WHITEPAPER IN SUPPORT OF

Minimum Examination Coverage Requirements for Class 1 and Class 2 Piping Welds

ASME Section XI
Working Group on the Implementation of Risk-Based Examinations
Item No. RI-01-09

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Partial Examination Coverage
- Evaluation Process -

Introduction:

Plant-specific experience has shown that there is the potential that examination locations selected by risk-informed inservice inspection (RI-ISI) programs may not be suitable for achieving 100 percent of the typical Section XI examination volume. Table 1 provides a summary of a typical partial scope (i.e. examination category B-J, excluding socket welds) RI-ISI application. For larger scope RI-ISI applications (e.g. small bore Class 1 and Class 2 applications), it is expected that the number of partial coverage examination issues will be even higher. The following paragraphs described the process portrayed in the attached flowchart which can be used to determine the minimum examination coverage requirements for a RI-ISI examination.

This process may optionally be applied to traditional Section XI examinations. When this process is applied to a traditional Section XI examination, an evaluation in accordance with Table 2 shall be conducted to determine if any of the mechanisms listed in the attached flowchart are applicable. If so, the applicable portion of this flowchart shall be followed.

The intent of this process is that it can be utilized either before or after examinations have been conducted. If examinations have already been conducted and only partial coverage was obtained, consideration shall be given to the additional dose that may be required in order to conduct alternate (additional) examinations.

This process has several important requirements that must be kept in consideration.

- For examinations that do not meet the standard 90% coverage requirement, a best effort examination shall always be conducted on the remaining, accessible examination volume. For example, if seventy percent "qualified" coverage is obtained, a best effort examination shall be conducted on the other thirty percent.
- Partial coverage examinations for physical constraint purposes (e.g. component support interferences) are not intended for convenience purposes. For example, recently installed supports, shall not be used as a reason for not obtaining full coverage.

Process Description:

The purpose of the first page of the flowchart is to partition the inspection location by its risk category (region). For high risk locations, with high failure potential, it is asked whether the failure assignment was overly conservative. If so, a more realistic assignment can be made that removes this mechanism from consideration. Examples of this include, assigning thermal fatigue to locations that have been shown by plant-specific monitoring to experience low delta Ts and assigning IGSCC in stagnated PWR environments which are long distances from a heat source.

If a more realistic assignment is warranted, then the risk ranking, element selection and delta risk evaluation shall be redone to reflect the updated information. For example, if this location was credited in the delta risk evaluation with a high failure rate, then the delta risk needs to be redone and documented.

Other risk categories 2, 4 and 5 (regions 1B, 2 and 3) are also defined on this page but treated in subsequent sections of the flowchart.

Page 6 of 10 -

The purpose of this page is to revisit the basis for the element's risk ranking for non-high risk/high failure potential locations (e.g. Region 3 or RC2). By understanding the basis for the element's risk significance, an evaluation can be made to determine if there is excess conservatism in the original risk significance determination. If there are excess conservatisms, the original analysis can be revised and the appropriate steps of the RI-ISI evaluation redone (e.g. risk ranking, delta risk) to determine if the examination is still required. This evaluation should include all applicable aspects of the RI-ISI methodology such as consequence of failure and defense in depth considerations.

A second option is to determine if there are other locations with the same degradation mechanism within the same risk category. Care should be taken in that the inspected location may have been chosen because it represents the location of highest failure potential within this risk category. If it was, generally it should be retained in the inspection population and additional steps within the attached process should be followed rather than selecting a new location.

If another location is selected, the new examination shall be conducted and documented. The delta risk evaluation shall also be assessed to determine if an update to the delta risk evaluation is required.

At this point, conservatisms have been removed, if they existed, and alternative locations are not available. Therefore, we need to assess the impact of limited coverage. In order to accomplish this, each inspection location (with limited coverage) is partitioned by the postulated degradation mechanism, if there is one (e.g. region 1B/2 or risk category 4).

Locations potentially susceptible to thermal fatigue including striping/stratification are defined via point "B". Locations potentially susceptible to several forms of stress corrosion cracking (SCC) are defined via point "C" and those potentially susceptible to external chloride stress corrosion cracking (ECSCC) are defined by point "D". Localized (LC) and flow sensitive attack (FS) are defined by point "E".

The following paragraphs will describe the evaluation process for each type of degradation and whether a relief request needs to be submitted.

Thermal Fatigue (TF):

Page 7 of 10 – Point "B"

The assessment process for thermal fatigue starts by asking whether the inspection location is located in a horizontal run of piping connected to a steam generator (or BWR

vessel). As there has been history of cracking in these locations, and in particular, in the counterbore section of the pipe-side weld, it needs to be assured that the examination will capture the volume of interest. As such, partial coverage of the safe end or nozzle is acceptable, but full coverage is required for the pipe side of the weld, HAZ, including the pipe side counterbore.

Next it is asked whether the remaining locations are other "pipe to component" configurations. If they are pipe to pipe welds, then it is asked whether there is a counterbore issue. For example, are the counterbores quite a distance from the weld fusion line. If the counterbore(s) are a distance from the welded joint then the multiplicative effect of stress concentration due to the welding process, countebore discontinuity and weld geometry are less than if the counterbore were in close proximity to the welded joint. As such, the acceptable examination volume does not need to capture the counterbore for pipe to pipe joints, if the counterbore is at least ½ inch from the edge of the weld fusion line.

For other pipe to component welds, it is also asked whether the examination coverage issue is a result of not capturing the counterbore. In this situation, we divide the area of concern into two parts. That is, the pipe side of the joint and the component side of the joint. There is sufficient evidence to assure that the dominate cracking will occur in the pipe side of the joint and as such, limited coverage on the component side may be acceptable.

