Duquesne Light

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September 19, 1984

U. S. Nuclear Regulatory Commission
Attn: Mr. Thomas T. Martin, Director
Division of Engineering and Technical Programs
Region 1
631 Park Avenue
King of Prussia, PA 19406

Reference: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Inspection Report 83-21

Gentlemen:

The referenced Inspection was conducted at our facility to determine the completeness of our actions taken in response to IE Bulletins 79-02 and 79-14. Two unresolved items remained open at that time pending NRC review of additional documentation.

Attached for your review is the additional information which was requested. Attachment I provides a summary of the bases for selecting anchor bolt stiffness values (83-21-01). Attachment II addresses the use of representative pipe support stiffness values versus the actual pipe support stiffness values (83-21-02).

We believe that these attachments fulfill the requirements for the unresolved items of Inspection Report 83-21.

Very truly yours,

J. J. Carey
Vice President, Nuclear

Attachments

IE01

cc: Mr. W. M. Troskoski, Resident Inspector
U. S. Nuclear Regulatory Commission
Beaver Valley Power Station
Shippingport, PA 15077

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ATTACHMENT I

SUMMARY
FLEXIBLE PLATE ANALYSIS DRILLED-IN ANCHOR STIFFNESS
IE BULLETIN 79-02

The discussion that follows summarizes the bases for the anchor bolt stiffness used in the structural analysis of base plates required to satisfy the requirements of IE Bulletin 79-02.

Anchor bolt stiffness used by Stone and Webster Engineering Corporation (SWEC) in the evaluation of flexible plates with drilled-in anchors is based on a review of actual bolt tension test data. Tension test data of drilled-in anchors was obtained from manufacturers of wedge and shell type anchors. This test data included bolt sizes from 1/2 inch diameter to 1-1/4 diameter, concrete strengths from 2000 psi to 6000 psi and variation in embedment length of anchors.

Review of the test data indicates a non-linear load deflection behavior of the anchors. The appropriate stiffness to use, the secant stiffness, was then calculated for the bolts over several load ranges.

For the purpose of design evaluation a single value of bolt stiffness, 250,000 lb/in was selected. This value is larger than approximately 90% of the secant stiffnesses of all test samples in the range from 10% to 30% of the ultimate bolt capacity. This range encompasses the design allowable loads for all sizes of both self-drilling and wedge type expansion anchors. Use of a larger than actual stiffness overestimates the prying action and therefore, represents a conservative value of bolt stiffness for the entire range of the bolt sizes since it was selected to envelope, with the exception of the expected scatter in test data, the secant stiffness of all bolt sizes, embedment lengths and concrete strengths of interest.

Attached are Anchor Bolt Stiffness Summary Tables I, II, and III. These tables provide additional information on which the 250,000 lb/in anchor stiffness is based.

	ANCHOR TYPE	PHILLIPS SELF-DRILL (1)		PHILLIPS WEDGE (2)	HILTI KWIK-BOLTS (3 & 4)		
	CONCRETE STRENGTH f'_c (PSI)	2000	4000	>4000	<3500	≥3500 ≤5500	>5500
PERCENT OF ANCHORS TESTED WITH STIFFNESS <250 K/IN	$.10\ P_{ult} \leq P \leq .30\ P_{ult}$	81	50	100	89	77	86
	$.30\ P_{ult} < P \leq .40\ P_{ult}$	100	100	100	100	–	90
	$.40\ P_{ult} < P \leq .60\ P_{ult}$	100	91	–	100	100	95

NOTES:

1. ITT PHILLIPS TEST DATA SELF DRILLED ANCHORS, PHILLIPS LETTER TO D. KEENAN SWEC DATED APRIL 16, 1979.
2. ITT PHILLIPS TEST DATA WEDGE TYPE, TEST DATA SHOREHAM SITE, PHILLIPS LETTER TO J. EARLE AND A. RAPHAEL OCT. 25, 1977.
3. HILTI KWIK-BOLTS TEST DATA, ABBOT A. HANKS REPORT NO. 8785, JAN. 30,1974.
4. HILTI KWIK-BOLTS SHEAR & TENSION TEST DATA, ABBOT A. HANKS REPORT NO. 9059, APRIL 15,1974.

DEFINITIONS:

P = LOAD ON BOLT AT WHICH STIFFNESS WAS MEASURED.

