ENCLOSURE 5

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

SUPPORTING ENGINEERING EVALAUTIONS

EC 16270

51 Pages Follow

Xcel Energy

EC-0441 EC Closeout Package Report (Rev. 3)

Report Date: 06/11/2010

EC Number: 0000016270 Revision: 000

Engineering Change

EC Number :	0000016270	000	**Facility**	:	PI
Status/Date :	CLOSED	06/10/2010	**Type/Sub-type**	:	EVAL /

EC Title: SCREENING OF PIPE WHIP INTERACTIONS FOR SDP

Mod Nbr: **KW1:** **KW2:** **KW3:** **KW4:** **KW5:**

Master EC	:	**Work Group**	:	**Temporary**	:
Outage	:	**Alert Group**	: E-ME/CS DE	**Aprd Req. Dt.**	: 06/30/2010
WO Required	: N	**Image Addr**	:	**Exp Insvc Date**	:
Adv Wk Appvd	:	**Alt Ref.**	:	**Expires On**	:
Auto-Advance	:	**Priority**	:	**Auto-Asbuild**	:
Caveat Outst	:	**Resp Engr**	: PTTD06		

Units and Systems

Facility	Unit	System	System Description
PI	0	OTH	OTHER

Attributes

Attribute Name	Value	Updated By	Last Updated	Notes
SCRN NO	NA	PTTD06	06/02/2010	This eval does not support design basis. Used as input into SDP. No 50.59 s creening required.
SIMULATOR				
SYSTEM HEALTH				
EVAL NO				
PORC DTE				
PRIORITY RANKING				

Xcel Energy

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Topic Notes

Topic	Notes
DESCRIPTION	See sharepoint purpose section.
JUSTIFICATION	See Sharepoint
REVIEWER COMMENTS	See QF0528 in sharepoint

Cross References

XRef	Number	Sub	Status	Date	Reference Description
AR	01178236		APPROVED	04/15/2009	No HELB flooding calculation for Turbine Building

Affected Documents

Milestone

Milestone	Date	ID	Name	Req By
APPROVED BY	06/10/2010	BRSM05	Brossart, Mark A	APPROVED
Notes: Preparer and Reviewer were verified to be qualified to perform the evaluation. Assumptions are validated and the evaluation is reasonable using sound engineering principles. The vendor eval captured in EC 16275 was received and approved (Ref 6). EC is approved.				
CLOSE	06/10/2010	LDWHIP01	Whipple, Linda D	CLOSED
Notes:				
PRE JOB BRIEF	05/05/2010	PTTD06	Potter, David J	
Notes:				
PREPARED (EVL)	06/02/2010	PTTD06	Potter, David J	H/APPR
Notes:				
TECHNICAL RVW	06/10/2010	N153792	Slack, Brian C	
Notes:				

Document References

Facilty	Doc-Type	Sub-Type	Doc #	Sheet	Rev	Minor Rev	Date
PI	EC		0000016270		000		06/10/2010

EC-0441 EC Closeout Package Report (Rev. 3)

Report Date: 06/11/2010

Xcel Energy	**Design Review Comment Form**

Sheet 1 of 3

DOCUMENT NUMBER/ TITLE: EC16270 / Screening of Pipe Whip Interactions for SDP

REVISION: N/A DATE: 6/02/10

ITEM #	REVIEWER'S COMMENTS	PREPARER'S RESOLUTION	REVIEWER'S DISPOSITION
1	Provide the basis that 4" pipe break = 5000 gpm in the acceptance criteria.	Added Assumptions section and an assumption.	ok
2	Element 1 basis: Additional areas beyond the 15FW heater were included. Add those areas to the technical justification.	Revised text to not limit the criteria to areas around 15 FW heaters	ok
3	Element 2 basis: The HELB criteria is "200F and greater and greater than 275psig"	Corrected text	ok
4	Element 3 basis: Provide references for the statements regarding the severity of a 5000 gpm flow.	Added assumptions and basis.	ok
5	Element 5 basis: I counted different numbers of tests for each category in the NUREG. 4, 17, and 11 for moving pipe thinner, equal wall, and moving pipe thicker, respectively. I could not validate the inputs or results of the LS-DYNA analysis as it is not complete. This will need to be validated prior to completion of this EC.	Counting corrected	ok
6	Element 6 basis: I found different nominal system pressures for CD and MS on the heat balance diagrams (444.7 psia & 841.7 psia) depending on unit and power level. I could not validate HD pressure from the heat balance diagram. In the pipe flailing calculations, I think the end conditions for the column should result in C=2 instead of C=1. I could not validate the neoprene mechanical properties in MERM. The stress calculations for the columns should include the C = 2 end condition. Although not the purpose of the flailing pipe calculations, the results given show that the 25 ft long steel column will buckle under the jet load described earlier. I believe a discussion stating that this is an unrealistically long unsupported length is warranted to eliminate this potential comment by readers.	Values in tables are gauge pressure rather than absolute. Values were changed to be consistant with 50% power on unit 2 which maximizes pressures. Corrected. Changed to Hypalon due to availability of data. Corrected. Added additional tables that indicated that for a slenderness ratio of 80, the pressures needed to cause buckling exceed pressures seen in the plant systems.	ok
7	Element 1 implementation: I don't think that	Agreed. Corrected.	ok

	interaction #39a should be excluded. There was no mention of it in the SDP report flooding tables.		
8	Element 2 implementation: Item 7 should not be excluded. It is high energy per ENG-ME-358.	Agreed. Text Adjusted.	ok
9	Element 4 implementation: The "CS" field in passport used as a reference in several locations is an uncontrolled field. A better reference should be given if possible. It was noted that VTM XH-195-22 is applicable to several of these valves and could potentially provide a better reference. Interaction 14: Valve CW-32-1 is present on the 14" line to the H2 coolers. This valve could see a significant bending moment if the 16" line were displaced. It should be discussed. Interaction 114: Valve 2CL-32-1 is present on the 14" line to the H2 coolers. This valve could see a significant bending moment if the 16" line were displaced. It should be discussed.	Changed references to tech manuals as appropriate. Added text for interaction 14 and 114.	ok
10	Element 5 implementation: Interaction 20a was screened for cast iron and meets the thickness criteria. It should be excluded from the SDP. The discussion related to interaction 151 failing the LS-DYNA work can not be validated.	Text Adjusted Interaction 151 failed the LS-Dyna analysis. Included for completeness but screened out due to geometry	ok
11	Remaining interactions: -20a should be included here unless excluded in element 5 -29 & 30 were screened out and should be removed. -143 was screened out due to <4" -197- 199 were screened out in attachment A -200 & 201 should remain in the SDP	-20a now excluded in element 5 -29&30- Agreed. Text Adjusted. -143- Agreed. Text Adjusted. -197 remains in, 198 &199 removed. -200 & 201 kept in and not screened out.	ok
12	Conclusion: Re-check the total numbers of interactions excluded. I got different numbers and the comments here will likely change a few.	Numbers updated.	ok
13	Attachments: I think Att B can be deleted, or at least changed to the SDP report.	Attachment B deleted.	ok
14	Att A, #53: The interaction is not shown on drawing A45.	Drawing number corrected.	ok
15	Att A, #76: A discussion is needed regarding a break at the west 90° elbow that pushes the pipe horizontally towards the vertical riser.	Added Text to this section	ok
16	Att A, #82: A break in the vertical portion of	Added Text.	ok

	16-FW-3 is also possible but not discussed. It is noted that this break does not appear to affect the results.		
17	Att A, #151: I don't quite follow the discussion of this break. The 20" line is a straight north-south line with no elbows. Breaks would need to be in the branch connections to cause pipe whip, which would be a different interaction.	Text Adjusted	ok
18	Att A, #159: The discussion references an isometric that is not included. The discussion states that the northernmost FW heater is applicable, but that piping is in a different grid reference and has no chance of interacting.	Added sketch and adjusted text.	ok
19	Att A, #180: The interaction is not shown on drawing A48 The 12" MS line goes from vertical to horizontal at ~725' elevation. This will cause a pipe whip, although not towards the ZX line. Add discussion as needed.	Adjusted drawing number and added text to clarify.	ok
20	Att A, #197: It is not clear that the break between 715.6' and 717' is acceptable based on the discussion. Clarify as needed. I believe that a sketch should be added to illustrate the dimensions and relative positions stated in this interaction.	Interaction cannot be excluded. Removed from appendix.	ok
21	Att A, #198: I believe that a sketch should be added to illustrate the dimensions and relative positions stated in this interaction.	Added Sketch.	ok
Reviewer: Brian Slack	Date: 6/05/10	Preparer: [signature]	Date: 6/10/2010

[signature] David Pitter

Purpose

The purpose of this evaluation is to provide a better understanding of the interactions associated with HELB. As part of the plant design basis assumptions, HELBs are required to be assumed as well as their direct consequence. If the assumed HELB is a circumferential break, pipe whip is an expected consequence. The targets that could result include other sources of water. This evaluation will review the possible interactions to determine if significant damage to the target piping is a reasonable event.

It should be noted that this evaluation is not to conclude that interactions do not exist. Rather, the intent of this evaluation is to lay out criteria associated with reviewing the circumferential break interactions and show which interactions are not expected or will result in neglible consequences.

Methodology

This evaluation will develop screening criteria to be applied to the high energy line interactions. The screening criteria is in the form of a flow chart. Each step of the flow chart will be justified on its own accord to determine its appropriateness. The justification will use engineering judgment and technical references.

After the establishment of the flow chart, the flow chart will be applied to the interactions listed in ENG-ME-732 [2].

Acceptance Criteria

It should be noted that while this evaluation will "screen out" HELB interactions, screening out merely establishes that damage to the target piping is "minimal".

It has been determined that pipe break flow rates less than 5,000 gpm do not result in significant consequences. 5,000 gpm is greater than the flow that would be expected from a complete guillotine break of a 4" line from the CL system (See Assumption 1). A four inch line has an approximate flow area of 12.5 square inches.

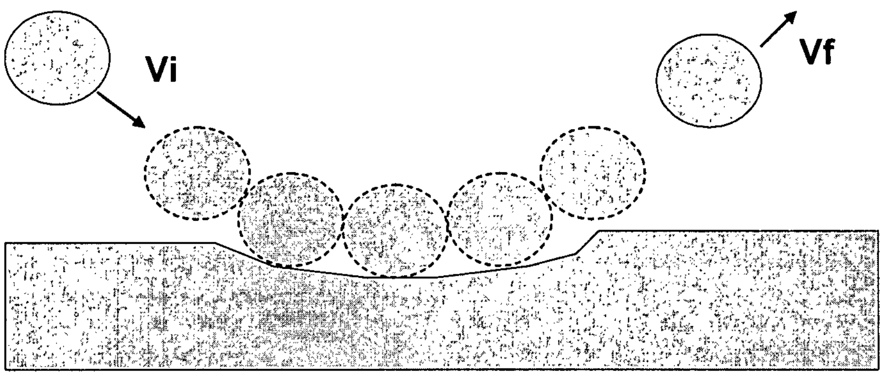
Piping "screened out" by this evaluation merely means that in the unlikely event the screened out interaction occurs the target pipe will not be so great as to exceed a 12.5 square inch opening area.

Inherent Conservatism

This analysis has some inherent conservatism built in that should be acknowledged.

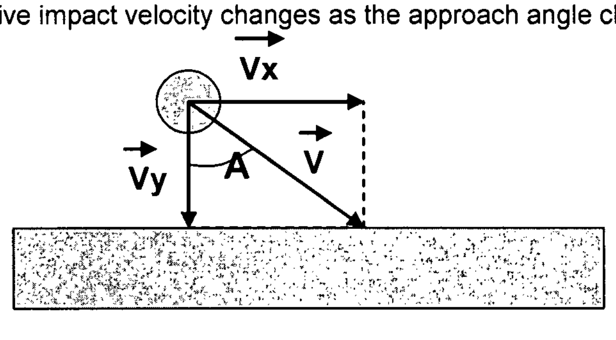
- Thrust forces- This analysis assumes that reaction forces from a break location are sufficient to cause pipe bending. Not all breaks are capable of generating significant reaction forces. This analysis does not calculate the reaction forces from a break location to determine if sufficient force is generated to cause whipping. Rather, it is assumed that if a break occurs, it generates sufficiently high forces to cause pipe whip.
- Moment Arm- This evaluation assumes that the break location, direction of the jet and hinge point are conducive to generation of pipe whip. This evaluation contains examples of moment arms needed to cause plastic elbow deformation. In the context it was used, this evaluation demonstrated a moment arm of finite length in order to cause pipe whip. That length of moment arm required is dependant on the assumed loads, direction of jet, and pipe diameter and size. Detailed hinge location calculations were not performed and this evaluation assumed that a sufficiently long moment arm is available associated with the force being applied.

- Kinetic energy- This evaluation assumes sufficient kinetic energy is developed in the moving pipe to cause damage in the target pipe. Kinetic energy is equal to the work applied from the jet force. Work is determined by multiplying the applied force by the distance the force acts. However, the work to create the plastic hinge must be subtracted from the kinetic energy. In several cases of field application, the distance between the whipping pipe and the target pipe is very small (i.e. inches). NUREG CR-3231[3] estimates that travel distances must be greater 3 pipe diameters of the moving pipe in order to develop sufficient kinetic energy.
- Energy transfer- For the interactions that are not excluded, it is assumed that sufficient kinetic energy is transferred from the moving pipe to the target pipe to cause failure of the impacted pipe. In a perfectly inelastic collision, the velocity of both objects are equal following the impact (consider two balls of clay colliding). This assumption is close to reality when the two pipe collide orthogonally with sufficient energy. However, in reality, until plastic deformation occurs in both the moving pipe and the target pipe, the collision will be elastic. As the impact angle between the swinging pipe and the target pipe approaches zero, the impact behaves more elastically. Additionally, the impact area is spread over a larger area of the target pipe. Because the targets are generally made of ductile steel, extending the impact zone results in a lower magnitude of deformation but the deformation occurring over a larger area. This is illustrated in the diagram below.



As can be seen, as the approach angle approaches zero, the length of contact on the target line is extended. As the impact length is extended, the same energy imparted into the target pipe results in deformation of smaller magnitude.

Additionally, the main cause of deformation of the target piping is the absorption of kinetic energy. The effective impact velocity changes as the approach angle changes.



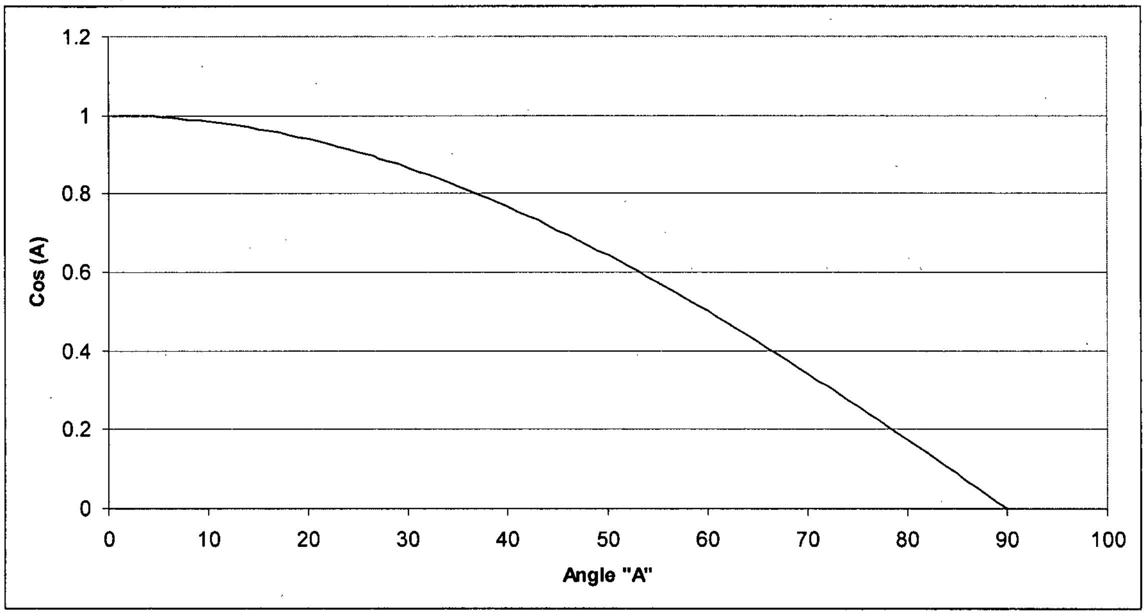
Therefore, if the moving pipe was moving towards the target pipe where angle "
A" is zero (an orthogonal impact). The following is the resulting velocity toward the target pipe.

$$V_y = Cos(A) * V = Cos(0) * V = V$$

Next consider the case where the angle "A" is 45 degrees.

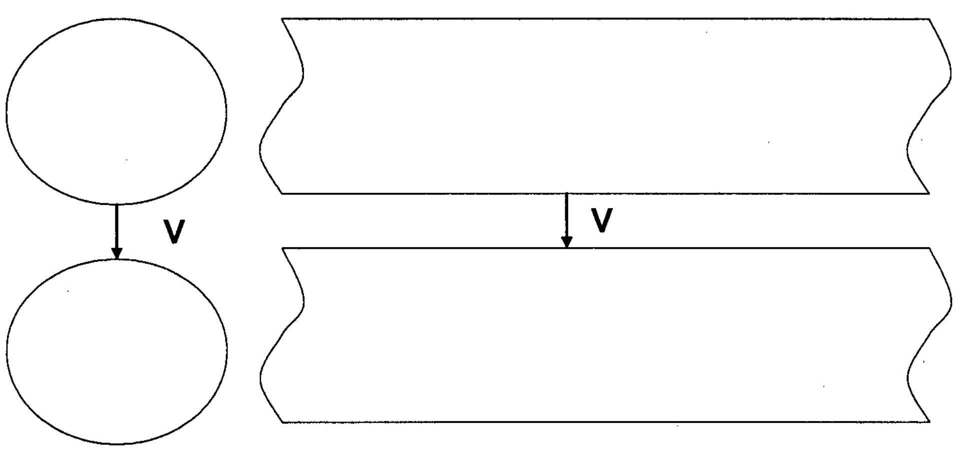
$$V_y = Cos(A) * V = Cos(45) * V = 0.707 * V$$

Graphically, the relation ship between Cos (A) (which is proportional to Vy) and Angle "A"



Therefore, it can be seen as the approach angle decreases, the impact velocity decreases for a fixed moving velocity.

Additionally, many of the interactions in the field are not between pipe that are perpendicular skew. Many of the HELB/target pipe combinations are parallel. Where the pipes are parallel, the worst case interaction geometry would be as follows:



Again, the impact energy is extended over a much longer length of the target piping. As the length of target piping impacted is extended, the amount of energy needed to deform the target piping increases and permanent, substantial deformation or pressure boundary failure is less likely.