Finally, the EPRI Material Reliability Program (MRP) has issued interim guidance on inspection of small bore piping susceptible to thermal fatigue (TR-1000701, MRP-24). Although interim, this guidance may be of value in determining appropriate examination coverage and should be reviewed prior to eliminating potential inspection candidates. For example, for socket welded connections susceptible to thermal fatigue, the recommended examination includes a UT or RT of base metal for a length of ½ inch past the toe of the socket weld as well as a visual examination of the socket welded fitting itself. This may also be applicable to other small bore fittings where full coverage can not be obtained.

Page 7 of 10 – Point "H"

Point "H" is used to identify the process that may be used for traditional Section XI examinations that do not accomplished full coverage. The degradation mechanisms and criteria listed in Table 4-2 shall be evaluated for applicability to these locations. If the traditional Section XI location is identified as susceptible, then appropriate volumes, which are discussed in the following paragraphs, should be considered.

Page 8 of 10 – Points "C" & "D"

ECSCC and the ID initiated forms of SCC (minus IGSCC in BWRs) are treated next.

The first step acknowledges the occurrences of SCC in some nozzle/SE to pipe welds. Welds consisting of A600/182/82 have experienced failures. As such, obtaining essentially 100% coverage is needed.

For all other locations, allowable partial coverage is a function of ferrite content. Experience and laboratory results have shown that with sufficient ferrite content, even at high carbon content, cracking is negligible and is reflected in the flowchart. Point "F", which is continued onto page 9, identifies the process for determining the acceptability of limited coverage for various counterbore configurations.

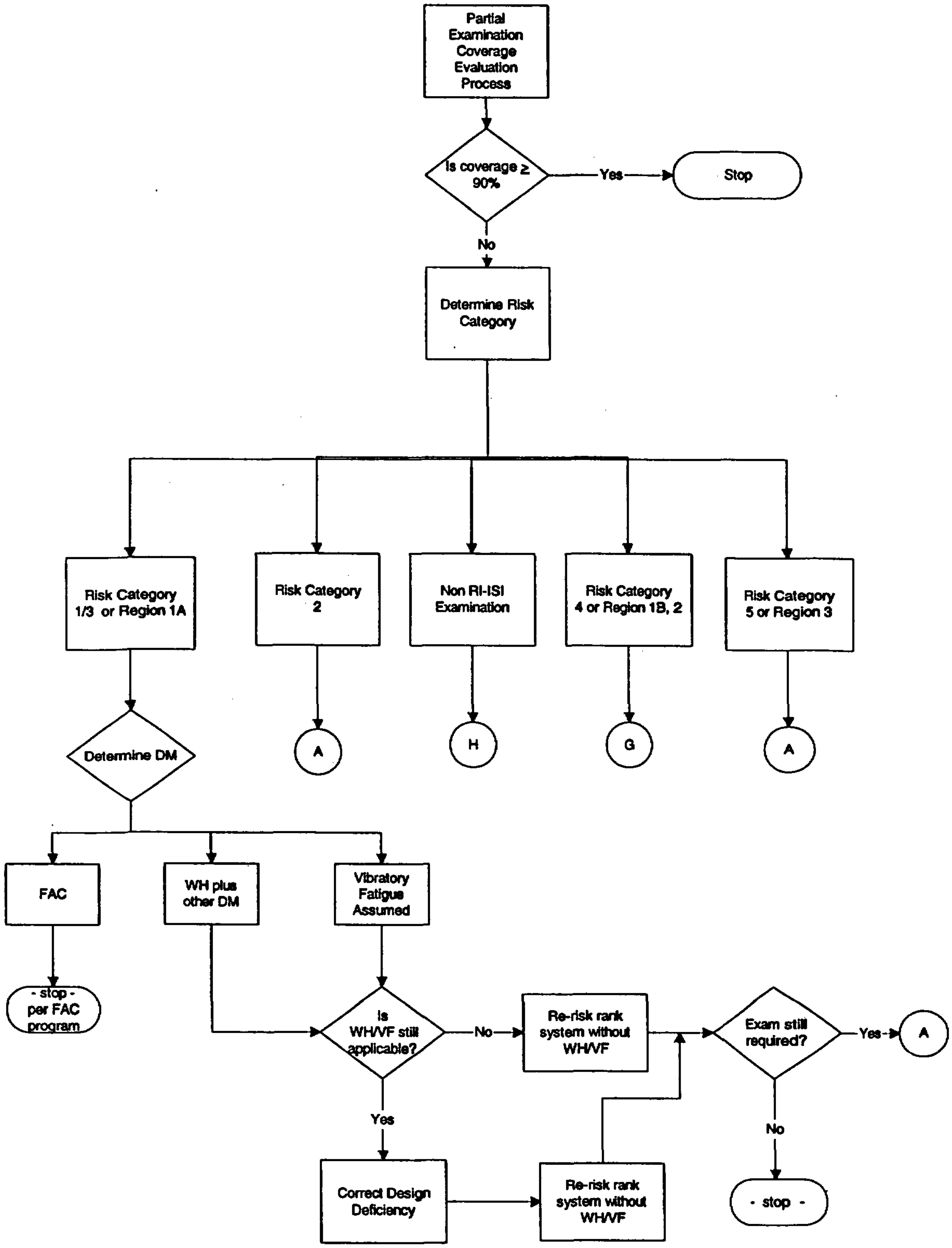
On the bottom of page 8, ECSCC is addressed (point "D"). This mechanism, which attacks the pipe from the outside diameter, is treated differently than other mechanisms. The criteria is developed recognizing that additional tools are available to the owner to determine if ECSCC is operative.