P_{ult} = ULTIMATE BOLT CAPACITY FROM TEST DATA

TABLE I

ANCHOR BOLT STIFFNESS SUMMARY
1/2" - 1 1/4" DIAMETER BOLTS
AT DIFFERENT STRESS LEVELS

STONE & WEBSTER ENGINEERING CORPORATION

ANCBOLTAB1

ANCHOR TYPE	PHILLIPS SELF-DRILL (1)		PHILLIPS WEDGE (2)	HILTI KWIK-BOLTS (3 & 4)		
CONCRETE STRENGTH f'_c (PSI)	2000	4000	>4000	<3500	≥3500 ≤5500	>5500
$.10\ P_{ult} \le P \le .30\ P_{ult}$	102.3* / ** 159.8	191.2* / ** 306.1	78.1* / ** 78.1	68.5* / ** 136.9	119.2* / ** 191.7	127.4* / ** 168.3
$.30\ P_{ult} < P \le .40\ P_{ult}$	73.0* / ** 73.0	141.1* / ** 141.1	131.7* / ** 131.7	104.5* / ** 104.5	–	119.9* / ** 141.4
$.40\ P_{ult} < P \le .60\ P_{ult}$	65.5* / ** 65.5	124.4* / ** 138.8	–	29.6* / ** 29.6	51.1* / ** 51.1	101.2* / ** 109.5

AVERAGE STIFFNESS* FOR TESTS WITH STIFFNESS <250 K/IN

** AVERAGE STIFFNESS FOR ALL TESTS IN K/IN

NOTES:

1. ITT PHILLIPS TEST DATA SELF DRILLED ANCHORS, PHILLIPS LETTER TO D. KEENAN SWEC DATED APRIL 16, 1979.
2. ITT PHILLIPS TEST DATA WEDGE TYPE, TEST DATA SHOREHAM SITE, PHILLIPS LETTER TO J. EARLE AND A. RAPHAEL OCT. 25, 1977.
3. HILTI KWIK-BOLTS TEST DATA, ABBOT A. HANKS REPORT NO. 8785, JAN. 30,1974.
4. HILTI KWIK-BOLTS SHEAR & TENSION TEST DATA, ABBOT A. HANKS REPORT NO. 9059, APRIL 15,1974.

DEFINITIONS:

P = LOAD ON BOLT AT WHICH STIFFNESS WAS MEASURED.

P_{ult} = ULTIMATE BOLT CAPACITY FROM TEST DATA

TABLE II

ANCHOR BOLT STIFFNESS SUMMARY 1/2" - 1 1/4" DIAMETER BOLTS AT DIFFERENT STRESS LEVELS

STONE & WEBSTER ENGINEERING CORPORATION

ANCBOLTAB2

ANCHOR TYPE	HILTI KWIK-BOLTS 1" DIAMETER (3 & 4)			HILTI KWIK-BOLTS 1 1/4" DIAMETER (3 & 4)		
CONCRETE STRENGTH f'_c (PSI)	<3500	≥3500 ≤5500	>5500	<3500	≥3500 ≤5500	>5500
AVERAGE STIFFNESS* FOR TESTS WITH STIFFNESS <250 K/IN / ** AVERAGE STIFFNESS FOR ALL TESTS IN K/IN						
.10 $P_{ult} \le P \le .30\ P_{ult}$	165.0* / 165.0**	187.0* / 187.0**	72.3* / 264.9**	54.6* / 54.6**	63.5* / 63.5**	142.5* / 203.3**
.30 $P_{ult} < P \le .40\ P_{ult}$	128.6* / 128.6**	–	–	–	–	–
.40 $P_{ult} < P \le .60\ P_{ult}$	47.1* / 47.1**	46.8* / 46.8**	38.0* / 38.0**	26.3* / 26.3**	35.8* / 35.8**	72.6* / 72.6**
.60 $P_{ult} < P \le .90\ P_{ult}$	–	–	–	–	–	–
.90 $P_{ult} < P \le P_{ult}$	23.6* / 23.6**	36.6* / 36.6**	35.8* / 35.8**	26.4* / 26.4**	41.1* / 41.1**	51.7* / 51.7**

NOTES:

1. ITT PHILLIPS TEST DATA SELF DRILLED ANCHORS, PHILLIPS LETTER TO D. KEENAN SWEC DATED APRIL 16, 1979.
2. ITT PHILLIPS TEST DATA WEDGE TYPE, TEST DATA SHOREHAM SITE, PHILLIPS LETTER TO J. EARLE AND A. RAPHAEL OCT. 25, 1977.
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4. HILTI KWIK-BOLTS SHEAR & TENSION TEST DATA, ABBOT A. HANKS REPORT NO. 9059, APRIL 15,1974.

DEFINITIONS:

P = LOAD ON BOLT AT WHICH STIFFNESS WAS MEASURED.

P_{ult} = ULTIMATE BOLT CAPACITY FROM TEST DATA

TABLE III

ANCHOR BOLT STIFFNESS SUMMARY 1" – 1 1/4" DIAMETER BOLTS AT DIFFERENT STRESS LEVELS

STONE & WEBSTER ENGINEERING CORPORATION

ATTACHMENT II

USE OF REPRESENTATIVE PIPE SUPPORT STIFFNESS VALUES IN COMPUTER BASED PIPING ANALYSIS Required by IEB 79-14

Duquesne Light Company was requested in a letter (Mr. T. T. Martin of Region I to Mr. J. J. Carey dated December 2, 1983) to determine the structural stiffness of 11 supports. The stiffness values determined were to be compared to the values used in the piping analysis.