Assumptions

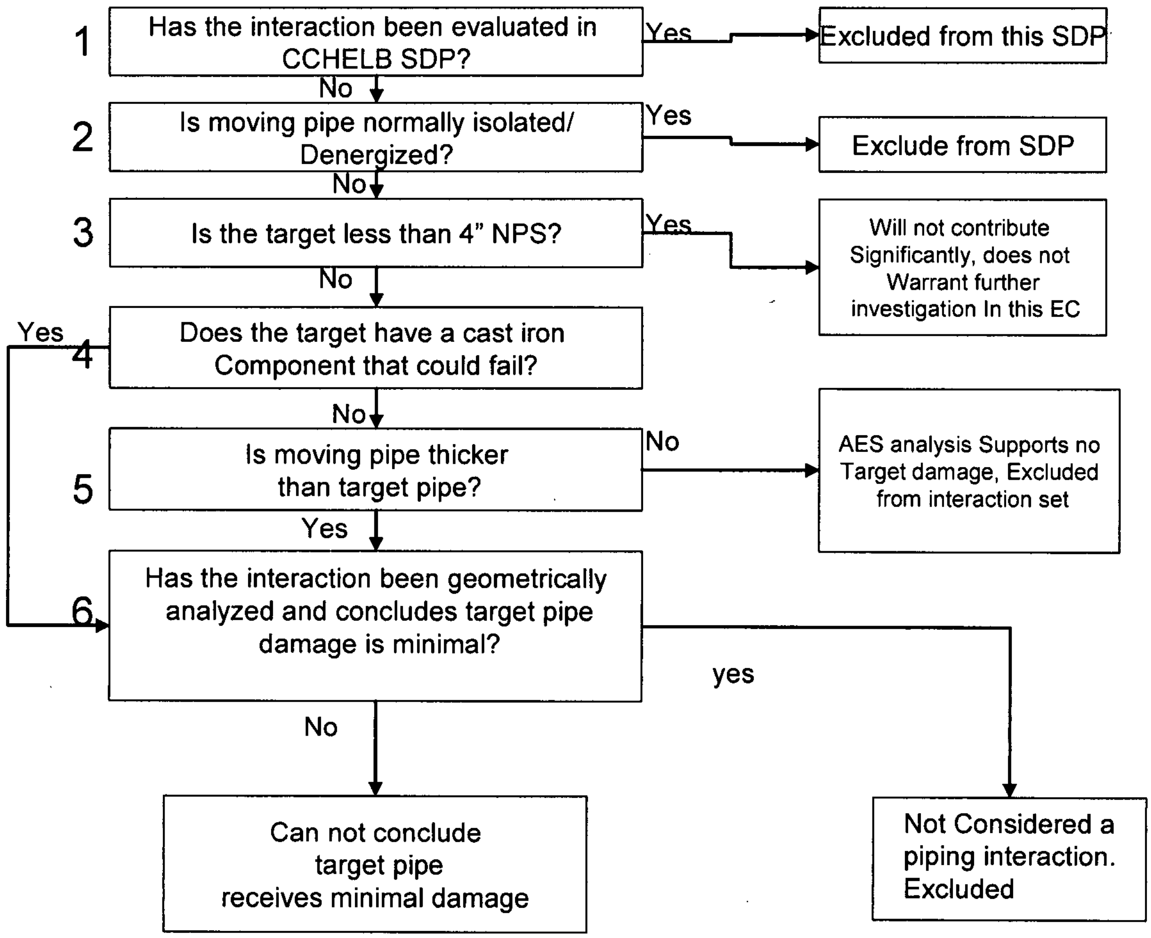
1. Piping less than 4" sch 40 NPS can be excluded from the analysis- The risks associated with a flood are associated with the time to isolate the event. As the allowable operator response time increases, the probability of success increases. Due to the large volume of the condenser pit and large area of the turbine hall, the time to reach critical flooding heights in the pre-April configuration is three hours with flow rates less than 5,000 gpm [21]. Although the probability of success is not 100% for a required isolation times greater than 3 hours, the success rate is high enough that judgment amongst personnel involved with this project indicate low flow events from pipes less than 4" will not be a significant contributor. This is an assumption that will be validated by later work associated with the SDP. EC 16090 [24] concludes that a 4" CL line break will result in 2911 gpm. Therefore, it can be seen that excluding target pipes less than 4" sch 40 NPS will result in required isolation times of approximately 3 hours.

2. Nominal wall thicknesses were assumed for both the moving pipe and the target pipe.- It is acknowledged that the target piping is subject to corrosion as it has been in service for several years. However inspection results (and engineering experience) indicates that nominal pipe wall thickness are suitable for this type of evaluation. The basis for using nominal wall thickness is based upon the experience that piping is typically manufactured at thicknesses greater than the nominal thickness for the pipe size and schedule. In fact, much of the service water piping system (even after 30 years of service) is greater than nominal thickness for the piping's diameter and schedule. Additionally, available industry guidance indicates that general corrosion (general uniform wall attack rather than localized wall attack such as Microbiologically Induced Corrosion) general corrosion rates of 1 mil per year [20]. The experience at PINGP is that general corrosion rate are less than 1 mil per year. Localized pipe wall thinning (areas of thinning approximately 1-2" in diameter) on 14, 16 and 24 NPS pipe represents a small fraction of the pipe's circumference (between approximately1% and 5% of the pipe circumference). Therefore, considering wall thickness equal to nominal is a reasonable estimate of wall thickness for a structural assessment.

Analysis

Screening Flow Chart

Below is the flow chart associated with screening.



The application and justification of each of the flow chart elements are discussed below.

Element 1: Was the target included in Previous CC HELB SDP?

This screening step considers whether the flooding affects have been previously assessed by the NRC.

Technical Justification

In CC HELB, high energy line breaks were assumed to affect the CC piping in Unit 1 and 2 of the TB. In addition to failure of the component cooling water line as a result of this postulated break location, significant flooding flows were postulated from the cooling water system. These effects were accounted for in the assessment of the "CC/HELB" finding.

Justification of Order

This criteria is non-subjective and simple to implement.

Element 2: Is moving pipe normally isolated?

This screening step considers whether the target pipe is normally de-energized. The licensing basis for Prairie Island requires the High Energy Line Break program to include piping systems for analysis if the piping is meets the HELB criteria of 200F operating temperature and greater and greater than 275 psig design pressure. Branch technical position MEB 3-1 [4] relaxes the guidance indicating that piping need not be considered high energy if the duration of time that it is high energy is less than 2% of the operating cycle.

Technical Justification

From a PRA perspective, application of the 2% guidance reduces the initiating event frequency to $1/50^{th}$ and from a PRA purist standpoint should still remain in the SDP but at a lower initiating event frequency. However, the lines that meet this criteria are in service much less than 2% of the plant normal operating cycle. In actuality, these lines are associated with plant start up conditions where the plant is only in this configuration for a day (or so) a year (approximately 0.3% of plant planned operation) or during transients such as condenser steam dump.

Justification of Order

This criteria is non-subjective and simple to implement. References are readily available (ENG-ME-732 Rev 1 [2] and ENG-ME-358 [5])

Element 3: Is target pipe so small that it does not contribute to the SDP (4")?

This screening step will consider the target pipe diameter. Targets less than 4" NPS are excluded from further examination.

Technical Justification

See Assumption for discussion.

Justification of Order

The element was chosen second. Assuming that 4" piping does not meet any of the later screening criteria, PRA personnel indicate that the lower flow rates will be screened out regardless. Following steps require additional work including field intensive walk downs. Therefore, placement of this criteria eliminates the need for further walk downs because the results of those walk downs are irrelevant. The flow is not sufficient to be a significant contributor.

Element 4: Does the target pipe have cast iron component that could fail?

This step will consider whether the target piping system has cast iron components. If it is determined that the target piping system has cast iron, then the interaction bypasses element 5.

Technical Justification

Many of the target piping systems have cast iron components. These components are items such as valve bodies, tee, reducers, et cetera. While cast iron is an engineering material with decent strength characteristics, it tends to be brittle in nature. Brittle materials will not yield greatly before breaking. Should the target piping systems have contact with a whipping pipe, the target system is more vulnerable if a cast iron component is in the load path generated by the piping interaction. If the cast iron component is near an anchor point (sufficiently larger pipe or restraint) or is at or near the location of the plastic hinge, then the cast iron piping is more likely to have a large rupture instead of small leakage crack. If the material of construction (valve, etc) what not known, it was assumed that the piping system had cast iron components.

Justification of Order

The element was placed prior to elements that rely on the ductile properties of steel.

The implications are that pipes with cast iron components are screened in to catastrophically fail even if a 2" steam line makes contact with a 16" heavy wall pipe with a cast iron valve 10' from the interaction point. This is very conservative for smaller whipping pipes but included due to uncertainty.

Element 5: Is the moving pipe thicker than the target pipe?

This element will compare the wall thickness of the target pipe versus that of the moving pipe. Only target pipes that are thinner than the moving pipe (regardless of pipe diameter) are considered vulnerable.

Technical Justification

Justification for this element is associated with field tests documented in NRC NUREG CR-3231 [3] and supporting computer simulations modeling piping interactions [6].

CR-3231 [3] provides guidance associated with pipe wall thickness screening. The report concludes that the probability of failure was considered high if the moving pipe was thicker than the target pipe. Review of test results indicate the following:

Category	Number of Tests	Number of Failures
Moving pipe wall thinner than target wall	4	0
Moving pipe wall equal to target wall	17	3
Moving pipe wall thicker than target wall	11	5
Total tests	32	8

In summary, no failures occurred when the moving pipe wall was thinner than the target pipe wall. Three failures out of 17 trials occurred when the pipe wall thicknesses were equal. Five failures out of eleven trials occurred when the moving wall thickness was greater than the target wall thickness. Failure criteria in CR-3231 [3] was any loss of pressure retaining function of the target piping. As discussed in the acceptance criteria section, the failure criteria of this evaluation is associated creating with large flow areas in the target piping. None of the failures in CR-3231 met the criteria of failure established by this evaluation.

As further validation of this screening criteria, a contractor performed simulations of selected cases using the LS-Dyna software package under EC 16275 [6]. LS-DYNA is an advanced general-purpose multiphysics simulation software package that is actively developed by the Livermore Software Technology Corporation (LSTC). While the package continues to contain more and more possibilities for the calculation of many complex, real world problems, its origins and core-competency lie in highly nonlinear transient dynamic finite element analysis (FEA) using explicit time integration. LS-DYNA is being used by the automobile, aerospace, construction, military, manufacturing, and bioengineering industries.

The computer simulation modeling utilized plant specific diameter size and thickness criteria from HELB interactions. The following is a list of possible piping combinations that were considered. [Ref 2]. (This list was developed by completing the screening criteria later in this evaluation and utilizing only those where the moving pipe wall thickness was not greater than the target pipe thickness.)

	Moving Pipe								
Target Pipe		Diameter	8	2.5	6	12	16	20	8
	Diameter	Schedule/ Nominal Wall Thickness	40/ 0.322"	80/ 0.276	80/ 0.432"	Std/ 0.375"	30/ 0.375"	20/ 0.375"	80/ 0.500"
	24	20/ 0.375"	x				x	x	
	14	XS/ 0.500	x	x	x	x			x
	16	30/ 0.375"				x	x	x	

Bounding scenarios were selected from the above interaction matrix. The demonstration of which cases were bounding were demonstrated using engineering techniques. If it was determined that an interaction combination could not be bounded by a simplified engineering analysis, then the specific interaction was evaluated. Because this evaluation was used as a screening criteria, an orthogonal configuration for pipe contact was selected as it represents the limiting case. Nominal pipe wall thickness were utilized based upon assumption 2.

Justification of Order

At this point in the screening criteria, only interactions comprised of carbon steel are included (due to element 4). The information needed to determine whether these interactions are screened out based upon this criteria is readily available in ENG-ME-732 [2].

Element 6: Has the interaction been geometrically analyzed and concludes target pipe damage is minimal?

This screening step determines if the geometry of the interaction is conducive to significant piping failure. It reviews data within ENG-ME-732 to determine if the interaction is a realistic event.

Technical Justification

There are several components needed for pipe whip to occur:

1. A complete guillotine break must occur.
2. Plastic hinge must form in the piping.

In ENG-ME-732 [2] both of these elements are assumed to occur on the base list. ENG-ME-732 [2] established the list of interactions in attachment one based upon proximity. Once the list was established, the interactions were evaluated. These are conservative assumptions to establish the interaction list. In order for a plastic hinge to occur additional items are required. From engineering statics, the moment developed at any one point is defined the cross product of two vectors. In the case of pipe whip the vectors are defined as the force vector from the jet and the displacement vector from the jet location to the plastic hinge.

It takes a sufficient bending moment to cause deformation of a pipe. The table below demonstrates total moments needed to cause stresses in excess of the yield stress in a schedule 40 pipe. (Pipe wall thickness taken from Mechanical Engineering Reference Manual [7]). The full mathematical computation will be written for a 5" schedule 40 pipe to demonstrate the methods used to develop the table.

$$Solid\_Rod : I_x = \frac{\pi}{4} r^4$$

$$Pipe : I_x = \frac{\pi}{4} r_{OD}^{\ 4} - \frac{\pi}{4} r_{ID}^{\ 4} = \frac{\pi}{4}\left(\left(\frac{D_{OD}}{2}\right)^4 - \left(\frac{D_{ID}}{2}\right)^4\right) = \frac{\pi}{4}\left(\left(\frac{D_{OD}}{2}\right)^4 - \left(\frac{D_{OD}}{2} - T\right)^4\right)$$

$$Pipe : I_x = \frac{\pi}{4}\left(\left(\frac{5.563"}{2}\right)^4 - \left(\frac{5.563""}{2} - 0.258\right)^4\right) = 15.16 In^4$$

$$\sigma_{b,\max} = \frac{Mc}{I_x}\_or\_M = \frac{(\sigma_{b,\max})I_x}{c}$$

$$c = Dis\tan ce\_From\_Neutral\_Axis = R_{OD} = 5.563"/2 = 2.7815"$$

$$M = 43KSI(yeild\_Strength\_for\_1020\_Steel[7]$$

$$M = \frac{(\sigma_{b,\max})I_x}{c} = \frac{(43{,}000\_PSI)15.16In^4}{2.7815"} = 234{,}000\_In - lbf$$

Pipe NPS	Sch	OD (in) [7]	T (in) [7]	Ix (IN^4)	Syt (PSI) [7]	Required Moment (Inch-lbs)
2	40	2.375	0.154	0.67	43000	24,000
3	40	3.500	0.216	3.02	43000	74,000
4	40	4.500	0.237	7.23	43000	138,000
5	40	5.563	0.258	15.16	43000	234,000
6	40	6.625	0.280	28.14	43000	365,000
8	40	8.625	0.322	72.49	43000	722,000
10	40	10.750	0.365	160.73	43000	1,280,000
12	40	12.750	0.406	300.21	43000	2,020,000
14	40	14.000	0.437	428.61	43000	2,630,000
16	40	16.000	0.500	731.94	43000	3,930,000
20	40	20.000	0.593	1703.71	53000	7,330,000

It should be noted that the force calculated above is based upon yield strength which is conservative. The yield strength is determined by a 0.2% parallel offset from the proportionality limit of the stress strain curve. In the application of pipe collapse and bending, deformation well beyond 0.2% is needed and significant work hardening may be occurring while the pipe is collapsing. The pipe deforming in shape and the material work hardening are counteracting affects, but using the yield strength is conservative in this application.

As can be seen from the table above, some very significant moments need be applied in order to cause deformation of the pipe section with a yield stress of 43 ksi. Assuming a jet force is applied perpendicular to the moment arm, the required length of the moment can be determined. For this example, a jet force is determined as follows (based upon ENG-ME-369 [8]).

$$Thrust = P * A * K = (920\,psia - 14.7\,psia) * 20.01 * 1.26 = 22{,}825\_lbf$$

$$L = \frac{Moment}{Thrust} = \frac{234{,}000\_in - lbf}{22825\_lbf} = 10.25$$

The pressure 920 psi is selected based upon heat balance diagrams and is the highest pressure in either unit 1 [9] or unit 2 [10] (pressures downstream of feedwater pumps).

Pipe NPS	Sch	Pipe Flow Area (Inches^2) [7]	Required Moment (Inch-lbs)	Thrust Load (1.26 x pipe flow AREA *(920-14.7) psi)	Moment Arm Length (in)
2	40	3.356	24,000	3,828	6.27
3	40	7.393	74,000	8,433	8.78
4	40	12.73	138,000	14,521	9.50
5	40	20.01	234,000	22,825	10.25
6	40	28.89	365,000	32,954	11.08
8	40	50.03	722,000	57,068	12.65
10	40	78.85	1,280,000	89,942	14.23
12	40	111.93	2,020,000	127,676	15.82
14	40	135.32	2,630,000	154,356	17.04
16	40	176.72	3,930,000	201,581	19.50
20	40	278.00	7,330,000	317,108	23.12

Therefore, it can be seen that even with the largest thrust loads available, a significant moment arm must be present to allow the piping to deform. If the forces act through the plastic hinge, then no whipping will occur. Applying discharge pressures from other systems (main steam, condensate, heater drain) would result the following moment arm increases from above(limiting pressure observed in [16]):

System	Nominal Operating Pressure (PSIG)	Previously assessed Pressure (psig)	Percent of evaluated pressure	Percent Increase in moment arm length
Heater Drain	685 ([11] for pipe 8-HD-6)	905.3	75%	32%
Condensate	430 [16]	905.3	47.5%	110%
Main Steam	827[16]	905.3	91.4%	9.4%

In order for a whip to occur a plastic hinge must be formed in the piping system. As previously discussed, significant moments must be generated in order to cause a bending point. Assuming the piping system is of consistent geometric characteristics (area moment of inertia in particular), bending will first occur at the point where the greatest moment is created between anchors. Secondary plastic hinges may be formed after the first hinge allows maximum displacement of the whipping pipe. However, it should also be noted that when plastic hinges are formed the hinging section of pipe is collapsing. The collapsing of the pipe will tend to reduce the net allowable flow area and only the remaining kinetic energy will remain to form the secondary hinge. Second, the forces required to cause a pipe whip are beyond the systems normal flow capability, the large forces are caused by rapid expansion of a subcooled liquid flashing to equilibrium conditions. These events occur rapidly such that the initial hinge is capable of forming but secondary hinges do not form.

In practical application, the motion of pipe whip can be demonstrated and applied. The following are geometric configurations which are common in the plants piping configurations.