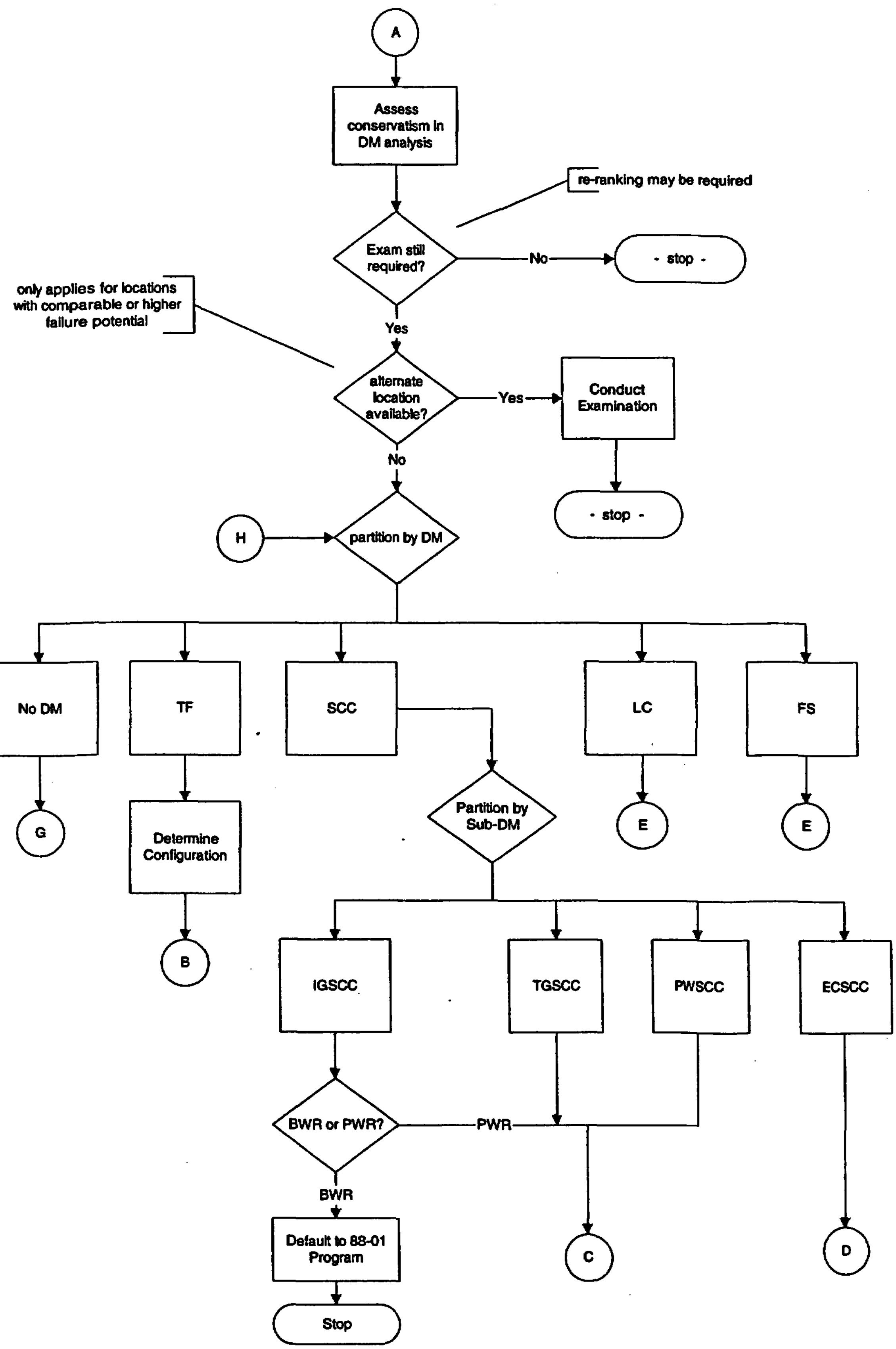
Page 9 of 10 –Points "E" & "F"

