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JOHN S. KEMPER
VICE-PRESIDENT
ENGINEERING AND RESEARCH

March 19, 1985

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Limerick Generating Station
High Energy Line Break Analysis

Reference: Letter from A. Schwencer, NRC, to E. G. Bauer, Jr., PECo, dated February 26, 1985

Files: GOVT 1-1 (NRC)
QUAL 12 (Design Review)

Dear Mr. Schwencer:

The reference letter requested additional information regarding the analysis of jet impact loads resulting from postulated high energy line breaks. The requested information, as well as responses to the concerns raised by NRC staff during a meeting on March 5, 1985, are contained in the attached report.

This report which basically confirms the responses given in the March 5, 1985 meeting, reflects the results of our completed efforts and confirms the adequacy of the current plant design. The results of this work are currently being incorporated into the appropriate project documentation.

We believe that this response is sufficient to allow closure of this item. However, should you have any questions please do not hesitate to contact us.

Sincerely,

John S. Kemper

8503210345 850319
PDR ADOCK 05000352
P PDR

GJB/pd03128507

See Attached Service List

B021
1/1

COMMONWEALTH OF PENNSYLVANIA :

ss.

COUNTY OF PHILADELPHIA

J. S. Kemper being first duly sworn, deposes and says:

That he is Vice President, Engineering and Research of Philadelphia Electric Company, the Applicant herein; that he has reviewed the foregoing information regarding high energy line break analysis for Limerick Generating Station and knowns the contents thereof; and that the statements and matters set forth therein are true and correct to the best of his knowledge, information and belief.

J. S. Kemper

Vice President

Subscribed and sworn to

before me this 19th day

of March , 1985

Patricia D. Scholl

Notary Public

PATRICIA D. SCHOLL
Notary Public, Philadelphia, Philadelphia Co.
My Commission Expires February 10, 1986

GJB/pd03128508

cc:	Judge Helen F. Hoyt	(w/enclosure)
	Judge Jerry Harbour	(w/enclosure)
	Judge Richard F. Cole	(w/enclosure)
	Troy B. Conner, Jr., Esq.	(w/enclosure)
	Ann P. Hodgdon, Esq.	(w/enclosure)
	Mr. Frank R. Romano	(w/enclosure)
	Mr. Robert L. Anthony	(w/enclosure)
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	Jay M. Gutierrez, Esq.	(w/enclosure)
	Atomic Safety & Licensing Appeal Board	(w/enclosure)
	Atomic Safety & Licensing Board Panel	(w/enclosure)
	Docket & Service Section	(w/enclosure)
	Mr. James Wiggins	(w/enclosure)
	Mr. Timothy R. S. Campbell	(w/enclosure)

March 15, 1985

JET IMPINGEMENT ANALYSIS
OF LARGE PIPE

I. SUMMARY

The Limerick project pipe rupture analysis program required that jet impingement loads resulting from high energy line breaks be considered on all piping with diameter less than the ruptured pipe. An exclusion was made for jet impingement loads on piping equal to or greater than the ruptured pipe diameter and wall thickness on the basis that this grouping was excluded from pipe whip consideration for equal or heavier wall thicknesses and that jet impingement loads can be shown to be less than pipe whip loads. The Limerick project position is discussed in IDVP potential finding PFR 019.

Because of the differences in the nature of the loads from a whipping pipe and jet flow, the NRC does not concur with this position. The NRC requested Limerick to assess the effects of jet impingement loads on piping and supports required for safe shutdown where the piping diameter is equal to or greater than the diameter of the ruptured pipe (Ref. 1).

In response to this request we have reviewed all break locations and identified all potential jet impingement target piping with a diameter equal to or greater than the ruptured pipe that could see jet impingement loads. Jet impingement of safety related equipment was not part of this study, but was performed in the previous Limerick high energy line break analysis.

Our review has shown that the previously excluded piping meets the established project criteria (allowable stress and safe shutdown analysis requirements) for jet impingement loads on piping and pipe supports.

II. DESCRIPTION OF REVIEW

A review of all previously postulated break locations was performed for both inside and outside Containment. The break locations postulated are given in FSAR Section 3.6 (Ref. 2). A complete review using piping layout drawings was performed for identification of target pipes. 320 piping breaks were reviewed.

1. All potential piping targets with diameter equal to or greater than the ruptured pipe were identified. Potential target piping was identified within a distance of 10 pipe diameters from the ruptured pipe. The diameters were that of the ruptured pipe.