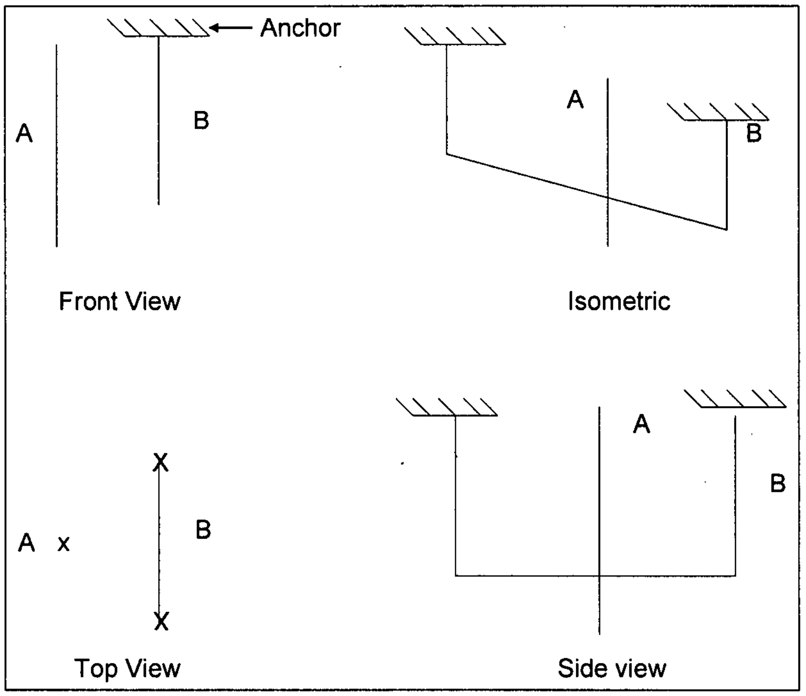


Figure 1

In the figure above, pipe "A" is the target pipe and the pipe "B" is the whipping pipe. It should be noted that if the target pipe is parallel with the plane defined by the plastic hinge and the force vector (jet from the end of the broken pipe) then contact will not occur. This case is outlined above in figure 1. This can be seen by severing the line in the horizontal section of line B and forming the plastic hinge at either anchor location.

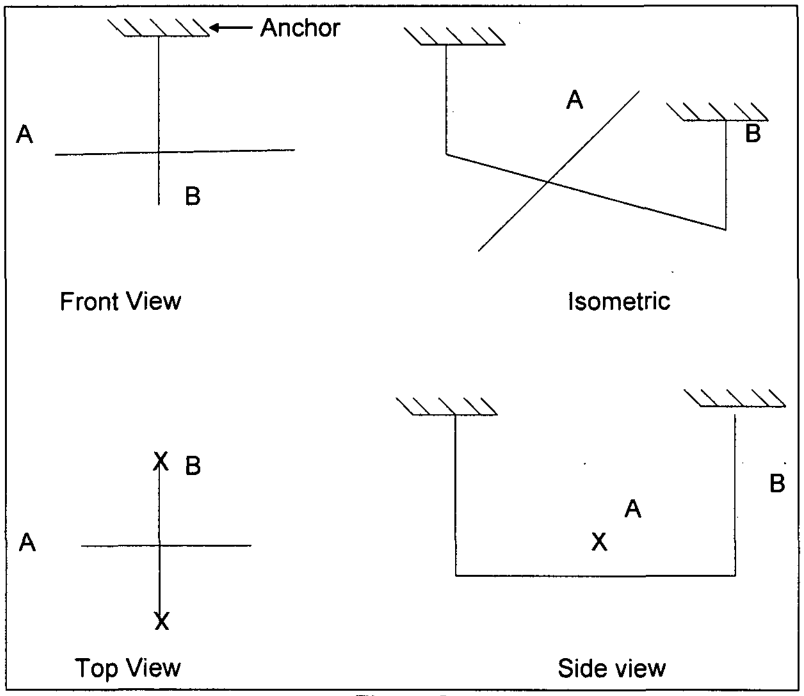


Figure 2

In the figure above, pipe "A" is the target pipe and the pipe "B" is the whipping pipe. It should noted that if the target pipe is parallel with the plane defined by the plastic hinge and the force vector (jet from the end of the broken pipe) then contact will not occur. Figure 2 illustrates a configuration where the target line is not parallel to the whip plane. However, the reaction forces from a break in the horizontal section of pipe B will tend to push the whipping pipe away from target pipe A. This can be seen by severing the line in the horizontal section of line B and forming the plastic hinge at either anchor location. While this is a simplistic piping system and often times field application appears much more complex, piping systems can often be reduced to such geometries by field observations.

Reduction of complex piping systems to a simple model can be done with simplifying assumptions. First, one can normally assume a plastic hinge occurring at the second elbow (both upstream and downstream). While it is not always true that the second elbow away from the break location often yields the largest moment arm (and therefore have the greatest moment applied), it is not uncommon for second elbow to result in the longest moment arm. The second assumption is to maximize the moment, the jet force should be perpendicular to the moment arm. It should be known that these assumptions are not bounding. However, it should also be acknowledged that most piping systems are predominantly constructed of 90 degree elbows. Other elbows geometries are present but occur much lower frequency. Considering that piping systems are constructed mostly of 90 degree elbows, inspection to determine the point in the piping system where the greatest moment arm is going to be generated is a simple act that can be accomplished with field inspections. Additionally, with the known direction of the reaction force from the jet, the anticipated travel of the whipping pipe can be anticipated.

Flailing of the Pipe
While a pipe whip has been likened to a "fire hose" with whipping direction being unpredictable, this is not a fair characterization of a piping system. The main reason why the fire hose analogy is not appropriate is understanding why a fire hose flails. A fire hose is made of very tough but very weak material. When the jet comes from the end of a fire hose, the length of hose is placed in compression and the hose supports the force of the jet like a slender column. Because the

hose is weak (compared to the thrust load), flexure occurs at a mid-point in the hose. This flexure results in a change in the force vector where the load is no longer applied through the hinge point (assumed to be along the hose) and the hose moves laterally. However, in comparison to a pipe, the pipe will support the load created by jet force.

To illustrate this principle consider the following table which applies Euler's rule for slender columns:

Parameter	Rubber	Steel
E [7]	1,000 psi [17]	2.9×10^7 psi
L (Assumed Length)	25 ft	25 ft
K (Radius of gyration, Assumed) [7]	2.245 in (6" Schedule 40 Pipe)	2.245 in (6" Schedule 40 Pipe)
Tensile Strength	2,000 psi (Hypalon)[17]	36,000 psi [7]
$(SR)_T$[7]	= $\frac{1}{C}\sqrt{\frac{2\pi^2 E}{S_y}} = \frac{1}{2}\sqrt{\frac{2\pi^2(1{,}000)}{(2000)}} = 1.57$	$= \frac{1}{C}\sqrt{\frac{2\pi^2 E}{S_y}} = \frac{1}{2}\sqrt{\frac{2\pi^2(2.9E7)}{(36{,}000)}} = 63$
Minimum length to consider a slender consider a slender column [7]	=(25ft)(12 (in/ft))/2.245 In= 133.6 (OK to consider a slender column)	=(25 ft)(12 (in/ft))/2.245 In= 133.6(OK to consider a slender column)
Sigma (e) [7]	$\sigma_e = \frac{\pi^2 E}{\left(\frac{CL}{k}\right)^2} = \frac{\pi^2(1{,}000)}{\left(\frac{2*25ft*12in/ft)}{2.245in}\right)^2}$ $\sigma_e = 0.138psi$	$\sigma_e = \frac{\pi^2 E}{\left(\frac{CL}{k}\right)^2} = \frac{\pi^2(2.9E7)}{\left(\frac{2*25ft*12in/ft)}{2.245in}\right)^2}$ $\sigma_e = 4007psi$

Therefore, in the application of Euler's to determine the allowable stresses for the same column, the allowable stress (and because the geometry is identical, the force) that can be applied to a rubber column is less than 1/29,000th that of the same steel column prior to component buckling. It is not reasonable to conclude that a pipe will behave in the same manner as rubber hose. The wild movement observed in a fire hose is the result of the column being too slender to support the axial loading resulting in the jet load exerting a lateral force and the process repeating. Due to the nature of the materials involved, random movement of a steel pipe would not be expected as a result of a jet leaving the end of the pipe.

It should be recognized that buckling needs the column to be considered slender. The slenderness ratio is the quotient of the length divided by the radius of gyration [7].

$$Slenderness\_Ratio = \frac{Length}{Radius\_of\_Gyration}$$

The radius of gyration is based upon the parallel axis theorem. Therefore, it is not appropriate to simply subtract the outer pipe diameter radius of gyration from the inner pipe diameter radius of gyration. The rudimentary definition must be used [7].

$$Radius\_of\_Gyration = \sqrt{\frac{Area\_Moment\_of\_Inertia}{Area}} = \sqrt{\frac{I_{OD} - I_{ID}}{A_{OD} - A_{ID}}}$$

Where :

$I_{OD} = Area\_Moment\_of\_Inertia\_Based\_On\_Outside\_Diameter(In^4)$

$I_{ID} = Area\_Moment\_of\_Inertia\_Based\_On\_Inside\_Diameter(In^4)$

$A_{OD} = Area\_Based\_On\_Outside\_Diameter(In^2)$

$A_{ID} = Area\_Based\_On\_Inside\_Diameter(In^2)$

The Area Moment of inertia of a circle is determined as follows:

$$I = \frac{\pi * r^4}{4}$$

The critical slenderness ratio is between 80 and 120. For various diameters of schedule 40 piping, the piping length needed to be considered slender is as follows (using the lower critical ratio of 80).

NPS	OD (IN)	WALL THICKNESS (IN)	I(OD) (IN^4)	I(ID) (IN^4)	I(OD)-I(ID) (IN^4)	A (IN^2)	RADIUS OF GYRATION	CRITICAL LENGTH (IN)	CRITICAL LENGTH (FT)
2.5	2.875	0.203	3.35	1.82	1.53	1.70	0.95	75.79	6.32
4	4.5	0.237	20.13	12.90	7.23	3.17	1.51	120.76	10.06
6	6.625	0.28	94.56	66.42	28.14	5.58	2.25	179.64	14.97
8	8.625	0.322	271.65	199.16	72.49	8.40	2.94	235.02	19.59
10	10.75	0.365	655.55	494.81	160.73	11.91	3.67	293.91	24.49
12	12.75	0.406	1297.21	997.00	300.21	15.74	4.37	349.33	29.11
16	16	0.5	3216.99	2485.05	731.94	24.35	5.48	438.63	36.55
20	20	0.593	7853.98	6150.27	1703.71	36.15	6.86	549.17	45.76

The critical length where slender column equations apply (where buckling failures occur in lieu of compressive material failure) are shown above for various schedule 40 pipes. The ratio of critical length to pipe diameter is approximately 26.

Determining pressure and thrust to buckle piping is as follows[8]:

$$P = \frac{Thrust}{A * K}$$

Where :

$K = 1.26[8]$

$A = Pipe\_Flow\_Area\_(In^2)$

$Thrust = Thrust\_Force\_(lbf)$

NPS	RADIUS OF GYRATION	CRITICAL LENGTH (IN)	SIGMA E	PIPE METAL AREA (IN^2)	THUST FORCE(LBF)	INTERNAL AREA (IN^2)	PRESSURE REQUIRED TO CAUSE FAILURE (PSI)
2.5	0.95	75.79	11180.41	1.704	19052	4.79	3158
4	1.51	120.76	11180.41	3.174	35487	12.73	2212
6	2.25	179.64	11180.41	5.581	62402	28.89	1714
8	2.94	235.02	11180.41	8.399	93907	50.03	1490
10	3.67	293.91	11180.41	11.908	133140	78.85	1340
12	4.37	349.33	11180.41	15.745	176031	111.93	1248
16	5.48	438.63	11180.41	24.347	272213	176.72	1223
20	6.86	549.17	11180.41	36.155	404223	278.00	1154

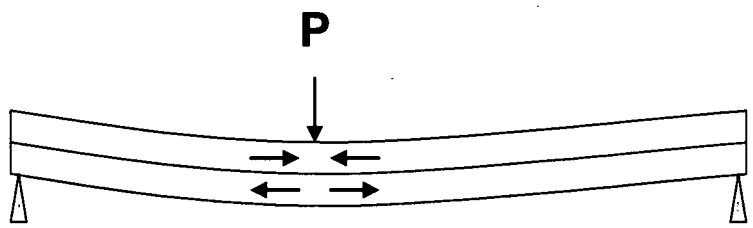
From review of references [9], [10], and [16], pressures do not exist in the system that could cause piping failure at the given column lengths.

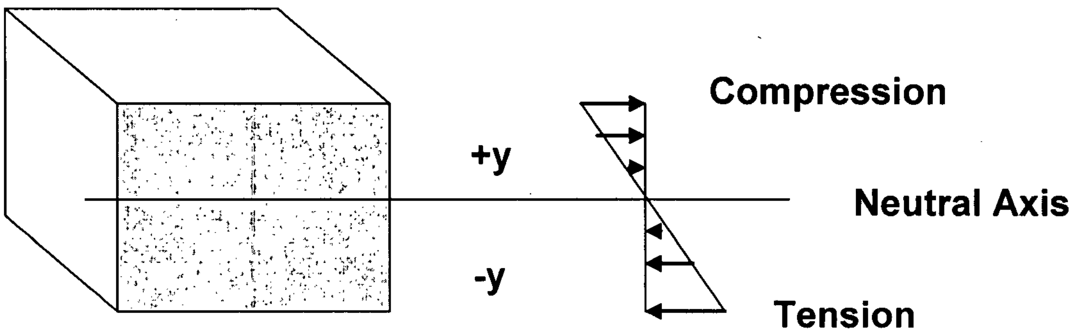
Break Plane perpendicular to the piping axis

The break plane is presumed to be perpendicular to the axis of the piping. Breaks of this geometry are only logical based on piping failure modes. For piping to break and have significant displacement, the piping must sever. If the piping does not sever, the remaining ligament will act as an tether preventing significant displacement of the piping at the break location. With a complete severance of the piping, the remaining restraint is the piping systems ability to resist the bending moment imparted by the jet forces.

For break to occur, either the internal forces within the pipe must exceed the allowable stress limits of the piping or the combined stresses induce a failure. If the forces are a result of internal pressure, axial stresses are ½ that of circumferential stress, therefore a longitudinal break is the outcome. As discussed previously, a longitudinal break is not expected to cause significant pipe whip displacement.

However, if the axial stress combined with other loads (dead weight, seismic, thermal stresses, etc) would cause the piping failure, then the break plane would be perpendicular to the pipe axis. The axial stress generated by internal loads is discussed previously but does add at the axial stress. The axial stress state of the pipe will be defined as follows [7]:





$$\sigma_{b,\max} = \frac{Mc}{I_C}$$

Where :

$M = Applied\_Moment$

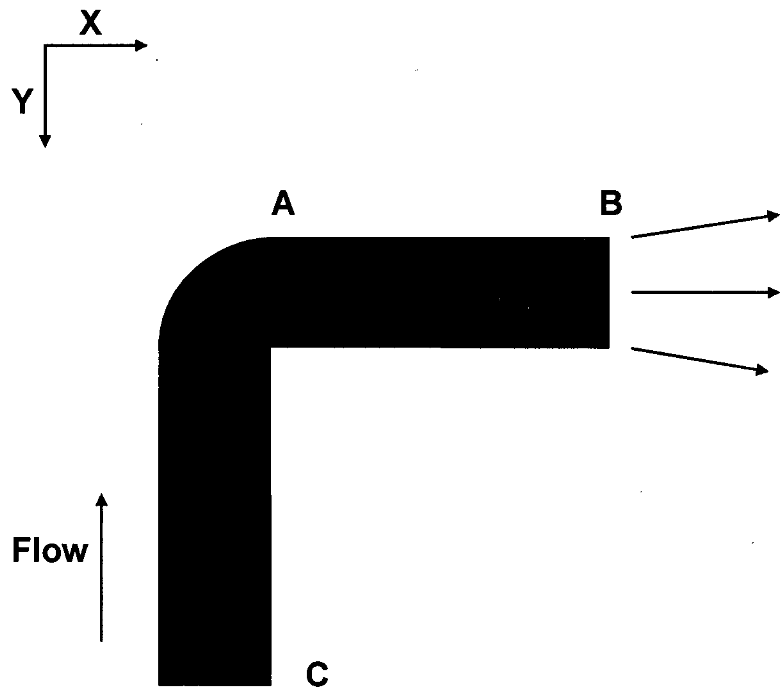
$c = Maximum\_Dis\tan ce\_From\_the\_Neutral\_Axis$

$I_c = Area\_Moment\_of\_Material$

The principle of superposition can be utilized to apply additional stresses from the internal pressure loads. This would result in more tension be added to the material in tension, and less compressive stress for the material in compression. Therefore, this would also result in a shift in the neutral axis. Ultimately, the piping material would fail first where the stress is the highest. Assuming the material is uniform (long pipe with no stress concentrators), the area of failure is the location of greatest moment is applied. Because the nature of this evaluation is a random failure, this applied moment could occur anywhere. However, if the random load is applied and local failure occurs, the first material failure would occur at the material in tension furthest away from the neutral axis. Because of this failure, the area moment of the beam will decrease where the material failure is occurring, weakening the pipe locally. The process would then be repeated until the moment load completely severed the pipe. Therefore it is only reasonable to conclude that, for a randomly assumed break due to an applied excessive moment load, the break plane will be perpendicular to the axis of the piping system.