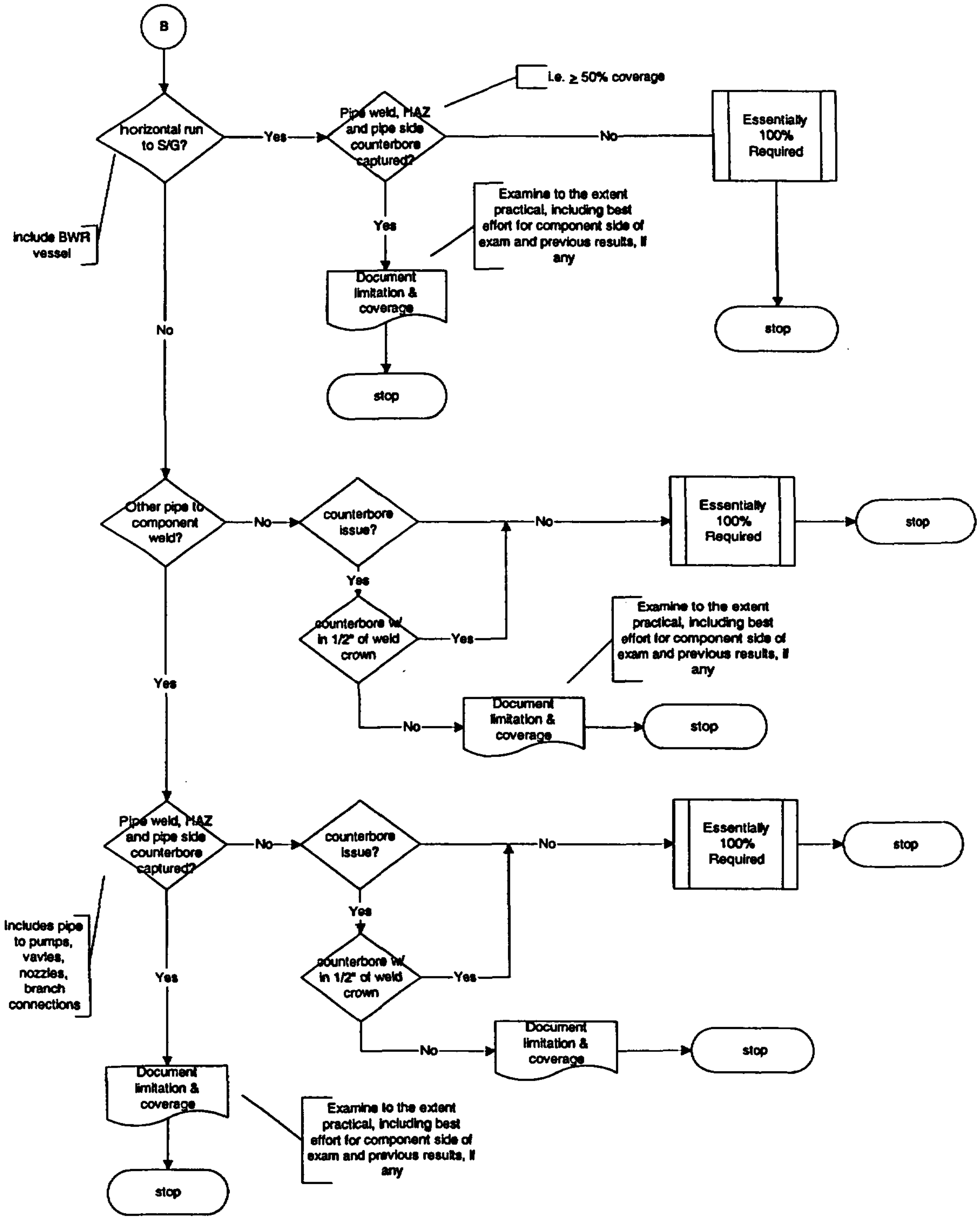
Point "E" defines the requirements for locations potentially susceptible to localized corrosion or flow sensitive attack. In general, the requirement is to follow existing plant augmented practices as defined by the owner's program. Ultimately, an examination of sufficient coverage and quality to determine if wastage is occurring should be performed.

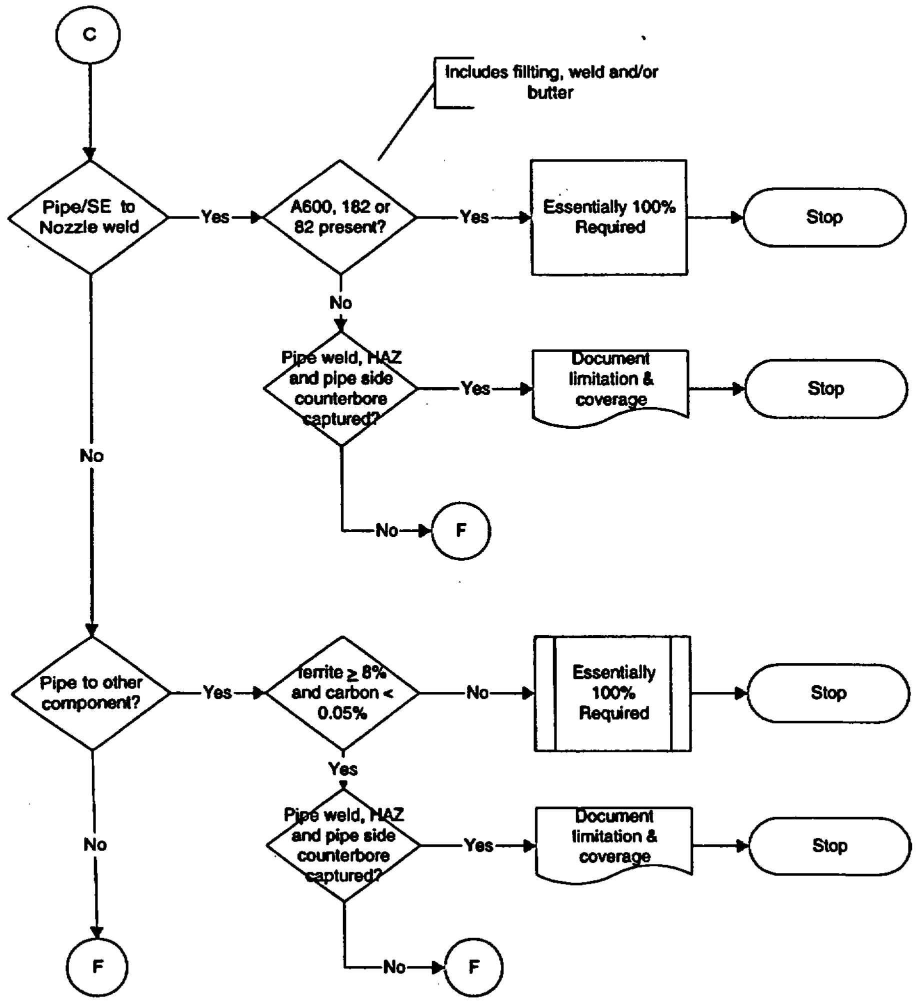
Page 10 of 10 – Point "G"