A "cut off" distance of 10 pipe diameters was used for this study since at greater distance the jet impingement cone pressure on piping of equal to or greater than the diameter of the ruptured pipe has been shown to be insignificant. This is true because there is little or no subcooling in the ruptured pipe relative to exit plane ambient conditons. The lack of subcooling results in some cone expansion in all the Limerick high energy break locations.

In order to expedite the target identification process, a conservative jet cone of 45 degree half angle was initially assumed until calculated jet cone half angles were available. Since 45 degrees is the largest calculated jet cone size for a ruptured pipe on Limerick, using this cone size assured that all potential target pipe was identified.

Initially 360 potential targets were identified. The number of targets was reduced by reviewing in detail the more realistic geometry and calculated cone expansion angle using the actual thermodynamic condition in the ruptured pipe and the methodology of BN-TOP-2, Rev. 2, previously approved by the NRC (Ref. 3).

2. A safe shutdown analysis was performed for each identified potential target. This safe shutdown analysis is consistent with previous work at Limerick. The methodology followed for this analysis is set forth in Limerick Specification 8031-G-23.

   This analysis and subsequent detailed review of the geometry showed that of the 360 potential targets identified in Step 1, only 24 targets were identified as piping that would be required to remain functional to assure safe shutdown. (These lines are listed in Table I).

3. Of the 24 lines required for safe shutdown, there were 12 symmetrical cases. Symmetrical cases were piping with the same configuration (or minor variation) with similar support configuration such that the postulated jet load would result in similar pipe stress. Out of the remaining 12 targets, 8 cases which would envelope the loads for all 24 targets were selected for stress analysis. (These cases are shown in Table II). The 8 cases were chosen to have the most severe jet impingement loading based upon closest distance to the ruptured pipe, the most severe jet impingement cone angle, and the worst support configuration for pipe loading from jet impingement.

Jet impingement loading on the target pipe was then calculated using the same methodology as previously used in Limerick analyses (FSAR Section 3.6, references 3.6-8 and 3.6-9).

4. The loading combination used for the piping stress for the effects of jet impingement was:

$$P+DW+JI \leq 1.5 \ S_y \text{ (Ref. 4)}$$

where

P = the longitudinal pressure stress

DW = the bending stress due to the static weight of the piping, including insulation and contents, concentrated masses, etc.

JI = the bending stress due to the jet impingement loading

S_y = the yield strength of the material at normal operating temperature

<u>Pipe Stress Margin</u>

All the piping analyzed met the above criteria.

Table II shows the calculated stress for each of the eight cases analyzed.

There were no new loads generated on active components as a result of this analysis.

5. Loading of pipe supports from piping impinged by the jet was evaluated using subsection NF of the ASME code. The combination used was:

$$T+DW+JI \leq \text{ max. allowable stress}$$

where

T = the stress in the support resulting from the constraint of free thermal expansion of the piping.

DW = the stress in the support resulting from the static (dead) weight of the piping

JI = the stress in the support resulting from the jet impingement loading on the piping.

Stress Allowable

The maximum allowable stress used was 29,400 PSI which is the lesser of Sy and 0.42 S_u. In addition, axial stress is limited to 2/3 critical buckling and shear stress is limited to 0.42 S_u. The faulted load from the load capacity data sheet (LCD) was used for all standard supports.

Pipe Support Stress Margin

Based upon the load combination and stress allowable outlined above, the average stress was found to be 10% of the allowable stress. The largest actual stress 20% of the allowable stress.

III. DISCUSSION OF COMBINATION OF SSE WITH JET IMPINGEMENT

Inclusion of jet impingement loads in the faulted loading combination is not a licensing commitment basis for Limerick. However, pursuant to the NRC staff request, the result of including jet impingement loading with other loads of the faulted loading combination is discussed.

Based upon the stress margin indicated by Table II and the section on pipe supports, II.5 above, it is apparent that margin exists in both the pipe and the supports for stresses due to SSE. We feel confident that the piping and supports could be demonstrated to be acceptable for a postulated combination of jet impingement plus SSE based on the following reasons:

1. Piping stresses are calculated for code compliance using the worst faulted load combination per FSAR, i.e. DW+P+Max ($\sqrt{SSE^2+DBA^2}$ or $\sqrt{SSE^2y+AP^2}$) $\leq 3\ S_m$ ($\approx$ 2 Sy). In surveying the results of these calculations, we have found that SSE stresses do not contribute significantly in the total calculated piping stresses. For the systems listed in Table II, the maximum calculated SSE stresses only account for about 20% of 1.5 Sy.