Jet forces Generated

The forces generated to cause pipe whip are from two areas but are from the same principles. The principle being applied is a change in momentum. Consider the following piping system:



In this figure, momentum changes which cause a moment about point "C" occur at two points, A and B. This is the "Impulse-Momentum Principle". The forces generated at point "A" are a result of the fluid changing direction at the elbow. The fluid is changing direction from the Y direction to the X direction. Note that the change in force resulting from the change in the Y direction momentum is through the hinge point and therefore applies zero moment. The impulse momentum equation can be reduced to the following:

Forces due to the elbow (Point A) in the X-direction [7]:

$$F = \frac{\dot{m}\,\Delta v}{g_c}$$

$$F_{x,A} = \frac{\dot{m}\,\Delta v_x}{g_c} = \frac{\dot{m}\left(v_{xfinal} - v_{x,initial}\right)}{g_c} = \frac{\dot{m}\left(v_{xfinal} - 0\right)}{g_c} = \frac{\dot{m}\left(v_{xfinal}\right)}{g_c}$$

Force due to the exit of the pipe

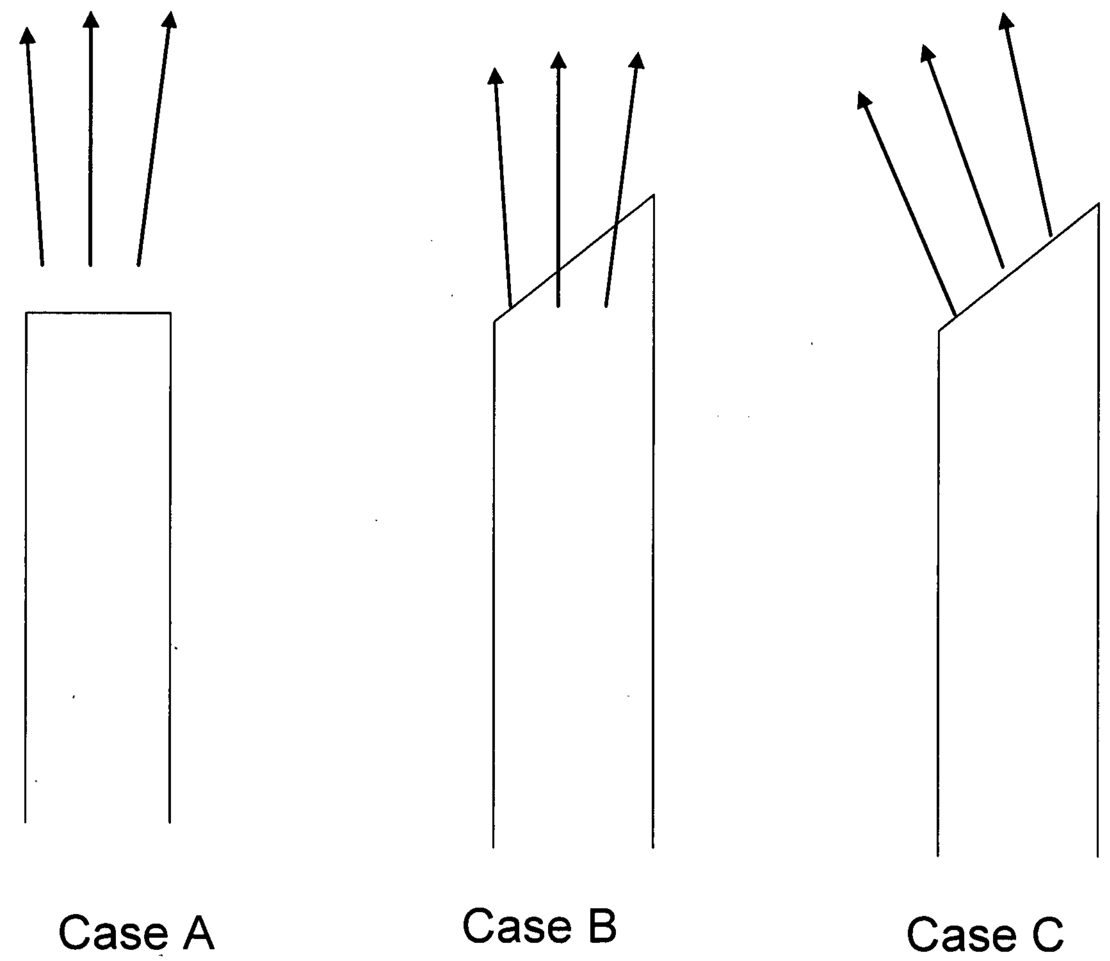
$$F = \frac{\dot{m}\,\Delta v}{g_c}$$

$$F_{x,B} = \frac{\dot{m}\,\Delta v_x}{g_c} = \frac{\dot{m}\left(v_{xfinal} - v_{x,initial}\right)}{g_c}$$

These forces can be combined as follows:

$$F_{x,total} = F_{x,A} + F_{x,B} = \frac{\dot{m}\left(v_{xfinal,A}\right)}{g_c} + \frac{\dot{m}\left(v_{xfinal} - v_{x,initial,B}\right)}{g_c} = \frac{\dot{m}\left(v_{xfinal,A} + v_{xfinal} - v_{x,initial,B}\right)}{g_c}$$

At the instant of the break at point "B", the initial velocity will equal the final velocity at point A. However, if the mass flow rate of the system is not sufficient to support the choked flow at point "B", the sonic plane will move back through the pipe until the pipe is depressurized or a minimum cross sectional area of the pipe is encountered where the upstream velocity is sufficient to maintain the choked flow at that throat.



Assuming the break occurs instantaneously (and the conditions are present for choked flow), the flow will be instantaneously choked perpendicular to the break plane for an instant. However, the sonic plane will move back up through the pipe to the smallest area upstream break location as the fluid in the pipe depressurizes. As a matter of fact, the sonic plane will continue to migrate through the pipe dependant upon the velocity of the fluid feeding the system. As such, the fluid exiting the pipe will have velocity vectors aligned predominantly axially with the pipe. There are some minor exceptions, the fluid leaving the pipe will expand (either steam or water flashing to steam) and cause a lateral force to the end of a beveled pipe. These forces are negligible compared to the overall forces acting axially along the pipe and should not cause the reactions forces shown in Case C.

Justification of Order

This element basically determines if the pipe will even make contact. If the whipping pipe does not make contact with the target pipe, then damage cannot occur.

Flowchart Implementation

Element 1- Included in CC HELB SDP

Reference [15] is the final report associated with CC/HELB significance determination. This report describes which lines were considered to be flooding sources coincident the component cooling water line.

The following interactions were excluded on this basis:

11, 16, 39, 40, 41 and 42

Element 2- Is the moving pipe normally isolated?

ENG-ME-732 Revision 0 did not identify which pipes were normally isolated. ENG-ME-732 Revision 1 did exclude interactions due to the high energy line being meeting the HELB rules less than 2% of normal expected operation.

The following interactions were excluded on this basis:

1 through 6, 8, 17, 86 through 94, 96, 97 and 108

Element 3- Is the target pipe so small that it does not contribute to the SDP (4")?

ENG-ME-732 Revision 0 and Revision 1 (which correct some discrepancies with target line designations). The following lines are excluded as their nominal pipe size is less than 4".

21, 24, 25, 29, 30, 48a, 48b, 57, 58 ,59, 62, 63, 72a, 98 through 107, 116, 116a, 119, 122a, 124, 125, 138a, 141, 143, 150, 152, 157

Element 4- Does the target pipe have cast iron component that could fail?

The following interactions were reviewed to determine if a cast iron valve or support was in the system that would affect it ability to absorb an impact. In this regard, only interactions that could possibly be screened out by element 5 (the moving pipe is not thicker than the target pipe were reviewed). The remaining interactions were assumed to have cast iron.

Interaction	Target Line	Basis	Reference(s)
10	14-CL-110	14-CL-110 was walked down in the Unit 1 TB. No valves were identified on that line with exception of CL-35-1. CL-35-1 valve body is identified as A-516 Gr 70.	[12],[18]
14	16-CL-67	16-CL-67 was reviewed on Ref [12]. No valves are present on 16-CL-67. Upstream the line has MV-32031. MV-32031 valve body is identified as A-516 Gr 70. Attached line 14-CL-67 does have a cast valve in it (CW-32-1). Passport indicates the valve is cast steel [11]. The 14" line is not structurally significant to 16-CL-67. Impacts to 16-CL-67 from 12-CD-7 (or 20-CD-7) will provide axial loading to CW-32-1 which would be non-consequential. 16-CL-67 pipe will deform (along with 12-CD-7 or other laterally impacting pipe) to absorb most of the energy from the event.	[12]
15	16-CL-67	See Interaction 14	[12]
18	16-CL-67	See Interaction 14	[12]
19	16-CL-67	See Interaction 14	[12]
20	24-CL-110	24-CL-110 was walked down in the Unit 1 TB. No valves were identified on that line with exception of CL-34-1. CL-34-1 valve body is identified as A-515 Gr 70..	[12], [19]
20a	24-CL-110	See Interaction 20	
48	24-CL-110	See Interaction 20	
49	24-CL-110	See Interaction 20	
56	24-CL-110	See Interaction 20	
60	24-CL-110	See Interaction 20	
109	16-2CL-9	No valves were identified on 16-2CL-9. Upstream the line	[18], [13]

Interaction	Target Line	Basis	Reference(s)
		has MV-32033. MV-32033 valve body is identified as A-516 Gr 70 Attached line 14-2CL-10 does have a cast iron valve in it (2CL-32-1). The 14" line is not structurally significant to 16-2CL-9. Impacts to 16-2CL-9 from 16-2CD-3 will provide axial loading to 2CL-32-1 which would be non-consequential. 16-2CL-9 pipe will deform (along with 16-2CD-3) to absorb most of the energy from the event.	
114	16-2CL-9	See Interaction 109	
115	16-2CL-9	See Interaction 109	
121	16-2CL-9	See Interaction 114	
123	24-2CL-56	The only valve on 24-2CL-56 is 2CL-34-1. Reference 18 identifies 2CL-34-1 1 valve body is identified as A-516 Gr 70.	[18], [13]
134	14-ZX-161	The only valve shown on line 14-ZX-161 in reference 14 is CL-114-1. Reference 18 identifies CL-114-1 valve body is identified as A-516 Gr 70.	[18], [14]
135	14-ZX-161	See Interaction 134	
136	14-ZX-161	See Interaction 134	
142	14-ZX-161	See Interaction 134	
151	16-ZX-128	The only valve shown on line 16-ZX-128 in reference 13 is ZX-19-1. Reference 11 identifies zx-19-1 with the material identifier "CS".	[11],[13]
161	24-2CL-56	See interaction 123	
164	24-2CL-56	See interaction 123	
168	24-2CL-56	See interaction 123	
169	24-2CL-56	See interaction 123	

Interaction	Target Line	Basis	Reference(s)
181	14-ZX-161	See Interaction 134	
182	14-ZX-161	See Interaction 134	
183	14-ZX-161	See Interaction 134	
184	14-ZX-161	See Interaction 134	
185	14-ZX-161	See Interaction 134	
187	14-ZX-161	See Interaction 134	
188	14-ZX-161	See Interaction 134	
189	14-ZX-161	See Interaction 134	
190	14-ZX-161	See Interaction 134	
191	14-ZX-161	See Interaction 134	
192	14-ZX-161	See Interaction 134	

Element 5- Is the moving pipe thicker than the target pipe?

This screening criteria is only applicable to lines that do not have cast iron components in them. Therefore, only items listed in element 4 can be screened out. (See element 4 above).

Additionally, only pipes where the moving pipe was equal to or thinner than the target pipe wall thickness was document in element 4.

Based upon the computer simulations conducted, the following interactions were successfully modeled to indicated that only minor (if any) would occur from the target piping.

14, 15, 18, 19, 20, 20a, 48, 49, 56, 60, 109, 114 , 115, 118, 121,123, 134, 135, 136, 142, 161, 164, 168, 169, 181, 182, 183, 184, 185, 187 through 192.

Interaction 151 was a limiting case that did not successfully pass computer simulation. Therefore, it will not be excluded from the SDP based upon criteria in element 5 and will be reviewed in element 6.

Interaction 10, while meeting the criteria of this block, cannot be considered bounding by [6]. Therefore, it will not be excluded from the SDP based upon criteria in element 5 and will be reviewed in element 6.

Element 6- Does geometry preclude interaction between the moving piping and the target pipe?

The following interactions have been evaluated to conclude that the likelihood of interaction is low based upon the geometric configuration of the target and moving pipes. The detailed write-up for each interaction is included in Attachment 1 of this evaluation.

10, 12, 13, 43, 46, 53, 58, 76, 82, 110, 111, 112, 113, 117, 151, 155, 156, 157, 159, 160, 163, 180, 198, 199

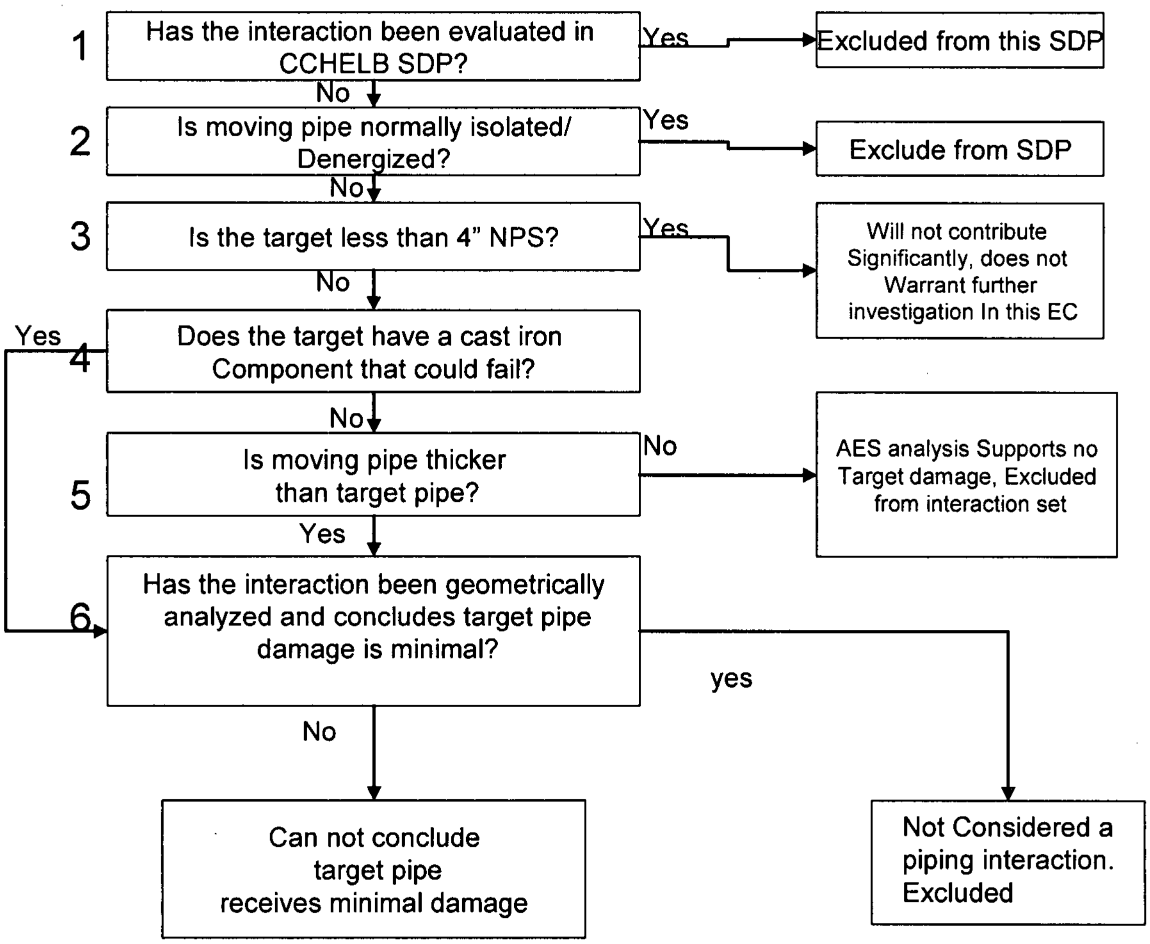
Remaining Interactions

The following interactions did not meet the screening criteria above and should therefore be included fully in the SDP.

7, 9, 22, 23, 26 through 28, 31 through 38, 39a, 40a, 44, 45, 47, 50, 51, 52, 54, 55, 61, 64 through 72, 73, 74, 75, 77, 78, 79, 81, 83, 84, 85, 95, 120, 122, 126 through 133, 137, 138, 139, 140, 144 through 149, 153, 154, 158, 158a, 159a, 162, 165, 166, 167, 170 through 179, 186, 193 through 197, 200, 201, 202, 203, 204, 205.

Conclusions

This evaluation has determined the interactions that should be included in the SDP. The criteria used to determine whether the interaction should be included is based upon the following flow chart.



Of the original 218 interactions, total lines were excluded as follows:

Element Number	Total Number Interactions Excluded
Previously Evaluated in CC/HELB	6
Normally Isolated	22
Less than 4" NPS	35
Not cast Iron and moving pipe not thicker than target	34
Geometry limited from interacting	24
Total Excluded	121

There are 98 interactions remaining following this screening whose numbers are listed above in the appropriate section.

Again, it is worth noting that several of the remaining items could be excluded if items in the "inherent conservatisms" section were implemented. However, these criteria tend to require specific analysis and did not lend themselves to a generic analysis but with additional resources could be applied to reduce the remaining interactions to less than 98.

It should also be noted the inherent conservatism are also applicable to items screened out due to geometry. For instance, many items whose geometry is not conducive to pipe whip affecting the target piping have very small distances between the moving pipe and the target pipe. Additionally, the piping geometries may not lend themselves to the generation of kinetic energy due to the work required to form the plastic hinges in the moving pipe. As a result of these inherent conservatism, the overall result of this analysis is conservative as it tends to over populate the interactions required to fully evaluate.

References

1. Calculation CA-1998-04320 (Film Location 3498-2714)
2. ENG-ME-732 (Revision 0 and Revision 1), "Determination of HELB / Flooding Interactions in the Turbine Building"
3. NUREG CR-3231, "Pipe-to-Pipe Impact Program"
4. Branch Technical Position MEB 3-1.
5. ENG-ME-358 Rev 1, "APPENDIX I - HELB - PIPING SYSTEM SELECTION"
6. EC16275, "EFFECTS OF PIPE WHIP INTERACTIONS FOR VARIOUS PIPE COMBINATIONS For Internal Flooding SDP"
7. Mechanical Engineering Reference Manual, Lindeberg, Twelfth Edition
8. ENG-ME-369 Rev 0, "JET IMPINGEMENT FOR HIGH ENERGY LINE BREAKS"
9. USAR Figure 11.2-5 Rev 30
10. USAR Figure 11.2-1 Rev 27
11. Passport Equipment Database
12. NF-39216-2 Rev 77
13. NF-39217-1 Rev 78
14. NF-86172-1 Rev 76
15. PINGP Report "Component Cooling Water / Turbine Building SDP Issue Risk Significance" Dated 6/5/2009
16. USAR Figure 11.2.4 Rev 27
17. Dupont Hypalon Synthetic Rubber Engineering Properties
18. Technical Manual XH-195-22, "Pratt Butterfly Valves"
19. Drawing XH-195-1, "Model R1-a Butterfly Valve
20. EPRI Technical Report 1010059, Service Water Piping Guideline
21. EC 15656, "EVALUATION OF FLOODING TIMES AND FLOW RATES ASSOCIATED WITH UNIT 1 AND UNIT 2 TB FOR SIGNIFICANCE DETERMINATION"
22. Crane Technical Paper No.410,
23. NSP Technical Manual Number X-HIAW-48-24, "#11, #21 Cooling Water Pump."
24. EC16090, "TURBINE BUILDING FLOODING SDP: CL TURBINE BUILDING PIPE BREAK ANALYSIS"

Attachments

A. Walk down exclusion write-ups

B. Base Spreadsheet from ENG-ME-732 Rev 0 (Amended with Rev 1 information if needed) with interaction review data.

Attachment A

Interaction 10

Interaction 10 is between 20-CD-7 and 14-CL-110 with the break occurring in Row B Column 2 Elevation 695. The interaction is shown on Scientel Drawing A52a and A52b. The high energy line is identified as P2 in those drawings. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-CD-7 which direct the west 45 degrees up from the horizontal plane followed be a 90 degree to the southbound run in a horizontal plane. As shown in plan view of A52a and plan view of A52b, 14-CL-110 runs under the southbound horizontal section of 20-CD-7. Break locations are assumed anywhere along the length of the line.

Assuming a break occurs in the east-west section of 20-CD-7, the upstream pipe will thrust axially to the west but will not whip. The downstream section of piping will rotate in the horizontal plane but not move toward 14-CL-110.

Postulating a break between the two elbows will result in the upstream pipe thrusting down and north, away from 14-CL-110. The downstream pipe will thrust upward and rotate clockwise (looking down) away from 14-CL-110 pipe (which runs underneath this section of pipe).