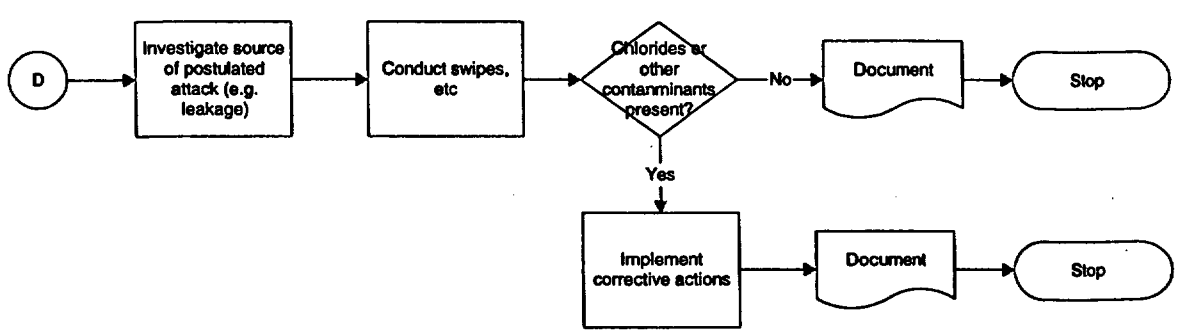
Point "G" is used to identified the process to be used for risk category 4 locations.

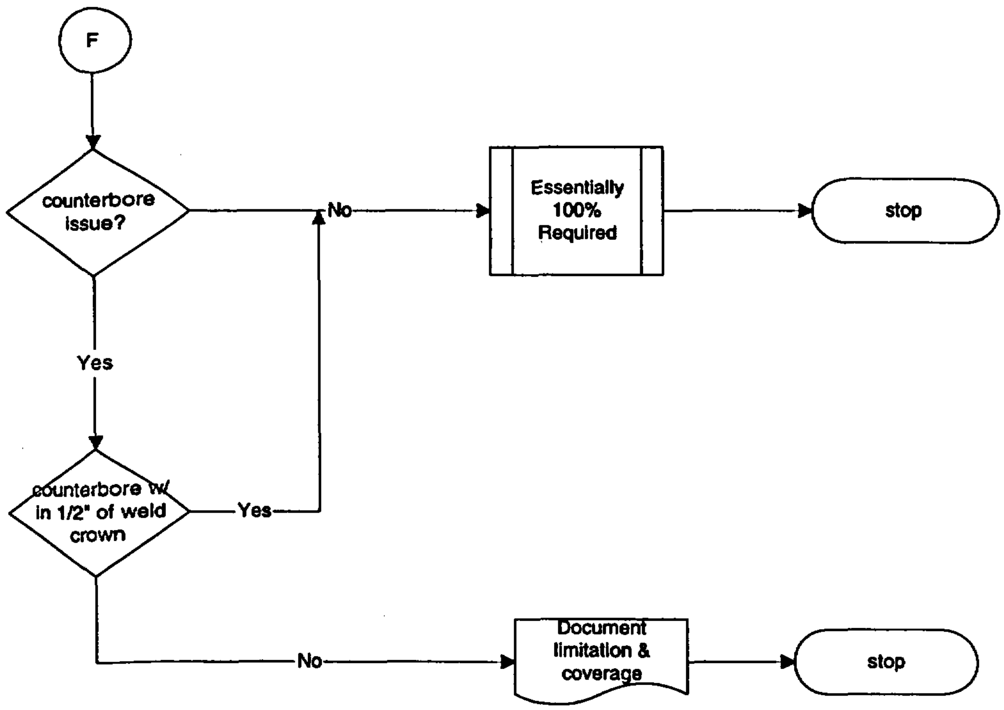

Partial Examination Coverage Evaluation Process
Is coverage ≥ 90%
Yes
Stop
No
Determine Risk Category
Risk Category 1/3 or Region 1A
Risk Category 2
Non RI-ISI Examination
Risk Category 4 or Region 1B, 2
Risk Category 5 or Region 3
A
H
G
A
Determine DM
FAC
WH plus other DM
Vibratory Fatigue Assumed
- stop - per FAC program
Is WH/VF still applicable?
No
Re-risk rank system without WH/VF
Exam still required?
Yes
A
Yes
No
Correct Design Deficiency
Re-risk rank system without WH/VF
- stop -