2. The worst faulted load combination used for piping supports per the FSAR is W+T+Max ($\sqrt{SSE^2+DBA^2}$ or $\sqrt{SSE^2+AP^2}$). This is calculated and compared with 0.9 Sy. Because of the conservatism in this design, there is sufficient support capacity to allow combining SSE with jet impingement loads.

3. Also, SSE stresses may be reduced if higher damping is used (1% damping is used as the design basis).

4. It should be recognized that of the cases analyzed the worst case jet impingement loadings on piping required for safe shutdown are on stainless steels. The ASME Code specifies relatively low yield strength for stainless steel at operating temperature, but their tensile strengths are substantially higher.

IV. CONCLUSION

A review was performed of all target piping of equal or greater diameter than the source pipe. An assessment of safe shutdown capability was made for all target piping. For those pipes which were required for safe shutdown, the analysis showed the previously established stress criteria was met. There were no hardware changes identified as a result of this review.

REFERENCES

(1) NRC Letter of February 26, 1985 from A. Schwencer to E.G. Bauer.

(2) Limerick FSAR, Section 3.6.

(3) BN-TOP-2, Rev. 2, approved by NRC letter dated 6-17-74.

(4) "Functional Capability Criteria for Mark II Piping" by E. C. Rodabaugh, Sept. 1978

TABLE I

TARGET LINES REQ'D FOR SAFE SHUTDOWN

Case No. (See Table II)	System	Break No.	Source Pipe	Target Pipe
	Recirc:			
1	Loop A	TE-296C	12"	12" DLA-112
3				12" DLA-112
	Loop B	TE-296C	12"	12" DLA-112
				12" DLA-112
	Core Spray:			
	Loop A	IB-65L	12" DCA-320 on 12" DCA-318 LPCI "C"	
5	Loop A	IB-63L	12" DCA-320 on 12" DCA-318 LPCI "C"	
4	Loop A	IB-30L	12" DCA-320 on 12" DCA-318 LPCI "C"	
	Loop B	IB-65L	12" DCA-319 on 12" DCA-318 LPCI "B"	
	Loop B	IB-63L	12" DCA-319 on 12" DCA-318 LPCI "B"	
	Loop B	IB-30L	12" DCA-319 on 12" DCA-318 LPCI "B"	
	Feedwater:			
	Loop A	IB-100C (2 target)	12" DLA-107 on 12" DLA-112 LPCI "B" 12" DLA-107 on 12" DLA-112 LPCI "D"	
		IB-100L	12" DLA-107 on 12" DLA-112 LPCI "D" 12" DLA-107 on 12" DLA-112 LPCI "B"	
	Loop B	IB-100C	12" DLA-108 on 12" DLA-112 LPCI "A" 12" DLA-108 on 12" DLA-112 LPCI "C"	
2		IB-100L	12" DLA-108 on 12" DLA-112 LPCI "A" 12" DLA-108 on 12" DLA-112 LPCI "C"	
	Residual Heat Removal:			
	LPCI Loop "B"	IB-100L	12"DCA-318 on 12" DCA-319 Core Spray "B"	
		IB-90L	12"DCA-318 on 12" DCA-319 Core Spray "B"	
		IB-67L	12"DCA-318 on 12" DCA-319 Core Spray "B"	
6	LPCI Loop "C"	IB-100L	12"DCA-318 on 12" DCA-320 Core Spray "A"	
7		IB-90L	12"DCA-318 on 12" DCA-320 Core Spray "A"	
8		IB-67L	12"DCA-318 on 12" DCA-320 Core Spray "A"	

TABLE II

LGS - JET IMPINGEMENT STUDY

PIPING STRESS SUMMARY FOR SAFE SHUTDOWN TARGET LINES

Case No.	Break ID	Calc. No.	Allowable 1.5 Sy (Psi)	P+DW+JI Max. Comp. Stress (Psi)	Percent Allow.
1	Recirc. TE296C	1-10-07	23175	9264	40%
2	Feedwater 100L	1-10-07	23175	18719	81%
3	Recirc. TE296C	1-10-08	23175	7201	31%
4	Core Spr. 30L	1-10-08	23175	15126	65%
5	Core Spr. 63L	1-10-08	23175	15386	66%
6	RHR LPCI "C" 100L	1-20-02	23175	15741	68%
7	RHR LPCI "C" 90L	1-20-02	23175	13967	60%
8	RHR LPCI "C" 67L	1-20-02	23175	13616	59%

NOTES: 1) P = Pressure Stress, DW = Weight Stress, JI = Jet Impingement Stress

2) Sy = 15450 psi at 550°F based on code allowable ASME-Section III- 1971