Lastly, should the break occur down stream of the second elbow in this pipe segment, the upstream pipe will be pushed north and will tend to rotate up and away from the 14-CL-110. The downstream segment will receive an axial load but will not bend as not moment will be generated to develop a plastic hinge.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 12

Interaction 12 is between lines 20-CD-7 and 14-CL-67 with the break occurring in Row B Column 3 Elevation 695. The interaction is shown on Scientel Drawing A52a. The high energy line is identified as P1 in isometric view of A52a. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-CD-7 which direct its flow from the west to 45 degrees up from a horizontal plane to finally a southbound run in a horizontal plane. As shown in plan view of A52a and plan view of drawing A52b, 14-CL-67 runs over the east west horizontal section of 20-CD-7. Break locations are assumed anywhere along the length of the line. Break locations upstream of the elbows would result in an axial load on 20-CD-7 but no moment is generated on the pipe while the downstream pipe moves away from the target pipe described in this interaction. The upstream pipe would not experience movement. Breaks downstream of the elbows would result in upstream section 20-CD-7 thrusting down and North, away from 14-CL-67.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 13

Interaction 13 is between line 20-CD-7 and target line 14-CL-84 in Row B, Column 3, elevation 695. The interaction is shown on Scientel drawing A52a. Line 14-CL-84 runs vertically, south of 20CD-7 turning south into row C column 3. Breaks in 20-2CD-7 will cause the upstream section of 20-2CD-7 to thrust north, down & west, or west (depending on the assumed location of the break). The downstream section will rotate clockwise (in plan view shown in A52b) away from the target pipe.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 43

Interaction 43 is between 16-FW-1 and 24-CL-110 with the break occurring in Row F Column 4 Elevation 695. The interaction is shown on Scientel Drawing A45. The high energy line is identified as P1 in those drawings. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. The pipe will tend to thrust up through the grating, moving past 24-CL-110. As no lateral thrust load is generated by the break, it is reasonable to conclude that no interaction will occur with 24-CL-110 as the 715 grid decking and steel structure will prevent lateral movement. The minimal lateral movement would result in incidental (if any) contact with 24-2CL-110 whose centerline is 24" south.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 46

Interaction 46 is between 16-FW-1 and 6" FP line with the break occurring in Row F Column 4 Elevation 695. The interaction is shown on Scientel Drawing A45. The high energy line is identified as P1. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. The pipe will tend to thrust up through the grating, moving past 6" FP line. Movement will continue until 16-FW-1 makes contact with the 735 ceiling. As no lateral thrust load is generated by the break, it is reasonable to conclude that no interaction will occur with 6" FP as the 715 grid decking and steel structure will tend to prevent lateral movement. The minimal lateral movement would result in incidental (if any) contact with 24-2CL-110 whose centerline is 24" south.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 53
Interaction 53 is between 16-CD-10 and 6" FP line with the break occurring in Row F Column 5 Elevation 695. The interaction is shown on Scientel Drawing A41. The high energy line is identified as P1. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. The pipe will tend to thrust up through the grating, moving past 6" FP line. As no lateral thrust load is generated by the break, it is reasonable to conclude that no interaction will occur with 6" FP as the 715 grid decking and steel structure will prevent lateral movement.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 58
Interaction 58 is between 3-MS-5 and various fire protection piping with the break occurring in Row F Column 7 Elevation 695. 3-MS-5 is enclosed in an engineered steel enclosure which prevent pipe whip. This enclosure is secured closed with a lock and administratively closed with shift supervision permission to open the enclosure during normal operations. This enclosure would prevent a failed pipe within the enclosure from whipping and affecting the fire protection piping adjacent to the enclosure from being affected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 76
Interaction 76 is between 16-FW-3 and 6" fire protection line with the break occurring in Row F Column 5 Elevation 715'. The interaction is shown on Scientel Drawing A46a and A46b. The high energy line is identified as P4 and P5 in those drawings. The 6" FP line runs horizontally 3' over 16-FW-3 then turns vertically down through the floor grating approximately 8' south of the horizontal section of 16-FW-3. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. If the break is assumed to occur in the vertical section from the 11 FWP, the ceiling will prevent significant travel of the whipping pipe. In this case, the 6" FP line (which is located some distance from the assumed break location) would not be contacted. Breaks occurring in the east-west horizontal section of 16-FW-3 will not affect the 6" FP line either. The assumed break locations in the horizontal section will not cause a thrust vertical upward. The assumed break location will cause piping west of the break location to receive a westward force and the piping east of the break location to receive an eastward force. The piping to the west of the break location will have limited travel due to two 16" pipes (16-FW-3 and 16-CD-10)

associated with the FWP inlet and discharge. The east ward pipe has upstream elbows that would tend to cause piping movement to the north (which is the opposite direction of the 6" FP vertical section). Assuming a break downstream of the elbow that directs flow from west to north will cause the upstream piping segment to thrust south causing 16-FW-3 to strike the G-line wall prior to contact with the 6" FP line.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 82

Interaction 82 is between 16-FW-3 and 10-FP-31 fire protection line with the break occurring in Row F Column 4 Elevation 715'. The interaction is shown on Scientel Drawing A46a and A46b. The 10-FP-31 line runs horizontally 4'6" above and 5' 6" south of 16-FW-3. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. Breaks occurring in the east-west horizontal section of 16-FW-3 will not affect the 10-FP-31 line. The assumed break locations in the horizontal section will not cause a thrust vertical upward. The assumed break location will cause piping west of the break location to receive a westward force and the piping east of the break location to receive an eastward force. The piping to the west of the break location will have limited travel due to two 16" pipes (16-FW-3 and 16-CD-10) associated with the 12 FWP inlet and discharge lines. The east ward pipe has upstream elbows that would tend to cause piping movement to the north (which is the opposite direction of the 10-FP-31). Breaks in the vertical section of 16-FW-3 will cause and upward thrust which will limit travel and preclude additional contact.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 110

Interaction 110 is between lines 20-2CD-7 and 10-2CL-53 with the break occurring in Row B Column 14 Elevation 695. The interaction is shown on Scientel Drawing A54. The high energy line is identified as P1 in isometric view of A54. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-2CD-7 which direct its flow from the east 45 degrees up from a horizontal plane to finally a southbound run in a horizontal plane. As shown in plan view of A54, 10-2CL-53 runs skew of 20-2CD-7. Break locations are assumed anywhere along the length of the line 20-2CD-7. Break locations upstream of the elbows would result in an axial load on 20-2CD-7 but no moment is generated on the pipe while the downstream pipe moves away from the target pipe described in this interaction. The upstream pipe would not experience movement. Breaks downstream of the elbows would result in upstream section 20-CD-7 thrusting down and North, away from 10-2CL-53. The horizontal section of 20-2CD-7 would thrust towards the "C" line but no moment is applied and therefore no whipping would be expected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 111
Interaction 111 is between lines 20-2CD-7 and 10-2CL-56 with the break occurring in Row B Column 14 Elevation 695. The interaction is shown on Scientel Drawing A54. The high energy line is identified as P1 in isometric view of A54. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-2CD-7 which direct its flow from the east 45 degrees up from a horizontal plane to finally a southbound run in a horizontal plane. As shown in plan view of A54, 10-2CL-56 runs under the of southbound section 20-2CD-7. Break locations are assumed anywhere along the length of the line 20-2CD-7. Break locations upstream of the elbows would result in an axial load on 20-2CD-7 but no moment is generated on the pipe while the downstream pipe moves away from the target pipe described in this interaction. The upstream pipe would not experience movement. Breaks downstream of the elbows would result in upstream section 20-2CD-7 thrusting down and North, away from 10-2CL-56. The horizontal section of 20-2CD-7 would thrust towards the "C" line but no moment is applied and therefore no whipping would be expected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 112
Interaction 118 is between line 20-2CD-7 and target line 14-2CL-10 in Row B, Column 14, elevation 695. The interaction is shown on Scientel drawing A54. Breaks in 20-2CD-7 in will cause the section of 20-2CD-7 to thrust north, down & east, or east (depending on the assumed location of the break). Due to one elbow, 14-2CL-10 passes over the horizontal straight length of 20-2CD-7 running east-west through row B column 14. There is no hinge point generated in the horizontal section of 20-2CD-7 as no moment arm is generated. Breaks in the elbows of 20-2CD-7 will cause the southbound section of 20-2CD-7 to thrust up and away from 14-2CL-10.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 113
Interaction 113 is between lines 20-2CD-7 and 14-2CL-53 with the break occurring in Row B Column 14 Elevation 695. The interaction is shown on Scientel Drawing A54. The high energy line is identified as P1 in isometric view of A54. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-2CD-7 which direct its flow from the east 45 degrees up from a horizontal

plane to finally a southbound run in a horizontal plane. As shown in plan view of A54, 14-2CL-53 runs skew vertically adjacent to the east west section of 20-2CD-7 passing through Row B Column 14. Break locations are assumed anywhere along the length of the line 20-2CD-7. Break locations upstream of the elbows would result in an axial load on 20-2CD-7 but no moment is generated on the pipe while the downstream pipe moves away from the target pipe described in this interaction. The upstream pipe would not experience movement. Breaks downstream of the elbows would result in upstream section 20-2CD-7 thrusting down and North, away from 14-2CL-56. The horizontal section of 20-2CD-7 would thrust towards the "C" line but no moment is applied and therefore no whipping would be expected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 117

Interaction 117 is between lines 20-2CD-7 and 6-2CL-9 with the break occurring in Row B Column 14 Elevation 695. The interaction is shown on Scientel Drawing A54. The high energy line is identified as P1 in isometric view of A54. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. There are two elbows on 20-2CD-7. The first direct its flow from the east 45 degrees up from a horizontal plane to finally a southbound run in a horizontal plane. As shown in plan view of A54, 6-2CL-9 runs above adjacent to the east west section of 20-2CD-7 passing through Row B Column 14. Break locations are assumed anywhere along the length of the line 20-2CD-7. Break locations upstream of the elbows would result in an axial load on 20-2CD-7 but no moment is generated on the pipe while the downstream pipe moves away from the target pipe described in this interaction. The upstream pipe would not experience movement. Breaks downstream of the elbows would result in upstream section 20-2CD-7 thrusting down and North, away from 6-2CL-9. The horizontal section of 20-2CD-7 would thrust towards the "C" line but no moment is applied and therefore no whipping would be expected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 151

Interaction 151 is between line 20-2CD-7 and target line 16-ZX-128 in Row E, Column 15, elevation 695. The interaction is shown on Scientel drawing A54. Breaks in 20-2CD-7 near 16-ZX-128 will cause the upstream section of 20-2CD-7 to thrust north and the down stream section to swing up and to the east. The 16-ZX-128 is above 20-2CD-7 by approximately 24". There is no hinge point generated in the horizontal section of 20-2CD-7 as no moment arm is generated. Breaks in 20-2CD-7 near 16-2CD-7 will cause the southbound section of 20-2CD-7 to thrust up and away from 16-ZX-128 while the horizontal piping near 16-ZX-128 will thrust down and away from the ZX line.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 155
Interaction 155 is between 16-2FW-3 and 24-2CL-56 with the break occurring in Row F Column 10 elevation 695. The interaction is shown on Scientel Drawing A49C and A49A. The line is identified as P1 in those drawings. Breaks in 16-2FW-3 (interaction 160, south 25 FW Heater) are below the 715 grating. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in plan view of A49C and plan view of drawing A49C, the section of piping below the 715 grating runs only in a vertical plane and therefore its whip would only be a vertical plane along the axis of the horizontal section of piping. The plan view of drawing A57 indicates that the vertical plane passing through 16-2FW-3 is offset by 5' from 24-2CL-56. Thus should a break occur in 16-2FW-3, it will pass by 24-2CL-56 with no contact.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 156
Interaction 156 is between 20-2FW-3 and 24-2CL-56 with the break occurring in Row F Column 10 elevation 695. The interaction is shown on Scientel Drawing A57. The line is identified as P1 in those drawings. Breaks in 20-2FW-3 (interaction 160, south 25 FW Heater) are below the 715 grating. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in plan view of A57 and plan view of drawing A49b, the section of piping below the 715 grating runs only in a vertical plane and therefore its whip would only be a vertical plane along the axis of the horizontal section of piping. The plan view of drawing A57 indicates that the vertical plane passing through 20-2FW-3 is offset by 5' from 24-2CL-56. Thus should a break occur in 20-2FW-3, it will pass by 24-2CL-56 with no contact.

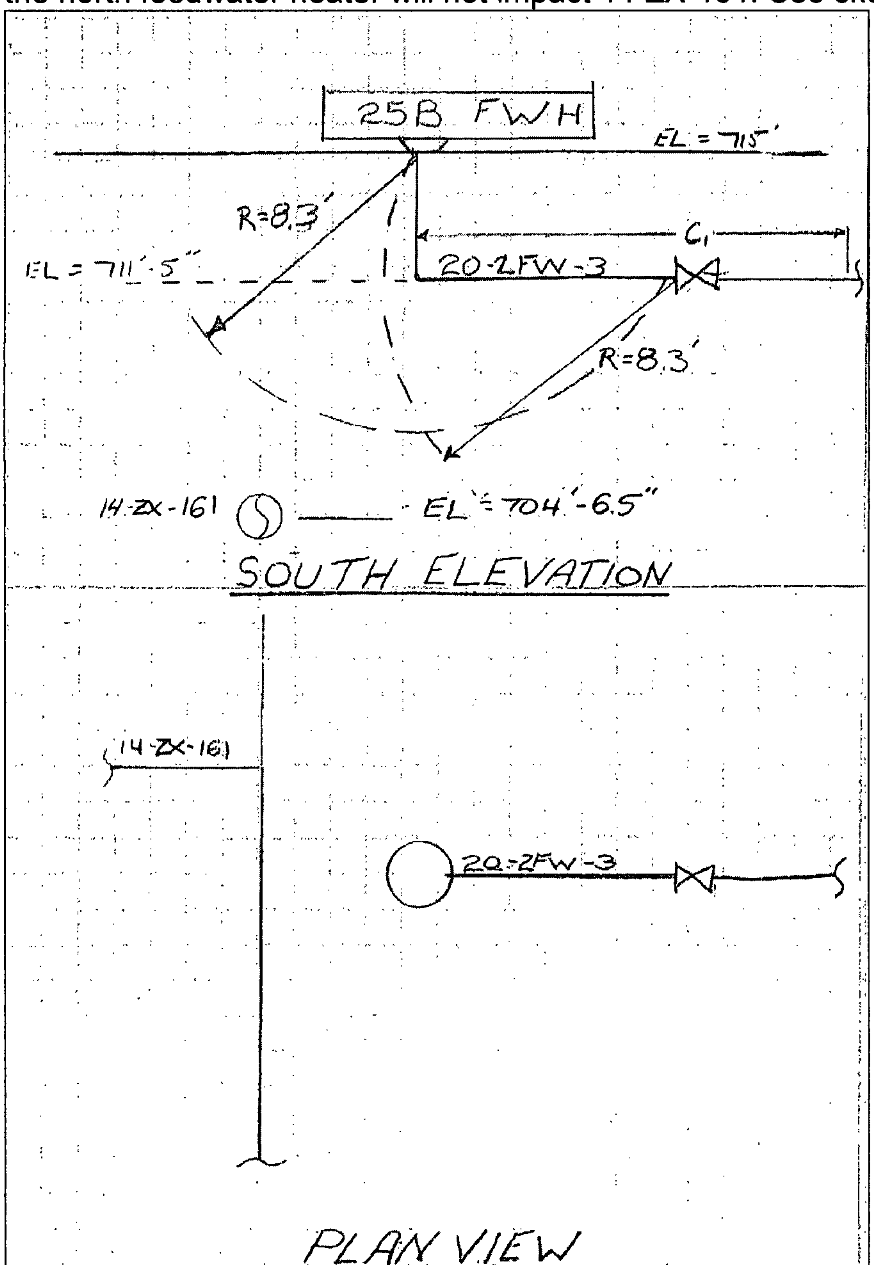
Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 157
Interaction 157 is between 3-2MS-6 and various fire protection piping with the break occurring in Row F Column 10 Elevation 695. 3-2MS-6 is enclosed in an engineered steel enclosure which prevent pipe whip. This enclosure is secured closed with a lock and administratively closed with shift supervision permission to open the enclosure during normal operations. This enclosure would prevent a failed pipe within the enclosure from whipping and affecting the fire protection piping adjacent to the enclosure from being affected.

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 159

Interaction 159 is an interaction between 20-2FW-3 and 14-ZX-161 with the break occurring in Row F column 11 elevation 695. This interaction is shown on Scientel Drawing A57. The line connects to the southern most 25 feedwater heater and runs approximately 3.5' below the 715 grating. Based upon the physical lengths of pipe available to whip, a break in line 20-2FW-3 attached to the north feedwater heater will not impact 14-ZX-161. See sketch below.



Creating a limiting length of whipping pipe by a circumferential break, if the breaks at valve 2FW-11-1 and hinges at the 715' grating penetration, the length of the swinging arm is 8.76". The 14-ZX-161 line is 10.5' below the 715' grating. Therefore, the whipping arc is not sufficient in length.

Creating a limiting length of whipping pipe by a circumferential break, if the breaks at 715' grating penetration and hinges in line 16-2FW-3, the swing radius is:

$$\sqrt{(715-711.5)^2 + C_1^{\ 2}} = \sqrt{(3.5)^2 + C_1^{\ 2}}$$

Where:
C_1 = the horizontal distance from the break location to hinge

The 14-ZX-161 line is 10.5' below the 715' grating. The radius of the ZX line to the hinge point is:

$$\sqrt{(711.5-704.542)^2 + C_1^{\ 2}} = \sqrt{(6.958)^2 + C_1^{\ 2}}$$

Therefore, the whipping arc is not sufficient in length because

$$\sqrt{(3.5)^2 + C_1^{\ 2}} < \sqrt{(6.958)^2 + C_1^{\ 2}}$$

Interaction is not possible due to pipe lengths and hinge points and is therefore excluded as an initiating event for this SDP.

<u>Interaction 160</u>

Interaction 160 is between 20-2FW-3 and 24-2CL-56 with the break occurring in Row F Column 11 elevation 695. The interaction is shown on Scientel Drawing A57. Breaks in 20-2FW-3 (interaction 160, south 25 FW Heater) are below the 715 grating. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in plan view of A57 and plan view of drawing A49b, the section of piping below the 715 grating runs only in a vertical plane and therefore its whip would only be a vertical plane along the axis of the horizontal section of piping. The plan view of drawing A57 indicates that the vertical plane passing through 20-2FW-3 is offset by 5' from 24-2CL-56. Thus should a break occur in 20-2FW-3, it will pass by 24-2CL-56 with no contact.

Therefore, this interaction is excluded as an initiating event for this SDP.

