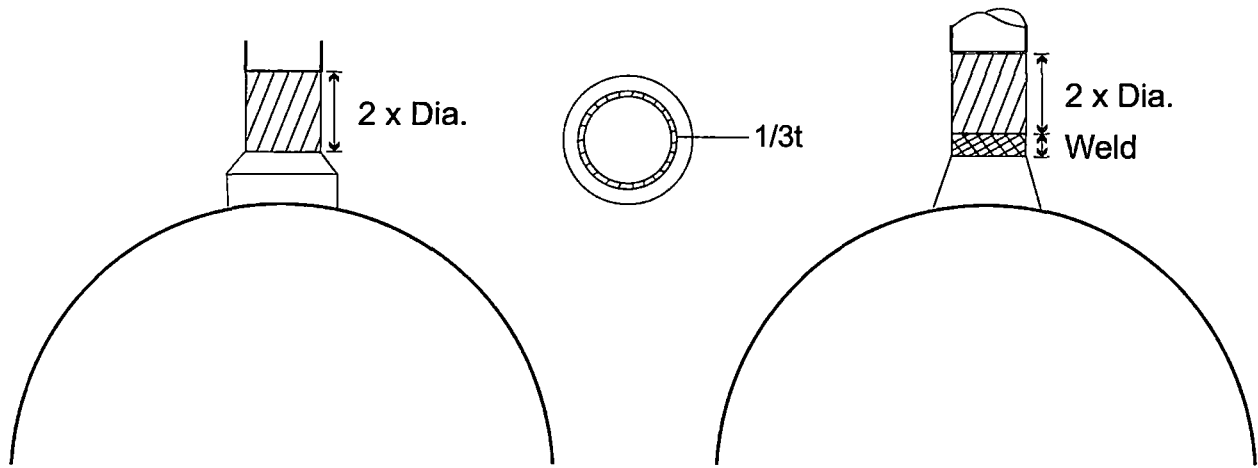
This examination shall be performed not later than the first refueling outage commencing after June 1, 2016.

Examinations performed after June 1, 2013 may be credited for meeting this needed requirement, if the additional volume was examined and the examination is determined acceptable by the responsible engineer. This determination should consider the adequacy of volumetric coverage consistent with the intent of section 2.4.3 of this letter.

Results from these examinations shall be communicated to the EPRI MRP Technical Support Advisory Committee for an assessment of whether branch lines between 2 and 4 inches NPS are susceptible to this thermal fatigue mode.



> 90% Base Metal (includes elbow)  
> 90% Weld (Fig. 2-16)



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**Figure 2**

Detailed view of the additional examination volume for Up Horizontal configured branch lines between 1 and 4 inches NPS that also have potential for in-leakage.

#### 2.4. Non Destructive Examination Process Improvements

Recent Operating Experience in thermal fatigue as well as other NDE applications have identified that greater engagement between inspection program owners and examiners is key to effective examinations and understanding of detection limitations. New requirements have been published in several examination areas such as Dissimilar Metal Welds, and Reactor Pressure Vessel Head penetrations that implement greater engineering engagement.

Several of the recent thermal fatigue events have involved missed crack detection opportunities which resulted in plant shutdown and reliability challenges. In some cases, lack of emphasis on examination coverage may have contributed to non-detection of operationally significant cracks. MRP-146 Section 2.4.1 states that it is not necessary to examine 100% of the recommended volume based on the generalized nature of thermal fatigue. However, recent Operating Experience has revealed instances where cracking was limited to small volumes such that 100% examination coverage would be critical to prevent exceeding allowable crack dimensions.

As a result of these observations, examination process changes are required for implementation. These process changes shall be implemented for Needed thermal fatigue

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examinations no later than the first refueling outage following October 1, 2015. These requirements are not applicable to examinations performed prior to that date.

2.4.1. Needed Requirement:  
*Examination Volume Specification*

For locations to be inspected in accordance with MRP-146 and as augmented in this interim guidance letter, Component examination sketches indicating the required coverage volumes of MRP-146 figures 2-11 through 2-19, and as augmented by this interim guidance (figure 2), shall be developed and provided to the examiners. These sketches shall be included in the completed thermal fatigue examination work package or applicable procedure. These sketches shall separately identify both the base metal examination volume and weld examination volume requirements. Butt weld volume requirements shall be established consistent with MRP-146 Figures 2-16 and 2-17. The base metal examination volume includes all required piping and fitting volumes exclusive of the specified weld volumes.

2.4.2. Needed Requirement:  
*Examination Documentation – Limitations and Coverage Calculations*

Examiners shall document the actual coverage obtained and calculate the percentage of required volumes examined for both the base metal and weld volumes. These results shall be provided for review by the responsible engineer.

2.4.3. Needed Requirement:  
*Examination Volume Coverage*

Essentially 100% of the examination volumes specified in MRP 146 and this Interim Guidance, shall be inspected. If the achieved examination coverage of the required base metal volume was not greater than 90%, or if the achieved examination coverage of the required weld volume was not greater than 90%, then the Responsible Engineer shall be informed and a Corrective Action Program (CAP) item shall be generated to document the coverage limitation and assess the actual coverage obtained. The Responsible Engineer shall assess the potential risk from cracking in the unexamined volumes and determine if compensatory measures such as alternate examination techniques or weld crown removal are warranted.

CAP items need not be replicated in subsequent examinations if coverage limitations are unchanged. Coverage limitations should be included in subsequent thermal fatigue examination briefings.

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