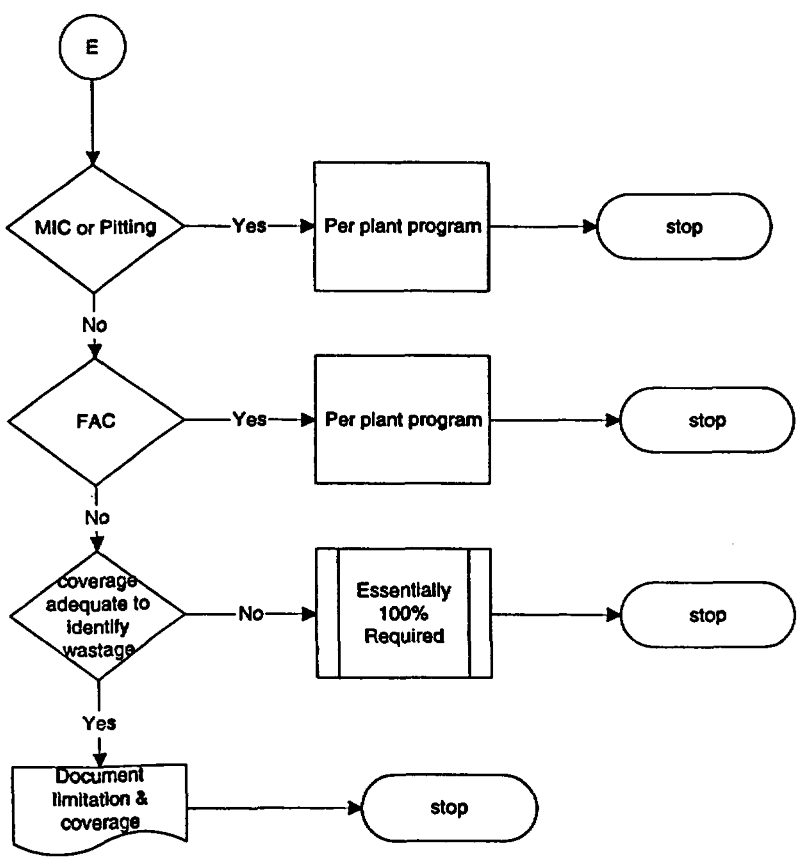

A
Assess conservatism in DM analysis
re-ranking may be required
Exam still required?
No
- stop -
Yes
only applies for locations with comparable or higher failure potential
alternate location available?
Yes
Conduct Examination
- stop -
No
H
partition by DM
No DM
TF
SCC
LC
FS
G
Determine Configuration
B
Partition by Sub-DM
E
E
IGSCC
TGSCC
PWSCC
ECSCC
BWR or PWR?
PWR
BWR
Default to 88-01 Program
Stop
C
D


B
horizontal run to S/G?
include BWR vessel
Yes
Pipe weld, HAZ and pipe side counterbore captured?
i.e. ≥ 50% coverage
No
Essentially 100% Required
stop
Yes
Examine to the extent practical, including best effort for component side of exam and previous results, if any
Document limitation & coverage
stop
No
Other pipe to component weld?
No
counterbore issue?
No
Essentially 100% Required
stop
Yes
counterbore w/ in 1/2" of weld crown
Yes
Examine to the extent practical, including best effort for component side of exam and previous results, if any
No
Document limitation & coverage
stop
Yes
Pipe weld, HAZ and pipe side counterbore captured?
No
counterbore issue?
No
Essentially 100% Required
stop
Includes pipe to pumps, vavles, nozzles, branch connections
Yes
Yes
counterbore w/ in 1/2" of weld crown
Yes
No
Document limitation & coverage
stop
Document limitation & coverage
Examine to the extent practical, including best effort for component side of exam and previous results, if any
stop


C
Includes filting, weld and/or butter
Pipe/SE to Nozzle weld
Yes
A600, 182 or 82 present?
Yes
Essentially 100% Required
Stop
No
Pipe weld, HAZ and pipe side counterbore captured?
Yes
Document limitation & coverage
Stop
No
F
No
Pipe to other component?
Yes
ferrite ≥ 8% and carbon < 0.05%
No
Essentially 100% Required
Stop
Yes
Pipe weld, HAZ and pipe side counterbore captured?
Yes
Document limitation & coverage
Stop
No
F
No
F


D
Investigate source of postulated attack (e.g. leakage)
Conduct swipes, etc
Chlorides or other contanminants present?
No
Document
Stop
Yes
Implement corrective actions
Document
Stop


F
counterbore issue?
No
Essentially 100% Required
stop
Yes
counterbore w/ in 1/2" of weld crown
Yes
No
Document limitation & coverage
stop


E
MIC or Pitting
Yes
Per plant program
stop
No
FAC
Yes
Per plant program
stop
No
coverage adequate to identify wastage
No
Essentially 100% Required
stop
Yes
Document limitation & coverage
stop