<u>Interaction 163</u>

Interaction 163 is between 16-2FW-1 and 24-2CL-56 with the break occurring in Row F Column 12 elevation 695. The interaction is shown on Scientel Drawing A48. Breaks in 16-2FW-1 occur below the 715 grating for this interaction. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in plan view of A48, the section of piping below the 715 grating runs only in a vertical direction and would not be expected to whip. The pipe will thrust up through the grating penetration (using the grating penetration as a guide) with minimal lateral movement. The minimal lateral movement would result in incidental (if any) contact with 24-2CL-56 whose centerline is 24" south.

Therefore, this interaction is excluded as an initiating event for this SDP.

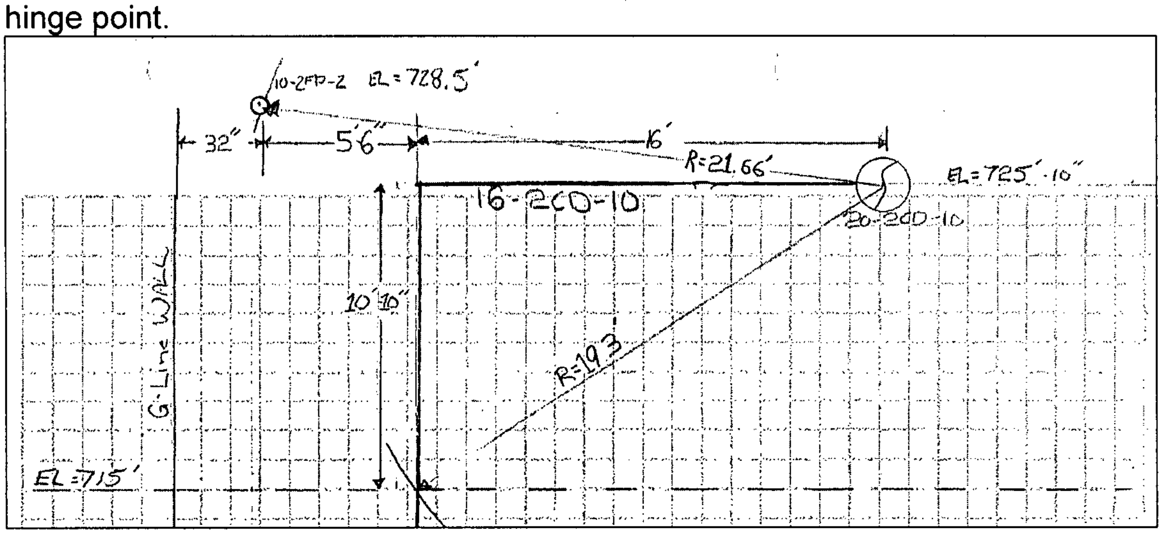
Interaction 180

Interaction 180 is between 12-2MS-36 and 14-ZX-128 with the break occurring in Row E Column 13 elevation 715. The interaction is shown on Scientel Drawings A34a and A34b. The exclusion credited in ENG-ME-732 is a design basis consideration and will not be credited for this write up. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in plan view of A48, the section of piping above the 715 grating runs vertical direction and would not be expected to whip due to ceiling interferences. Breaks in the horizontal section will move away from the the ZX-14-128 line. The ZX-14-128 line runs parallel to the plane defined by the axis of the broken pipe and the plastic hinge point.

Therefore, this interaction is excluded as an initiating event for this SDP.

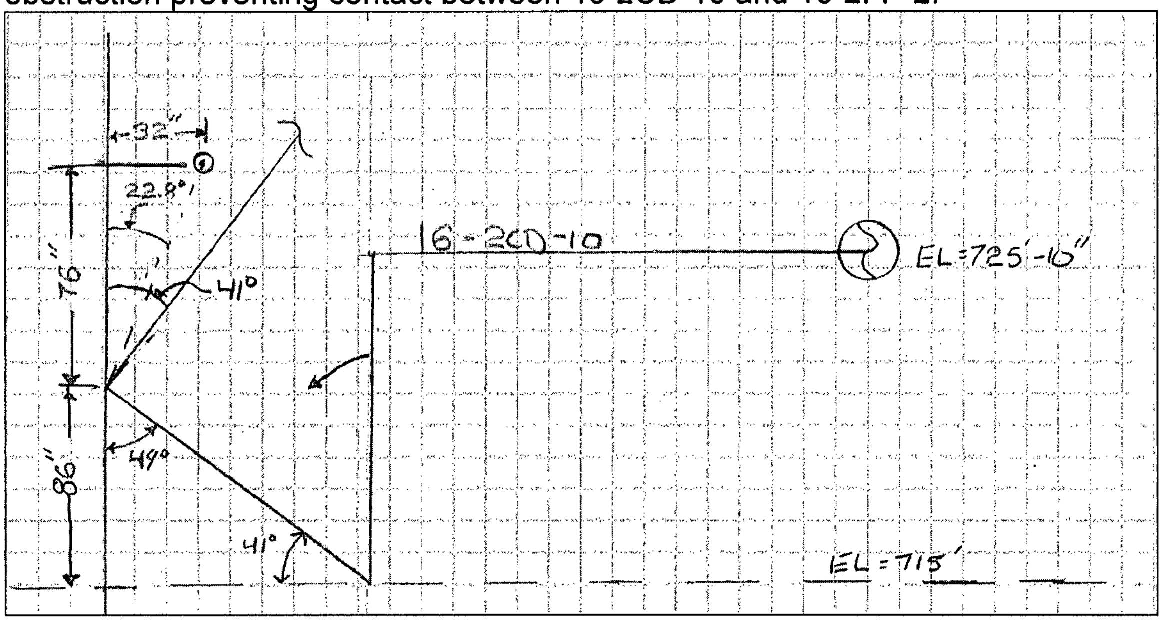
Interaction 198

Interaction 198 is between 16-2CD-10 and 10-2FP-1 with the break occurring in Row F Column 13 elevation 715. The interaction is shown on Scientel Drawing A44a and A44b. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in the SE isometric view of A44a, the vertical portion of piping above the 715' grating is 5'-6" from the fire protection line. The tee connection to 20-CD-10 is 16' north of this vertical section pipe. Considering a break at the 715' grating, the whip are radius is 18.36' from the hinge location. The line 10-2FP-2 is 21.67' from the hinge point.



West View

Assuming a hinge occurs at the grating, a break in the horizontal section will strike the G-line wall which is 98" from 16-2CD-10. The hypotenuse of the triangle will be 10'-10.5" and the adjacent leg will be 98". The piping will come to rest at a 41 degree angle from the grating (49 degree angle on the wall). The contact point will be 86" above the 715' grating (722.8'). From this contact point, 10-2FP-2 is 22.8 degrees from the G-line wall. The G-line wall will act an obstruction preventing contact between 16-2CD-10 and 10-2FP-2.



West View

Therefore, this interaction is excluded as an initiating event for this SDP.

Interaction 199

Interaction 199 is between 20-2CD-10 and 10-2FP-1 with the break occurring in Row F Column 13 elevation 715. The interaction is shown on Scientel Drawing A55. The direction of whip will be along the plane generated by the axis of pipe where the break occurs and the plastic hinge point. As shown in south view and plan view of A55, all of the 20-2CD-10 piping near 10-2FP-1 is horizontal at an elevation of 725'-10.5". The 10-2FP-2 at an elevation of 728'-6". Should a break occur in an area close enough to reach the 10-2-FP-2 pipe, the 20-2CD-2 pipe would pass below 10-2FP-2.

Therefore, this interaction is excluded as an initiating event for this SDP.

Turbine Building HELB / Flooding Interactions

Note 1: Numbers in [ ] refer to the applicable reference for the data.
Note 2: Some HELBs may results in more than one interaction at the same time. These combinations have been listed.
Note 3: The schedule listed is as specified in passport. However, this schedule does not match the thickness given in passport.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
1	1	679	B	4	8-MS-35 [38]	80	7.625	0.5	45.7	0.95	1A inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	12"	Deaerating steam line travels beneath the water boxes.	Excluded (assumption 6.2.1)	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Included	Steam jet could impact condenser water box	No	Yes						
2	1	679	B	4	12-MS-35 [38]	80	11.374	0.688	101.6	1.96	1A/1B inner pass waterboxes	N/A	0.75 (assumption 6.2.3)	6 ft	Deaerating steam line decends vertically between the inner pass water boxes on the north side of 1A and 1B Condenser.	Excluded (assumption 6.2.1)	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	Yes						
3	1	679	B	4	8-MS-35 [38]	80	7.625	0.5	45.7	0.95	piping @ MD-3-7 (4" pipe)	unknown		8"	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Included	None		Included	Steam jet could impact pipe @ valve MD-3-7	No	Yes						
3a	1	679	B	4	8-MS-35 [38]	80	7.625	0.5	45.7	0.95	piping @ MD-3-8 (4" pipe)	unknown		8"	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CW line	Included	Same as interaction 3 conclusion	No	Yes						
3b	1	679	B	5	6-MS-35 [38]	80	5.761	0.432	26.1	0.62	piping @ MD-3-5 (4" pipe)	unknown		2 ft	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CW line	Included	Steam jet could impact pipe @ valve MD-3-6 and the condenser water box	No	Yes						
4	1	679	B	5	12-MS-35 [38]	80	11.374	0.688	101.6	1.96	1A/1B inner pass waterboxes	N/A	0.75 (assumption 6.2.3)	6 ft	Deaerating steam line decends vertically between the inner pass water boxes on the north side of 1A and 1B Condenser.	Excluded (assumption 6.2.1)	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	yes						
5	1	679	B	5	6-MS-35 [38]	80	5.761	0.432	26.1	0.62	1B inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	1 ft	Deaerating steam line travels beneath the water boxes.	Excluded (assumption 6.2.1)	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Included	Same as interaction 3b conclusion	No	yes						
6	1	679	E	4	16-MS-37 [38]	40	15	0.5	176.7	1.88	1A inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	1 ft	MS dump to 1A Cdsr. Downcomer passes with in 3 ft of the outer pass of the circ water piping, on south side. MS piping then passes beneath the outer pass CS piping and enters 1A Cdsr between the 1A Cdsr inlet water boxes, inner and outer pass.	Excluded (assumption 6.2.1)	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	yes						
7	1	679	E	4	12-MS-36 [38]	80	11.374	0.688	101.6	1.96	6-CL-78 [30]	40	0.28	2 ft	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
8	1	679	E	4	16-MS-37 [38]	40	15	0.5	176.7	1.88	6-CL-78 [30]	40	0.28	5 ft	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	yes						
9	1	679	E	4	6-MS-36 [38]	80	5.761	0.432	26.1	0.62	6-CL-78 [30]	40	0.28	8 ft	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
10	1	695	B	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	14-CL-110 [30]	30	0.375	12"	CL return from the generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact pipes 14-CL-110, 24-CL-110, & 6-CL-67	No	No	no	No cast iron valves or fitting			No	Exclude
11	1	695	B	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	6-CL-67 [30]	40	0.28	2 ft	CL supply to hydrogen seal oil coolers	Included	also can hit 2 1/2" FP		Included	Same as interaction 10 conclusion	yes							
12	1	695	B	3	20-CD-7 [44]	20	19.25	0.375	291	1.80	14-CL-67 [30]	30	0.375	2 ft	CL supply to the generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	exclude		
13	1	695	B	3	20-CD-7 [44]	20	19.25	0.375	291	1.80	14-CL-84 [30]	30	0.375	3 ft	CL return from the generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
14	1	695	B	3	12-CD-7 [44]	40S	12	0.375	113.1	1.13	16-CL-67 [30]	30	0.375	3 ft	CL main turbine building supply header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	No cast iron valves or fitting			No	
15	1	695	B	3	20-CD-7 [44]	20	19.25	0.375	291	1.80	16-CL-67 [30]	30	0.375	16"	CL main turbine building supply header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	No cast iron valves or fitting			No	
16	1	695	B	3	20-CD-7 [44]	20	19.25	0.375	291	1.80	6-CL-67 [30]	40	0.28	16"	CL main turbine building supply header (reduced size)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	yes							
17	1	695	B	4, 5, 6	12-MS-35 [38]	80	11.374	0.688	101.6	1.96	16-CL-67 [30]	30	0.375	8"	CL main turbine building supply header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	yes						
18	1	695	B	4, 5, 6	16-CD-7 [44]	30	15.25	0.375	182.7	1.43	16-CL-67 [30]	30	0.375	16"	CL main turbine building supply header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
19	1	695	B	4, 5, 6	16-CD-9 [44]	30	15.25	0.375	182.7	1.43	16-CL-67 [30]	30	0.375	3 ft	CL main turbine building supply header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 16-CL-67	No	No	no	No cast iron valves or fitting			No	
20	1	695	B, C, D, E	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	24-CL-110 [30]	20	0.375	2 ft	CL return header.	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipes 14-CL-110, 24-CL-110, & 6-CL-67	No	No	no	No cast iron valves or fitting			No	
20a	1	695	E	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	24-CL-110 [30]	20	0.375	2 ft	CL return header.	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipes 14-CL-110, 24-CL-110, & 6-CL-67	No	No	no	No cast iron valves or fittings			No	
21	1	695	E	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	3-CL-110 [30]	40	0.216	16"	CL from heater drain tank pump unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
22	1	695	E	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	6-CL-78 [30]	40	0.28	16"	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
23	1	695	E	2	20-CD-7 [44]	20	19.25	0.375	291	1.80	8-CL-97 [30]	40	0.322	4 ft	CL from roof drains	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
24	1	695	E	3	14-HD-36 [45]	30	13.25	0.375	137.9	1.24	2-ZE-2 [49]	80	0.218	12"	CL return piping from the heater drain tank pump unit coolers	Included	None		Included	Steam jet could impact pipes 6-CL-78 & 2-ZE-2	No	No	yes					
25	1	695	E	3	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	2-ZE-2 [49]	80	0.218	4"	CL return piping from the FW pump unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the ZE line	Excluded	-	No	No	yes					

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
26	1	695	E	3	14-HD-36 [45]	30	13.25	0.375	137.9	1.24	6-CL-78 [30]	40	0.28	12"	CL from turbine building sump pump	Included	None	Limited flow potential *(design input 4.4.5)*	Included	Same as interaction 24 conclusion	No	No	no	Contains cast iron valve	Cast	Included		
27	1	695	E	3	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	6-CL-78 [30]	40	0.28	2 ft	CL from turbine building sump pump	Included	None	Limited flow potential *(design input 4.4.5)*	Excluded	-	No	No	no	Contains cast iron valve	Cast	Included		
28	1	695	E	3	6-FW-7 [47]	80	5.761	0.432	26.1	0.62	6-CL-78 [30]	40	0.28	2 ft	CL from turbine building sump pump	Included	None	Limited flow potential *(design input 4.4.5)*	Excluded	-	No	No	no	Contains cast iron valve	Cast	Included		
29	1	695	E	4	12-MS-36 [38]	80	11.374	0.688	101.6	1.96	3-ZE-5 [49]	40	0.237	3"	CL from feedwater pump motor unit cooler	Included	30		Included	Steam jet could impact pipes 6-CL-78, 4-CL-110, & 4-ZE-3	No	No	yes					
30	1	695	E	4	12-MS-36 [38]	80	11.374	0.688	101.6	1.96	3-ZE-5 [49]	40	0.237	3"	CL to feedwater pump motor unit cooler	Potentially excluded.	29	This break will result in an SI signal (design input 4.3.1). If the CL break is large enough to result in low header pressure, the MV will isolate the TB CL loads (design input 4.4.1).	Included	Same as interaction 29 conclusion	No	No	yes					
31	1	695	E	4	12-MS-36 [38]	80	11.374	0.688	101.6	1.96	6-CL-78 [30]	40	0.28	6"	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the ZE line	Included	Same as interaction 29 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
32	1	695	E	4	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	6-CL-78 [30]	40	0.28	2 ft	CL from turbine building sump pump	Included	None	Limited flow potential *(design input 4.4.5)*	Included	Steam jet could impact pipe 6-CL-78	No	No	no	Contains cast iron valve	Cast	Included		
33	1	695	E	4	6-FW-7 [47]	80	5.761	0.432	26.1	0.62	6-CL-78 [30]	40	0.28	4"	CL from turbine building sump pump	Included	None	Limited flow potential *(design input 4.4.5)*	Included	Steam jet could impact pipe 6-CL-78	No	No	no	Contains cast iron valve	Cast	Included		
34	1	695	E	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	4-CL-110 [30]	40	0.237	4 ft	CL from feedwater pump motor unit cooler	Excluded	35	Cannot whip enough to cause damage due to obstructions in the area.	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
35	1	695	E	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	4-ZE-3 [49]	40	0.237	4 ft	CL to feedwater pump motor unit cooler	Excluded	34	Cannot whip enough to cause damage due to obstructions in the area.	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
36	1	695	E	6	8-HD-29 [45]	40	7.981	0.322	50.0	0.64	12-CL-110 [30]	40S	0.375	3 ft	CL return from turbine oil coolers.	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
37	1	695	E	6	8-HD-29 [45]	40	7.981	0.322	50.0	0.64	4" FP	unknown		0	4" FP supply line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
37a	1	695	E	6	8-HD-29 [45]	40	7.981	0.322	50.0	0.64	4-ZE-3 [49]	40	0.237	5 ft	CL to feedwater pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
38	1	695	E	6	8-HD-29 [45]	40	7.981	0.322	50.0	0.64	4-CL-68 [30]	40	0.237	12"	CL supply piping to turbine oil coolers from main CL header in safeguards aisle	Included	None		Excluded	-	No	No	no	Contains cast iron valve	Cast	Included		
39	1	695	E	7	16-FW-3 [47]	100	13.938	1.031	152.6	3.59	12-CL-67 [30]	40S	0.375	52"	CL supply to turbine oil coolers. Piping is directly below the high energy piping	Included	41		Included	Steam jet could impact pipes 4-CL-68 & 12-CL-67	Yes							
39a	1	695	E	7	16-FW-3 [47]	100	13.938	1.031	152.6	3.59	4" FP	unknown		6 ft	4" FP supply line from CL header	Excluded	-	Piping is normally isolated by valve CW-15-15 and check valve CW-77-3.	Included	Same as interaction 39 conclusion	no	No	no	Contains cast iron valve	Cast	Include		
40	1	695	E	7	20-FW-3 [47]	100	17.438	1.281	238.8	5.58	12-CL-67 [30]	40S	0.375	52"	CL supply to turbine oil coolers. Piping is directly below the high energy piping	Included	42, 40a	Terminal end break. Will impact CL and affect cast-iron nozzles on TO coolers	Included	Steam jet could impact pipes 4-CL-68 & 12-CL-67	Yes							
40a	1	695	E	7	20-FW-3 [47]	100	17.438	1.281	238.8	5.58	4" FP	unknown		6 ft	4" FP supply line	Excluded	-	Piping is normally isolated by valve CW-15-15 and check valve CW-77-3.	Included	Same as interaction 40 conclusion	no	No	no	Contains cast iron valve	Cast	Include		
41	1	695	E	7	16-FW-3 [47]	100	13.938	1.031	152.6	3.59	4-CL-68 [30]	40	0.237	2"	CL piping is directly below the high energy piping	Included	39		Included	Same as interaction 39 conclusion	Yes							
42	1	695	E	7	20-FW-3 [47]	100	17.438	1.281	238.8	5.58	4-CL-68 [30]	40	0.237	2"	CL piping is directly below the high energy piping	Included	40, 40a	Terminal end break	Included	Same as interaction 40 conclusion	Yes							
43	1	695	F	4	16-FW-1 [47]	100	13.938	1.031	152.6	3.59	24-CL-110 [30]	20	0.375	6"	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
44	1	695	F	4	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	24-CL-110 [30]	20	0.375	16"	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact 6" FP piping	No	No	no	Contains Cast Iron valve	Cast	Include		
45	1	695	F	4	16-FW-1 [47]	100	13.938	1.031	152.6	3.59	4" FP	unknown		3 ft	4" FP supply line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
46	1	695	F	4	16-FW-1 [47]	100	13.938	1.031	152.6	3.59	6" FP	unknown		6"	6" FP supply line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
47	1	695	F	4	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	6" FP	unknown		6"	6" FP supply line	Included	None		Included	Same as interaction 44 conclusion	No	No	no	Contains cast iron valve	Cast	Included		
204	1	695	F	4	6-FW-6 [47]	80	5.761	0.432	26.1	0.62	4" FP	unknown		4 ft	4" FP supply line	Excluded	-	Excluded due to combined stress analysis (Reference 27)	Excluded	Excluded due to combined stress analysis (Reference 27)	no	no	no	Contains Cast Iron valve	Cast	Include		
48	1	695	F	5	16-CD-10 [44]	30	15.25	0.375	182.7	1.43	24-CL-110 [30]	20	0.375	5 ft	CL return header	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact 6" FP piping	No	No	no	No cast iron valves or fitting			No	
48a	1	695	F	5	16-FW-2 [47]	100	13.938	1.031	152.6	3.59	3" FP	unknown		12"	3" FP supply line near FWP	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	yes					
48b	1	695	F	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	3" FP	unknown		2 ft	3" FP supply line near FWP	Included	None		Included	Steam jet could impact 3" FP piping	No	No	yes					
49	1	695	F	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	24-CL-110 [30]	20	0.375	16"	CL return header	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 48b conclusion	No	No	no	No cast iron valves or fitting			No	
50	1	695	F	5	6-FW-7 [47]	80	5.761	0.432	26.1	0.62	4-CL-110 [30]	40	0.237	6 ft	CL from feedwater pump motor unit cooler	Included	None		Included	Steam jet could impact 3" FP piping	No	No	no	Contains Cast Iron valve	Cast	Included		
51	1	695	F	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	4-CL-110 [30]	40	0.237	6"	CL from feedwater pump motor unit cooler	Included	52		Included	Same as interaction 48b conclusion	No	No	no	Contains Cast Iron valve	Cast	Included		
52	1	695	F	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	4" FP	unknown		3 ft	4" FP supply line, away from FWP	Included	51		Included	Same as interaction 48b conclusion	No	No	no	Contains cast iron valve	Cast	Included		
53	1	695	F	5	16-CD-10 [44]	30	15.25	0.375	182.7	1.43	6" FP	unknown		12"	6" FP supply line	Excluded	-	Inspection shows that the high energy pipe could whip into the FP line.	Included	Same as interaction 48 conclusion	No	No	no	Contains Cast Iron valve	Cast	exclude		
54	1	695	F	5	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	6" FP	unknown		2 ft	6" FP supply line	Included	None		Included	Same as interaction 48b conclusion	No	No	no	Contains cast iron valve	Cast	Included		
55	1	695	F	6	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	12-CL-110 [30]	40S	0.375	2 ft	CL return from turbine oil coolers.	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipes 24-CL-110 & 3-CL-69	No	No	no	Contains cast iron valve	Cast	Include		

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
56	1	695	F	6	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	24-CL-110 [30]	20	0.375	6"	CL return header near feed pumps	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 55 conclusion	No	No	no	No cast iron valves or fitting			No	
57	1	695	F	6	8-HD-28 [45]	40	7.981	0.322	50.0	0.64	3-CL-69 [30]	40	0.216	4 ft	CL supply to feedwater pump oil coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 55 conclusion	No	No	yes					
58	1	695	F	7	3-MS-5 [38]	80	2.9	0.3	6.6	0.22	N/A			N/A	Aux feed steam supply piping	Excluded	-	The steam supply to AFW turbine is shielded by the security barrier.	Excluded	-	No	No	no	Contains cast iron valve	Cast	exclude		
59	1	695	F	2, 3	16-CD-7 [44]	30	15.25	0.375	182.7	1.43	1 1/2-CL-276 [30]	80	0.2	2 ft	CL from heater drain tank pump oil coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact 6" FP piping & pipe 24-CL-110	No	No	yes					
60	1	695	F	2, 3	16-CD-7 [44]	30	15.25	0.375	182.7	1.43	24-CL-110 [30]	20	0.375	3 ft	CL return header	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 59 conclusion	No	No	no	No cast iron valves or fitting			No	
61	1	695	F	2, 3	16-CD-7 [44]	30	15.25	0.375	182.7	1.43	6" FP	unknown		3 ft	6" FP supply line	Included	None		Included	Same as interaction 59 conclusion	No	No	no	Contains cast iron valve	Cast.	Included		
62	1	715	C	7	6-HD-5 [45]	80	5.761	0.432	26.1	0.62	2" CL from EH cooler	unknown		10 ft	CL from EH coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
63	1	715	C	7	6-HD-5 [45]	80	5.761	0.432	26.1	0.62	2" CL to EH cooler	unknown		10 ft	CL to EH coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
64	1	715	C, D	3	2 1/2-HD-75 [43]	80	2.323	0.276	4.2	0.16	5-CL-84 [30]	40	0.258	4 ft	Heater Drain line near CL from all hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
65	1	715	C, D	3	8-HD-6 [45]	80	7.625	0.5	45.7	0.95	5-CL-83 [30]	40	0.258	4 ft	Heater Drain line near CL to hydrogen coolers #11C and #12C	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
66	1	715	C, D	3	8-HD-6 [45]	80	7.625	0.5	45.7	0.95	5-CL-83 [30]	40	0.258	3 ft	Heater Drain line near CL to hydrogen coolers #11D and #12D	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
67	1	715	C, D	3	8-HD-6 [45]	80	7.625	0.5	45.7	0.95	5-CL-84 [30]	40	0.258	2 ft	Heater Drain line near CL from all hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
68	1	715	E	3	2 1/2-HD-75 [43]	80	2.323	0.276	4	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	2 ft	4" FP header near piping from 2A MSR to 15A FW heater	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
69	1	715	E	3	8-HD-6 [45]	80	7.625	0.5	45.7	0.95	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	2 ft	MSR drains near 6" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
70	1	715	E	4	2 1/2-HD-77 [43]	80	2.323	0.276	4.2	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	3 ft	4" FP header near bleed steam condenser dump line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
71	1	715	E	5	16-CD-10 [44]	30	15.25	0.375	182.7	1.43	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	1 ft	4" FP header near CD piping to #12 FW pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
72	1	715	E	6	12-BL-1 [43]	40S	12	0.375	113.1	1.13	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	2 ft	4" FP header near bleed steam from HP turbine	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
72a	1	715	E	6	12-BL-1 [43]	40S	12	0.375	113.1	1.13	3" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	2 ft	3" FP header near bleed steam from HP turbine	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	yes					
73	1	715	E	6	2 1/2-HD-76 [43]	80	2.323	0.276	4.2	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	1 ft	4" FP header near MSR drain line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
74	1	715	E	6	2 1/2-HD-77 [43]	80	2.323	0.276	4.2	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	1"	4" FP header near MSR drain line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
75	1	715	F	3	20-CD-10 [44]	20	19.25	0.375	291	1.80	10-FP-31 [50]	40	0.365	6 ft	20" main CD line to FW pumps	Included	-		Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Included		
76	1	715	F	5	16-FW-3 [47]	100	13.938	1.031	152.6	3.59	6" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.28	3 ft	main FW from FW pump 11	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-FP 31	No	No	no	Contains Cast Iron valve	Cast	exclude		
77	1	715	F	6	22-FW-8 [47]	100	19.25	1.375	291	6.62	10-FP-31 [50]	40	0.365	4 ft	main FW line near 10" FP header	Excluded *(design input 4.2)*	-	No design basis break	Included	Steam jet could impact pipe 10-FP 31	No	No	no	Contains Cast Iron valve	Cast	include		
78	1	715	F	6	30-MS-3 [38]	1.045"	27.91	1.045	612	7.29	10-FP-31 [50]	40	0.365	3 ft	MS headers near 10" FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains Cast Iron valve	Cast	include		
79	1	715	F	6	30-MS-4 [38]	1.045"	27.91	1.045	612	7.29	10-FP-31 [50]	40	0.365	3 ft	MS headers near 10" FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains Cast Iron valve	Cast	include		
203	1	715	F	6, 7	16-FW-3 [47]	100	13.938	1.031	152.6	3.59	10-FP-31 [50]	40	0.365	6 ft	FW line near 10" FP header	Excluded	-	Excluded due to combined stress analysis (Reference 27)	Excluded	Excluded due to combined stress analysis (Reference 27)	no	no	no	Contains Cast Iron valve	Cast	include		
~~80~~	~~1~~	~~715~~	~~F~~	~~7~~	~~30-MS-3 [38]~~	~~1.045"~~	~~27.91~~	~~1.045~~	~~612~~	~~7.29~~	~~10-FP-31 [50]~~	~~40~~	~~0.365~~	~~3 ft~~	~~MS headers near 10" FP header.~~	Deleted - duplicate listing with #79			Deleted - duplicate listing with #79		NA	NA	NA	NA	NA	NA	NA	NA
81	1	715	F	4	16-CD-10 [44]	30	15.25	0.375	182.7	1.43	10-FP-31 [50]	40	0.365	8 ft	CD line to 11 FW pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-FP 31	No	No	no	Contains Cast Iron valve	Cast	include		
82	1	715	F	4	16-FW-8 [47]	100	13.938	1.031	152.6	3.59	10-FP-31 [50]	40	0.365	6 ft	FW line from 11 FW pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-FP 31	No	No	no	Contains Cast Iron valve	Cast	exclude		
83	1	715	F	4	16-FW-8 [47]	100	13.938	1.031	152.6	3.59	4" FP (T.O. Sprklr System)	40 (DI 4.5.1)	0.237	6 ft	FW line from 11 FW pump near 4" FP line	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-FP 31	No	No	no	Contains Cast Iron valve	Cast	Include		
84	1	735	F	6	30-MS-3 [38]	1.045"	27.91	1.045	612	7.29	10-FP-31 [50]	40	0.365	16"	Both 11 & 12 MS lines are near the 10" FP header which goes into the Aux Bldg at this level. Main FW line is also about 10' from the FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains Cast Iron valve	Cast	include		
85	1	735	F	6	30-MS-4 [38]	1.045"	27.91	1.045	612	7.29	10-FP-31 [50]	40	0.365	16"	Both 11 & 12 MS lines are near the 10" FP header which goes into the Aux Bldg at this level. Main FW line is also about 10' from the FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains Cast Iron valve	Cast	include		

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area). (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
86	2	679	B	12	8-2MS-35 [42]	80	7.625	0.5	45.7	0.95	2A inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	12"	Deaerating steam line travels beneath the water boxes.	Excluded *(assumption 6.2.1)*	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Included	Steam jet could impact condenser water box	No	yes						
87	2	679	B	12	12-2MS-35 [42]	80	11.374	0.688	101.6	1.96	2A/2B inner pass waterboxes	N/A	0.75 (assumption 6.2.3)	6 ft	Deaerating steam line decends vertically between the inner pass water boxes on the north side of 2A and 2B Condenser.	Excluded *(assumption 6.2.1)*	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	yes						
88	2	679	B	12	6-2MS-35 [42]	80	5.761	0.432	26.1	0.62	piping @ 2MD-3-5 (4" pipe)	unknown		2 ft	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CW line	Excluded	-	No	yes						
89	2	679	B	12	6-2MS-35 [42]	80	5.761	0.432	26.1	0.62	piping @ 2MD-3-6 (4" pipe)	unknown		6 ft	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CW line	Excluded	-	No	yes						
90	2	679	B	13	8-2MS-35 [42]	80	7.625	0.5	45.7	0.95	piping @ 2MD-3-7 (4" pipe)	unknown		6"	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Included	None		Excluded	-	No	yes						
91	2	679	B	13	8-2MS-35 [42]	80	7.625	0.5	45.7	0.95	piping @ 2MD-3-8 (4" pipe)	unknown		8"	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	yes						
92	2	679	B	13	12-2MS-35 [42]	80	11.374	0.688	101.6	1.96	2A/2B inner pass waterboxes	N/A	0.75 (assumption 6.2.3)	6 ft	Deaerating steam line decends vertically between the inner pass water boxes on the north side of 2A and 2B Condenser.	Excluded *(assumption 6.2.1)*	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	yes						
93	2	679	B	13	6-2MS-35 [42]	80	5.761	0.432	26.1	0.62	2B inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	1 ft	Deaerating steam line travels beneath the water boxes.	Excluded *(assumption 6.2.1)*	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Included	Steam jet could impact condenser water box	No	yes						
94	2	679	E	13	16-2MS-37 [42]	40	15	0.5	176.7	1.88	2A inner and outer pass waterboxes	N/A	0.75 (assumption 6.2.3)	16"	MS dump to 2A cdsr. Steam line comes down above the outer pass of the CW piping, then around and beneath it. The steam line enters the 2A cdsr below and between the inner pass inlet and outer pass inlet water boxes.	Excluded *(assumption 6.2.1)*	-	Assumption 6.2.3 and the large size of the water box results in assumption 6.2.1 being applicable	Excluded	-	No	yes						
95	2	679	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	6-2CL-51 [32]	40	0.28	6 ft	CL from turbine building sump pump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
96	2	679	E	13	16-2MS-37 [42]	40	15	0.5	176.7	1.88	piping @ 2MD-3-1 (4" pipe)	unknown		6 ft	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CW line	Excluded	-	No	yes						
97	2	679	E	13	16-2MS-37 [42]	40	15	0.5	176.7	1.88	piping @ 2MD-3-2 (4" pipe)	unknown		6 ft	Piping is a condenser drain line but no piping ID is shown on the CW PID. Pipe whip could break the pipe off the condenser and breach the CW pressure boundary.	Included	-		Excluded	-	No	yes						
98	2	679	E	13	6-2MS-36 [42]	80	5.761	0.432	26.1	0.62	1 1/2-2ZE-3 [49]	80	0.2	6 ft	CL to heater drain tank pump motor unit cooler	Included	-		Included	Steam jet could impact the piping @ valve 2MD-3-2	No	No	yes					
99	2	679	E	14	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	1 1/2-2ZE-4 [49]	80	0.2	2'-6"	CL from heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact pipes 1 1/2 2ZE-4 & 3-2ZE-3	No	No	yes					
100	2	679	E	14	10-2FW-7 [39]	100	9.312	0.719	68.1	1.67	1 1/2-2ZE-4 [49]	80	0.2	12"	CL from heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact pipes 1 1/2 2ZE-4 & 3-2ZE-3	No	No	yes					
101	2	679	E	14	12-2HD-36 [41]	40S	12	0.375	113.1	1.13	1 1/2-2ZE-4 [49]	80	0.2	6"	CL from heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
102	2	679	E	14	14-2HD-36 [41]	40S (Note 6)	13.25	0.375	138	1.24	1 1/2-2ZE-4 [49]	80	0.2	6"	CL from heater drain tank pump motor unit cooler	Excluded	107	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
103	2	679	E	13	6-2MS-36 [42]	80	5.761	0.432	26.1	0.62	1 1/2-2ZE-4 [49]	80	0.2	5 ft	CL from heater drain tank pump motor unit cooler	Included	None		Included	Same as interaction 98 conclusion	No	No	yes					
104	2	679	E	14	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	3-2ZE-3 [49]	40	0.216	2'-6"	CL to heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 99 conclusion	No	No	yes					
105	2	679	E	14	10-2FW-7 [39]	100	9.312	0.719	68.1	1.67	3-2ZE-3 [49]	40	0.216	12"	CL to heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 100 conclusion	No	No	yes					
106	2	679	E	14	12-2HD-36 [41]	40S	12	0.375	113.1	1.13	3-2ZE-3 [49]	40	0.216	6"	CL to heater drain tank pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
107	2	679	E	14	14-2HD-36 [41]	40S (Note 3)	13.25	0.375	138	1.24	3-2ZE-3 [49]	40	0.216	6"	CL to heater drain tank pump motor unit cooler	Excluded	102	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
108	2	695	B	12	12-2MS-35 [42]	80	11.374	0.688	101.6	1.96	16-2CL-9 [32]	30	0.375	12"	CL supply header for TB loads near MS dump to condenser	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	yes						
109	2	695	B	12	16-2CD-9 [40]	30	15.25	0.375	182.7	1.43	16-2CL-9 [32]	30	0.375	3 ft	CL supply header for TB loads near CD between 22B & 23B FW heaters	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 16-2CL-9	No	No	no	No cast iron valves or fitting			No	
110	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	10-2CL-53 [32]	40	0.365	2 ft	CL return from generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Steam jet could impact pipes 3-2CL-56, 24-2CL-56, or a 2 1/2" FP pipe	No	No	no	Contains Cast Iron valve	Cast	exclude		
111	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	10-2CL-56 [32]	40	0.365	2 ft	CL return from generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	Contains Cast Iron valve	Cast	exclude		