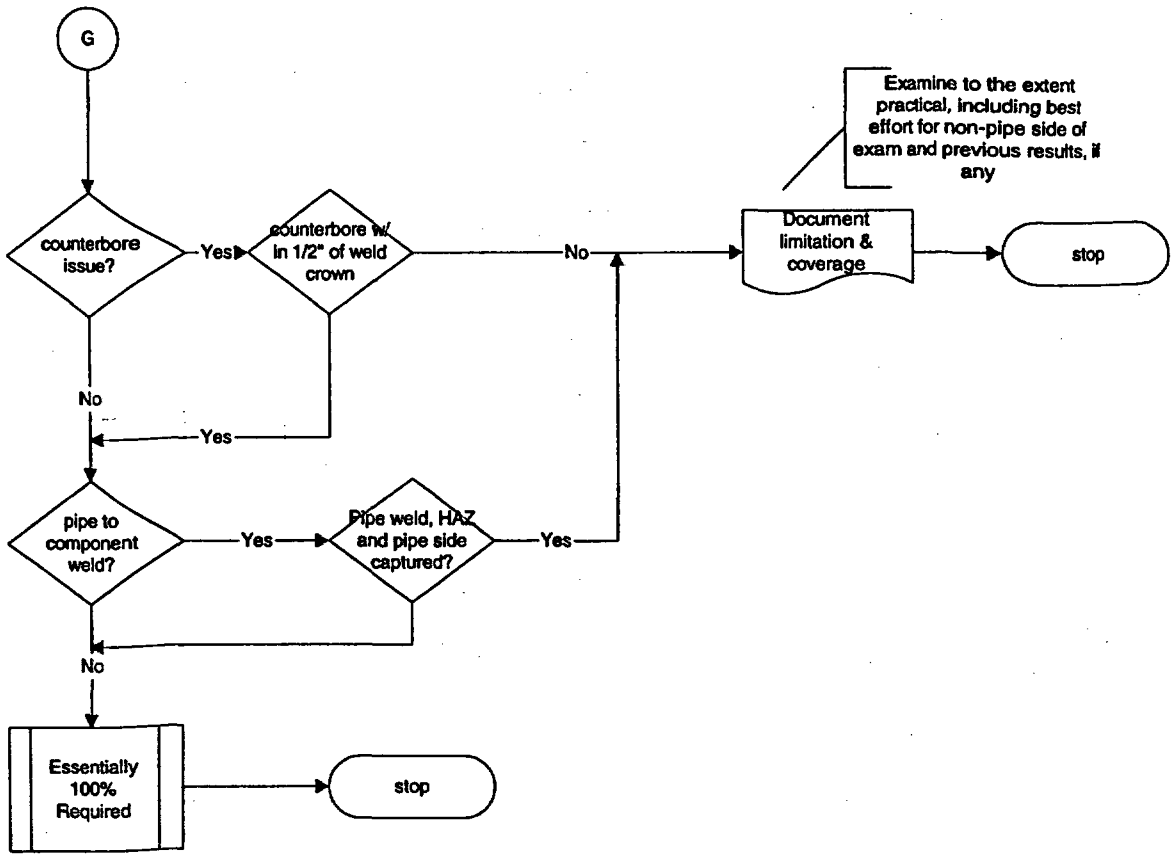

G
counterbore issue?
Yes
counterbore w/ in 1/2" of weld crown
No
Examine to the extent practical, including best effort for non-pipe side of exam and previous results, if any
Document limitation & coverage
stop
No
Yes
pipe to component weld?
Yes
Pipe weld, HAZ and pipe side captured?
Yes
No
Essentially 100% Required
stop

Table 1: Example Plant Risk-Informed Element Selections

System	Element	Description	Risk Category	Damage Mechanisms	Examination Period			Examination Coverage	
					1st	2nd	3rd	Pre-PDI	Post-PDI
RCS	16-005	Elbow-to-Pipe	2	TASCS, TT		X		-	-
RCS	16-008	Pipe-to-Elbow	2	TASCS, TT		X		-	-
RCS	16-010	Pipe-to-Elbow	2	TASCS, TT		X		-	-
RCS	18-005	Tee-to-Pipe	2	TASCS, TT			X	-	-
RCS	18-007	Pipe-to-Reducer	2	TASCS, TT			X	-	-
RCS	18-009	Pipe-to-Elbow	2	TASCS, TT			X	-	-
RCS	18-010	Valve-to-Pipe	2	TASCS, TT			X	-	-
RCS	16-001	Nozzle-to-Pipe	2	TT, PWSCC		X		-	-
RCS	18-001A	Pipe-to-Safe End	2	TT, PWSCC		X		-	-
RCS	25-031	Pipe-to-Valve	2	TASCS	C			61%	45%
RCS	09-006	Branch Connection	2	TT		X		-	-
RCS	16-012	Pipe-to-Safe End	2	TT		X		-	-
RCS	25-011	Nozzle-to-Pipe	2	PWSCC			X	-	-
RCS	09-001	Pump-to-Pipe	4	None		X		-	-
RCS	09-007	Pipe-to-Elbow	4	None		X		-	-
RCS	09-015	Pipe-to-Nozzle	4	None			X	-	-
RCS	12-001	Pipe-to-Pump	4	None	C			100%	70%
RCS	13-015	Pipe-to-Nozzle	4	None		X		-	-
RCS	14-001	Pipe-to-Nozzle	4	None			X	-	-
RCS	14-028	Nozzle-to-Pipe	4	None			X	-	-
MU&P	20-041	Pipe-to-Valve	2	TT			X	-	-
MU&P	20-044	Elbow-to-Safe End	2	TT			X	-	-
MU&P	20-045	Safe End-to-Nozzle	2	TT			X	-	-
MU&P	21-063	Elbow-to-Safe End	2	TT			X	-	-
MU&P	21-064	Safe End-to-Nozzle	2	TT			X	-	-
MU&P	22-066	Pipe-to-Valve	2	TT	C			100%	70%
MU&P	22-070	Elbow-to-Safe End	2	TT			X	-	-
MU&P	23-064	Elbow-to-Safe End	2	TT			X	-	-
MU&P	24-024	Pipe-to-Valve	2	TT	C			71%	56%
MU&P	24-008	Pipe-to-Elbow	4	None			X	-	-
MU&P	24-009	Elbow-to-Pipe	4	None			X	-	-
MU&P	22-060	Pipe-to-Valve	5	TASCS, IGSCC	C			99%	69%
MU&P	23-053	Pipe-to-Pipe	5	TASCS	C			100%	100%
DHR	19-019	Pipe-to-Safe End	2	TASCS, TT			X	-	-
DHR	19-022	Pipe-to-Safe End	2	TASCS, TT		X		-	-
DHR	17-013	Elbow-to-Elbow	2	TASCS		X		-	-
DHR	19-018	Elbow-to-Pipe	2	TASCS	C			100%	100%
DHR	19-026	Pipe-to-Elbow	2	TASCS	C			100%	100%
DHR	17-017	Nozzle-to-Elbow	2	PWSCC		X		-	-
DHR	17-006	Elbow-to-Pipe	4	None	C			100%	100%

TABLE 2
DEGRADATION MECHANISMS

Mechanisms (1)		Attributes	Susceptible Regions
TF	*TASCS*	– piping > NPS 1; and – pipe segment has a slope < 45° from horizontal (includes elbow or tee into a vertical pipe), and • potential exists for low flow in a pipe section connected to a component allowing mixing of hot and cold fluids, or • potential exists for leakage flow past a valve (i.e., in-leakage, out-leakage, cross-leakage) allowing mixing of hot and cold fluids, or • potential exists for convection heating in dead-ended pipe sections connected to a source of hot fluid, or • potential exists for two phase (steam / water) flow, or • potential exists for turbulent penetration in branch pipe connected to header piping containing hot fluid with high turbulent flow, and – calculated or measured $\Delta T > 50°F$, and – Richardson number > 4.0	nozzles, branch pipe connections, safe ends, welds, heat affected zones (HAZ), base metal, and regions of stress concentration
	TT	– operating temperature > 270°F for stainless steel, or operating temperature > 220°F for carbon steel, and – potential for relatively rapid temperature changes including cold fluid injection into hot pipe segment, or hot fluid injection into cold pipe segment, and – $\|\Delta T\| > 200°F$ for stainless steel, or $\|\Delta T\| > 150°F$ for carbon steel, or $\|\Delta T\| > \Delta T$ allowable (applicable to both stainless and carbon)	
SCC	*IGSCC (BWR)*	– evaluated in accordance with existing plant IGSCC program per NRC Generic Letter 88-01, or alternative (e.g. BWRVIP-075)	austenitic stainless steel welds and HAZ
	IGSCC (PWR)	– operating temperature > 200°F, and – susceptible material (carbon content ≥ 0.035%), and – tensile stress (including residual stress) is present, and – oxygen or oxidizing species are present OR – operating temperature < 200°F, the attributes above apply, and – initiating contaminants (e.g., thiosulfate, fluoride, chloride) are also required to be present	
	TGSCC	– operating temperature > 150°F, and – tensile stress (including residual stress) is present, and – halides (e.g., fluoride, chloride) are present, or caustic (NaOH) is present, and – oxygen or oxidizing species are present (only required to be present in conjunction w/halides, not required w/caustic)	austenitic stainless steel base metal, welds, and HAZ

TABLE 2 (Cont'd)
DEGRADATION MECHANISMS

Mechanisms (1)		Attributes	*Susceptible Regions*
SCC	*ECSCC*	- operating temperature > 150°F, and - tensile stress is present, and - an outside piping surface is within five diameters of a probable leak path (e.g., valve stems) and is covered with non-metallic insulation that is not in compliance with Reg. Guide 1.36, or an outside piping surface is exposed to wetting from chloride bearing environments (e.g., seawater, brackish water, brine)	austenitic stainless steel base metal, welds, and HAZ
	PWSCC	- piping or weld material is Inconel (Alloy 600,182,82), and - exposed to primary water at T > 570°F, and - the material is mill-annealed and cold worked, or cold worked and welded without stress relief	nozzles, welds, and HAZ without stress relief
LC	*MIC*	- operating temperature < 150°F, and - low or intermittent flow, and - pH < 10, and - presence/intrusion of organic material (e.g., raw water system), or water source is not treated w/biocides (e.g., refueling water tank)	fittings, welds, HAZ, base metal, dissimilar metal joints (e.g., welds, flanges), and regions containing crevices
	PIT	- potential exists for low flow, and - oxygen or oxidizing species are present, and - initiating contaminants (e.g., fluoride, chloride) are present	
	CC	- crevice condition exists (e.g., thermal sleeves), and - operating temperature > 150°F, and - oxygen or oxidizing species are present	
FS	*E-C*	- existence of cavitation source (i.e., throttling or pressure reducing valves or orifices) - operating temperature < 250°F, and - flow present > 100 hrs/yr, and - velocity > 30 ft/s, and - $(P_d - P_v) / \Delta P < 5$	fittings, welds, HAZ, and base metal
	FAC	- evaluated in accordance with existing plant FAC program	per plant FAC program

Notes:

(1) Thermal Fatigue (TF)
- Thermal Stratification, Cycling, and Striping (TASCS)
- Thermal Transients (TT)

Stress Corrosion Cracking (SCC)
- Intergranular Stress Corrosion Cracking (IGSCC)
- Transgranular Stress Corrosion Cracking (TGSCC)
- External Chloride Stress Corrosion Cracking (ECSCC)
- Primary Water Stress Corrosion Cracking (PWSCC)

Localized Corrosion (LC)
- Microbiologically Influenced Corrosion (MIC)
- Pitting (PIT)
- Crevice Corrosion (CC)

Flow Sensitive (FS)
- Erosion-Cavitation (E-C)
- Flow Accelerated Corrosion (FAC)

LETTER BALLOT COMMENT FORM

COMMITTEE: WG / RI   SUBMITTED BY: Syed A. Ali   DATE: 4/1/03

LETTER BALLOT # RI 01-09   SUBJECT: Proposed Code Action to Evaluate the Need for Relief Requests for Limited Examinations.

PAGE & PARAGRAPH REFERENCE	D/C	COMMENTS AND/OR RECOMMENDATIONS	DISPOSITION OF COMMENTS
	D	The RI-ISI program is based on NRC approved methodologies described in the EPRI Topical Report TR-112657 Rev. B-A or Westinghouse Owners Group Topical Report, WCAP-14572, Revision 1-NP-A. Both methodologies stipulate examination of 100% volume of designated welds in high and medium risk category characterized in the topical reports for a specific degradation mechanism. With the application of the RI-ISI program, the change in risk (CDF or LERF) is estimated to be either zero or negative or an extremely small increase consistent with the intent of the Commission's Safety Goal Policy Statement. By deviating from the examination requirement of the topical report with the performance of partial examination of designated welds, it will more than likely result in a reduction of safety margin and/or an increase in core damage frequency or risk, thereby, violating Regulatory Guide 1.174 requirements.	
	D	The white paper addressed when the selection of an additional "equivalent" weld would be warranted. This issue does not appear to be represented in the proposed code case.	

KEY: D - SIGNIFIES NEGATIVE COMMENTS   C - SIGNIFIES COMMENTS OTHER THAN NEGATIVES

	C	The proposal includes the ability to essentially change the RI-ISI analysis on page 6 by removing the water hammer or vibration fatigue. Up date of the RI-ISI analysis to include new information is normally allowed but was not envisioned on a weld by weld basis. However, the re-evaluation of the change in risk if the inspection is discontinued at a location because of re-ranking appears to comport with the approved methodology. Also, re-evaluation with the WCAP method requires consideration of the relative methodology because individual changes can affect the whole analysis.	
	D	Proposal allow piece part reduction of current program without re-working the program.	

KEY: D - SIGNIFIES NEGATIVE COMMENTS C - SIGNIFIES COMMENTS OTHER THAN NEGATIVES