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
112	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	14-2CL-10 [32]	30	0.375	2 ft	CL supply to generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	Contains cast iron valve	Cast	exclude		
113	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	14-2CL-53 [32]	40S	0.375	2 ft	CL return from generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	Contains Cast Iron valve	Cast	exclude		
114	2	695	B	14	12-2CD-7 [40]	40S	12	0.375	113.1	1.13	16-2CL-9 [32]	30	0.375	16"	CL supply header for TB loads	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
115	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	16-2CL-9 [32]	30	0.375	6"	CL supply header for TB loads	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	No cast iron valves or fitting			No	
116	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	3-2CL-56 [32]	40	0.216	4 ft	CL return from condensate pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	yes					
116a	2	695	B	13	20-2CD-7 [40]	20	19.25	0.375	291	1.80	3-2CL-9 [32]	40	0.216	3 ft	CL supply to condensate pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	yes					
117	2	695	B	14	20-2CD-7 [40]	20	19.25	0.375	291	1.80	6-2CL-9 [32]	40	0.28	3 ft	CL supply to generator exciter coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	Contains cast iron valve	Cast	exclude		
118	2	695	B	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	14-2CL-56 [32]	30	0.375	6"	CL from generator hydrogen coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	no	No cast iron valves or fitting			No	
119	2	695	B	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	2-2CL-130 [32]	80	0.218	4 ft	CL from CD pump oil cooler	Included	120		Included	Same as interaction 110 conclusion	No	No	yes					
120	2	695	B	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	6-2CL-9 [32]	40	0.28	16"	CL to generator exciter cooler	Included	119		Included	Same as interaction 110 conclusion	No	No	no	Contains cast iron valve	Cast	Included		
121	2	695	B	12, 13	16-2CD-7 [40]	30	15.25	0.375	182.7	1.43	16-2CL-9 [32]	30	0.375	12"	CL supply header for TB loads near CD from 23B FW heater	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
122	2	695	B, C, D	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	4-2FP-39 [54]	40	0.237	8 ft	4" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
122a	2	695	B	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	2 1/2" FP			2 ft	2 1/2" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 110 conclusion	No	No	yes					
123	2	695	B, C, D, E	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	24-2CL-56 [32]	20	0.375	2 ft	CL return header near 20" CD line to #4 heaters	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
124	2	695	D	14	14-2HD-36 [41]	40S	13.25	0.375	137.9	1.24	3-2CL-56 [32]	40	0.216	6 ft	CL from HD pump motor unit coolers	Excluded	--	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
125	2	695	D	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	3-2CL-56 [32]	40	0.216	2 ft	CL from HD pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
126	2	695	E	10	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	12-2CL-9 [32]	40S	0.375	6 ft	CL to turbine oil coolers (piping is directly below the high energy line)	Included	None		Included	Steam jet could impact pipe 12-2CL-9	No	No	no	Contains cast iron valve	Cast	Included		
127	2	695	E	10	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	12-2CL-9 [32]	40S	0.375	6 ft	CL to turbine oil coolers (piping is directly below the high energy line)	Included	None		Included	Steam jet could impact pipes 12-2CL-9, 4-2CL-9, or 4-2CL-11	No	No	no	Contains cast iron valve	Cast	Included		
128	2	695	E	10	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	4-2CL-11 [32]	40	0.237	6"	CL from main header to turbine oil coolers (isolation bypass line)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 126 conclusion	No	No	no	Contains cast iron valve	Cast	Include		
129	2	695	E	10	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	4-2CL-11 [32]	40	0.237	6"	CL from main header to turbine oil coolers (isolation bypass line)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 127 conclusion	No	No	no	Contains cast iron valve	Cast	Include		
130	2	695	E	10	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	4-2CL-9 [32]	40	0.237	7 ft	CL to HD tank pump unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 126 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
131	2	695	E	10	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	4-2CL-9 [32]	40	0.237	7 ft	CL to HD tank pump unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 127 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
132	2	695	E	11	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	10-2CL-11 [32]	40	0.365	6 ft	CL to turbine oil coolers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipes 12-2CL-9, 4-2CL-9, or a 4" FP pipe	No	No	no	Contains cast iron valve	Cast	Include		
133	2	695	E	11	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	12-2CL-56 [32]	40	0.406	3 ft	CL from turbine oil coolers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 132 conclusion	No	No	no	Contains cast iron valve	Cast	Include		
134	2	695	E	11	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	14-ZX-161 [53]	XS [57]	0.5	7 ft	CL supply to ZX chillers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 132 conclusion	No	No	no	No cast iron valves or fitting			No	
135	2	695	E	12	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	14-ZX-161 [53]	XS [57]	0.5	2"	CL supply to ZX chillers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
136	2	695	E	12	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	14-ZX-161 [53]	XS [57]	0.5	3 ft	CL supply to ZX chillers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 132 conclusion	No	No	no	No cast iron valves or fitting			No	
137	2	695	E	12	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	4" FP	unknown		4"	4" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Same as interaction 132 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
138	2	695	E	12	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	4-2ZE-3 [49]	40	0.237	4 ft	CL to FW pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 132 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
138a	2	695	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	2-2ZE-3 [49]	80	0.218	5 ft	CL to FW pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the ZX line	Included	Steam jet could impact pipes 6-2CL-51 or 4-2CL-9 or CW piping	No	No	yes					
139	2	695	E	12	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	4-2ZE-5 [49]	40	0.237	4 ft	CL from FW pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
140	2	695	E	12	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	6-2FP-20 [50]	40	0.28	1"	6" FP header over condenser pit	Included	None		Included	Steam jet could impact 6" FP piping	No	No	no	Contains cast iron valve	Cast	Included		

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
141	2	695	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	1 1/2-2ZE-5 [49]	80	0.2	2 ft	CL from FW pump motor unit cooler	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 138a conclusion	No	No	yes					
142	2	695	E	13	8-2HD-29 [41]	40	7.981	0.322	50.0	0.64	14-ZX-161 [53]	XS [57]	0.5	4 ft	CL supply to ZX chillers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 6-2CL 51	No	No	no	No cast iron valves or fitting			No	
143	2	695	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	3-2ZE-3 [49]	40	0.237	6"	CL to FW pump motor unit coolers	Potentially excluded.	None	This break will result in an SI signal (design input 4.3.1). If the CL break is large enough to result in low header pressure, the MV will isolate the TB CL loads (design input 4.4.2)	Included	Same as interaction 138a conclusion	No	No	yes					
144	2	695	E	13	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	6-2CL-51 [32]	40	0.28	3 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
145	2	695	E	13	10-2FW-7 [39]	100	9.312	0.719	68.1	1.67	6-2CL-51 [32]	40	0.28	4 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
146	2	695	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	6-2CL-51 [32]	40	0.28	1 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 138a conclusion	No	No	no	Contains cast iron valve	Cast	Include		
147	2	695	E	13	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	6-2CL-51 [32]	40	0.28	2 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 140 conclusion	No	No	no	Contains cast iron valve	Cast	Include		
148	2	695	E	14	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	6-2CL-51 [32]	40	0.28	3 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
149	2	695	E	14	10-2FW-7 [39]	100	9.312	0.719	68.1	1.67	6-2CL-51 [32]	40	0.28	3 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
150	2	695	E	15	16-2CD-7 [40]	30	15.25	0.375	182.7	1.43	1 1/2-2CL-131 [32]	80	0.2	12"	CL from HD pump motor unit coolers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
151	2	695	E	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	16-ZX-128 [53]	30	0.375	4 ft	CL return from ZX chillers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the ZE line	Excluded	-	No	No	no	No cast iron valves or fitting			No	Exclude
152	2	695	E	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	2-ZX-155 [53]	80	0.218	5 ft	Chilled water filter media backflush to CL discharge	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	yes					
153	2	695	E	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	6-2CL-51 [32]	40	0.28	2 ft	CL discharge from turbine building sump	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
154	2	695	E	15	20-2CD-7 [40]	20	19.25	0.375	291	1.80	8-2CL-56 [32]	40	0.322	4 ft	Roof drain to CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
155	2	695	F	10	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	24-2CL-56 [32]	20	0.375	6 ft	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
156	2	695	F	10	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	24-2CL-56 [32]	20	0.375	4 ft	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
157	2	695	F	10	3-2MS-6 [42]	80	2.9	0.3	6.6	0.22	Various FP	unknown		N/A	Steam line to Aux feed pump turbine	Excluded	-	The steam supply to AFW turbine is shielded by the security barrier.	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
158	2	695	F	11	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	12-2CL-56 [32]	40	0.406	12"	CL from turbine oil coolers	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 24-2CL-56	No	No	no	Contains cast iron valve	Cast	Include		
158a	2	695	F	11	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	12-2CL-56 [32]	40	0.406	8 ft	CL from turbine oil coolers	Included	159a	Terminal end break	Excluded	-	No	No	no	Contains cast iron valve	Cast	Included		
159	2	695	F	11	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	14-ZX-161 [53]	XS [57]	0.5	7 ft	CL supply to ZX chillers	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the ZX line	Included	Steam jet could impact pipes 12-2CL-56 or 14-ZX-161	No	No	no	Contains Cast Iron valve	Cast	exclude		
159a	2	695	F	11	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	14-ZX-161 [53]	XS [57]	0.5	7 ft	CL supply to ZX chillers	Included	158a	Terminal end break	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Included		
160	2	695	F	11	20-2FW-3 [39]	100	17.438	1.281	238.8	5.58	24-2CL-56 [32]	20	0.375	4 ft	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Included	Same as interaction 159 conclusion	No	No	no	Contains Cast Iron valve	Cast	exclude		
161	2	695	F	11	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	24-2CL-56 [32]	20	0.375	1"	CL return header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 158 conclusion	No	No	no	No cast iron valves or fitting			No	
162	2	695	F	12	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	24-2CL-56 [32]	20	0.375	3"	CL return header	Included	None		Included	Steam jet could impact pipe 24-2CL-56	No	No	no	Contains Cast Iron valve	Cast	Included		
163	2	695	F	12	16-2FW-1 [39]	100	13.938	1.031	152.6	3.59	24-2CL-56 [32]	20	0.375	1"	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	exclude		
164	2	695	F	12	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	24-2CL-56 [32]	20	0.375	8 ft	CL return header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
165	2	695	F	12	10-2FW-6 [39]	100	9.312	0.719	68.1	1.67	4-2ZE-5 [49]	40	0.237	3 ft	CL from FW pump motor unit coolers	Included	None		Included	Same as interaction 162 conclusion	No	No	no	Contains Cast Iron valve	Cast	Included		
166	2	695	F	12	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	4-2ZE-5 [49]	40	0.237	3 ft	CL from FW pump motor unit coolers	Included	None		Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Included		
205	2	695	F	12	8-2HD-28 [41]	40	7.981	0.322	50.0	0.64	4" FP	unknown		4"	4" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	no	no	no	Contains cast iron valve	Cast	Include		
167	2	695	F	13	10-2FW-7 [39]	100	9.312	0.719	68.1	1.67	24-2CL-56 [32]	20	0.375	8 ft	CL return header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
168	2	695	F	13	16-2CD-10 [40]	30	15.25	0.375	182.7	1.43	24-2CL-56 [32]	20	0.375	3 ft	CL return header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
169	2	695	F	15	16-2CD-7 [40]	30	15.25	0.375	182.7	1.43	24-2CL-56 [32]	20	0.375	2 ft	CL return header	Excluded (assumption 6.2.1)	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 24-2CL-56	No	No	no	No cast iron valves or fitting			No	

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	X	Y	Z	AA	AB	BA	BB	BC	BD		BJ	BM	BN
																Circumferential break evaluation (pipe whip)			Circumferential Break (Jet Impingement during pipe whip)		Element 1	Element 2	Element 3	Element 4		cast- Element 6	Non-Cast Element 5	Non-Cast-Element 6
No.	UNIT	ELEV	ROW	COLUMN	HE Pipe	HE Pipe schedule [36]	HE Pipe I.D. (in) [37]	HE Pipe thickness (in) [37]	HE Pipe design basis break size (I.D. area) (in2)	HE Pipe design basis crack size (1/2 I.D. x 1/2 thickness) (in2)	Impacted Pipe	Impacted Pipe schedule [36]	Impacted Pipe thickness (in) [37]	Approximate Distance between HE and impacted pipe	Interaction comments	Included?	Other Interactions	Comments	Included?	Comments	Was included in CC HELB?	Not High Energy	Is target less than 4" NPS?	Is the target cast?		Do walkdowns indicate interaction reasonable?	Is moving Pipe Thicker?	Do walkdowns indicate interaction reasonable?
170	2	695	F	15	16-2CD-7 [40]	30	15.25	0.375	182.7	1.43	4-2FP-39 [54]	40	0.237	6 ft	4" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Same as interaction 169 conclusion	No	No	no	Contains Cast Iron valve	Cast	Include		
171	2	715	C	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-10 [32]	40	0.258	3 ft	CL to generator hydrogen coolers (Valve 2CL-28-8)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Cast Iron Piping "Support"	Cast	include		
172	2	715	C	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-10 [32]	40	0.258	5 ft	CL to generator hydrogen coolers (Valve 2CL-28-7)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Cast Iron Piping "Support"	Cast	include		
173	2	715	C	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-53 [32]	40	0.258	3 ft	CL from generator hydrogen coolers (Valves 2CL-29-5, 6, 7, 8)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
174	2	715	D	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-10 [32]	40	0.258	3 ft	CL to generator hydrogen coolers (Valve 2CL-28-1)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Cast Iron Piping "Support"	Cast	include		
175	2	715	D	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-10 [32]	40	0.258	5 ft	CL to generator hydrogen coolers (Valve 2CL-28-2)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Cast Iron Piping "Support"	Cast	include		
176	2	715	D	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	5-2CL-53 [32]	40	0.258	3 ft	CL from generator hydrogen coolers (Valves 2CL-29-1, 2, 3, 4)	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the CL line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
177	2	715	D	15	2 1/2-2HD-83 [46]	80	2.323	0.276	4	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.2)	0.237	6"	4" FP header near HD line from 25B heater to 2A condenser.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
178	2	715	E	11	16-2BL-1 [46]	30	15.25	0.375	182.7	1.43	4" FP (T.O. Sprklr System)	40 (DI 4.5.2)	0.237	2 ft	Bleed Steam in close proximity to 4" FP header	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	include		
179	2	715	E	12	2 1/2-2HD-81 [46]	80	2.323	0.276	4	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.2)	0.237	3 ft	4" FP header near HD line from 25A heater to 2B condenser.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
180	2	715	E	13	12-2MS-36 [42]	80	11.374	0.688	101.6	1.96	14-ZX-161 [53]	XS [57]	0.5	6"	CL supply to ZX chillers	Excluded	-	This break will result in an SI signal (design input 4.3.1). The SI signal will isolate the ZX chiller loads (design input 4.4.3)	Included	Steam jet could impact pipe 14-ZX-161	No	No	no	Contains Cast Iron valve	Cast	Exclude		
181	2	715	E	13	2 1/2-2HD-82 [46]	80	2.323	0.276	4	0.16	14-ZX-161 [53]	XS [57]	0.5	3"	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
182	2	715	E	13	6-2HD-6 [41]	80	5.761	0.432	26.1	0.62	14-ZX-161 [53]	XS [57]	0.5	3 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
183	2	715	E	13	6-2HD-8 [41]	80	5.761	0.432	26.1	0.62	14-ZX-161 [53]	XS [57]	0.5	2"	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
184	2	715	E	13	8-2HD-6 [41]	80	7.625	0.5	45.7	0.95	14-ZX-161 [53]	XS [57]	0.5	12"	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
185	2	715	E	13	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	14-ZX-161 [53]	XS [57]	0.5	1"	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
186	2	715	E	13	2 1/2-2HD-84 [46]	80	2.323	0.276	4.2	0.16	4" FP (T.O. Sprklr System)	40 (DI 4.5.2)	0.237	2"	4" FP header near HD line to 2A condenser near valve 2HD-4-6.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains Cast Iron valve	Cast	Include		
187	2	715	E	14	14-2HD-36 [41]	40S	13.25	0.375	137.9	1.24	14-ZX-161 [53]	XS [57]	0.5	2 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 14-ZX-161	No	No	no	No cast iron valves or fitting			No	
188	2	715	E	14	8-2HD-6 [41]	80	7.625	0.5	45.7	0.95	14-ZX-161 [53]	XS [57]	0.5	4 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
189	2	715	E	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	14-ZX-161 [53]	XS [57]	0.5	3 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 14-ZX-161	No	No	no	No cast iron valves or fitting			No	
190	2	715	E	14	8-2HD-8 [41]	80	7.625	0.5	45.7	0.95	14-ZX-161 [53]	XS [57]	0.5	4 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Same as interaction 189 conclusion	No	No	no	No cast iron valves or fitting			No	
191	2	715	E	15	12-2CD-10 [40]	40S	12	0.375	113.1	1.13	14-ZX-161 [53]	XS [57]	0.5	4 ft	CL supply to ZX chillers	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Included	Steam jet could impact pipe 14-ZX-161	No	No	no	No cast iron valves or fitting			No	
192	2	715	E	15	2 1/2-2HD-83 [46]	80	2.323	0.276	4	0.16	14-ZX-161 [53]	XS [57]	0.5	2 ft	CL supply to ZX chillers. HD line is from 2B MSR to 25B FW heater.	Excluded *(assumption 6.2.1)*	-	equal or larger impacted pipe size and schedule	Excluded	-	No	No	no	No cast iron valves or fitting			No	
193	2	715	F	10	30-2MS-3 [42]	1.045"	27.91	1.045	612	7.29	10-2FP-2 [50]	40	0.365	2 ft	MS line near 10" FP header at G wall.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains cast iron valve	Cast	include		
202	2	715	F	10, 11	16-2FW-3 [39]	100	13.938	1.031	152.6	3.59	10-2FP-2 [50]	40	0.365	8 ft	FW line near 10" FP header at G wall.	Excluded	-	Excluded due to combined stress analysis (Reference 27)	Excluded	Excluded due to combined stress analysis (Reference 27)	no	no	no	Contains cast iron valve	Cast	Include		
194	2	715	F	11	22-2FW-8 [39]	100	19.25	1.375	291	6.62	10-2FP-2 [50]	40	0.365	3 ft	FW line near 10" FP header at G wall.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains cast iron valve	Cast	include		
195	2	715	F	11	30-2MS-4 [42]	1.045"	27.91	1.045	612	7.29	10-2FP-2 [50]	40	0.365	2 ft	MS line near 10" FP header at G wall.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains cast iron valve	Cast	include		
196	2	715	F	12	16-2CD-10 [40]	30	15.25	0.375	182.7	1.43	10-2FP-2 [50]	40	0.365	6 ft	10" FP header. High energy line is the supply to 21 FWP pump.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-2FP-2	No	No	no	Contains cast iron valve	Cast	include		
197	2	715	F	12	16-2FW-1 [39]	100	13.938	1.031	152.6	3.59	10-2FP-2 [50]	40	0.365	5 ft		Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Excluded	-	No	No	no	Contains cast iron valve	Cast	Include		
198	2	715	F	13	16-2CD-10 [40]	30	15.25	0.375	182.7	1.43	10-2FP-2 [50]	40	0.365	7 ft	10" FP header. High energy line is the supply to 21 FWP pump.	Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-2FP-2	No	No	no	Contains cast iron valve	Cast	exclude		
199	2	715	F	13	20-2CD-10 [40]	20	19.25	0.375	291	1.80	10-2FP-2 [50]	40	0.365	7 ft		Excluded	-	inspection of the high energy line configuration shows the pipe will not whip towards the FP line	Included	Steam jet could impact pipe 10-2FP-2	No	No	no	Contains cast iron valve	Cast	exclude		
200	2	735	F	11	30-2MS-3 [42]	1.045"	27.91	1.045	612	7.29	10-2FP-2 [50]	40	0.365	16"	Both 21 & 22 MS lines are near the 10" FP header which goes into the Aux Bldg at this level. Main FW line is also about 10' from the FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains cast iron valve	Cast	include		
201	2	735	F	11	30-2MS-4 [42]	1.045"	27.91	1.045	612	7.29	10-2FP-2 [50]	40	0.365	16"	Both 21 & 22 MS lines are near the 10" FP header which goes into the Aux Bldg at this level. Main FW line is also about 10' from the FP header.	Excluded *(design input 4.2)*	-	No design basis break	Excluded	No design basis break.	No	No	no	Contains cast iron valve	Cast	include		