The stiffness values calculated for the subject supports are shown in Tables I and II. The values shown are not exact as is indicated in the note on the tables. Exclusion of the effects described in the note was agreed to by Mr. J. Durr in a Telecon on November 7 with Mr. W. Falk of DLCo.

We feel that the use of representative stiffness values for the modeling of pipe supports in the piping analysis of Unit I is more than adequate and is in accordance with the calculational techniques that were reviewed in Boston by NRC representatives in 1979.

The instructions as delineated in the 79-14 Bulletin specifically stated that the effect of as-built conditions is to be evaluated with respect to the analysis requirements "as described in the FSAR or other NRC approved Documents".

The NRC was at that time reviewing the pipe and support analysis methods used to satisfy the requirements of the IEB 79-07 (show-cause order). The analytical requirements agreed to for IEB 79-07 were used in addressing the IEB 79-14 concerns as required by that bulletin.

A discussion concerning support stiffness was included in the July 11, 1979 submittal concerning IEB 79-07. This is the only licensing document that affects this issue. The pertinent section of this submittal is shown in Enclosure 1. As is delineated in this document, the use of infinite stiffness was one of the acceptable methods for handling support stiffness along with the use of representative values.

During the IEB 79-07 effort, the methods used to establish the adequacy of the safety related piping were re-evaluated and accepted by the NRC. If it was felt that accurate modeling of support stiffness was significant with respect to safety, it would have been addressed during the Question and Answer phase of the bulletin, especially since all the supports had detailed construction drawings on file at that time.

The methods of analysis used in addressing the 79-07 Bulletin were used without modification in satisfying the requirements of the IEB 79-14 because they constitute the definition of safety with respect to piping for Unit I.

Based on the above, we feel that since calculated support stiffness reviews were not established as an analytical requirement during the 79-07 effort, it was not necessary to re-evaluate this characteristic to satisfy IE Bulletin 79-14. The position that the as-built conditions were to be reviewed with respect to previously defined non-seismic plants stated in Revision 1 of the

79-14 Bulletin dated July 18, 1979. "For older plants, where Seismic Category I requirements did not exist at the time of licensing, it must be shown that the actual configuration of these safety-related systems, utilizing 2 1/2" diameter piping and greater, meets design requirements."

Technically, we agree that the various parameters determined in a computer based analysis could possibly be affected by a change in the support stiffness used in the analysis. A review of the estimated stiffness values in Tables I and II shows that the stiffness used in the piping analysis is probably higher than the actual stiffness. The probable effects of this trend on the analysis would affect primarily the seismic and thermal aspects. The thermal support loads and stresses would probably be reduced with the use of more accurate support stiffness. The modal frequencies estimated for seismic analysis would tend to shift downward to lower frequencies. If the modes that contribute significantly to a particular parameter are close to a peak in the ARS, the estimated quantity could be increased. Alternately, if the frequency of the significant mode was initially within the peak area, the results could decrease due to a reduction of the earthquake input. The thermal and seismic effects oppose each other with respect to support loads because these loads are combined directly to determine the design load of the support, thus minimizing the overall result. The most significant effect will involve the piping primary stress check. If the supports involving the area of maximum seismic response have significantly reduced stiffness, and if the frequency of the modes involved are close to an area in the ARS where a reduction in frequency constitutes an increase in the exciting acceleration, then the estimated response would increase. If this occurred in conjunction with the situation where the stress estimated previously was close to the allowable, then the code allowable might be exceeded. Considering the probability of all of these specific conditions being coincident, the overall probability of exceeding the allowable stress is remote.

The code design allowables are selected to encompass many variables. These include material manufacturing, construction NDT practies, design methods, maintenance procedures and uncertainties. We feel support stiffness effects are one of the uncertainties that the safety margins in the code address.

Another issue that should be considered is the inability to estimate accurate stiffness numbers. Significant uncertainties exist in estimating support stiffness due to thermal clearances between the pipe and support, coupling effects (off diagonal terms in a 6 x 6 stiffness matrix), bolt stiffness variations (See Attachment I), base plate flexibility, etc. These uncertainties render it almost impossible to develop an accurate flexibility value. Due to problems like this, it is more effective to design into the analysis and construction practice conservatisms that cover these uncertainties, and others. The writers of the subject codes have done just that.

It can be concluded that use of the analysis methods of Unit I result in an approximation of the actual stress. When the Unit I analysis methods, code allowables and construction requirements are considered in conjunction, what results are piping systems which are inherently conservative.

In conclusion, we believe that the Unit No. 1 piping systems have been designed, constructed, analyzed and verified in a manner that assures that the allowable stresses of ANSI B.31.1 will not be exceeded during a seismic event of intensity equal to or less than the SSE and OBE values for our site.

TABLE I

Isometric Drawing Number	Support Number	Restraint Type	Frame Stiffness In #	Type of Stiffness Analysis	Piping Analysis Modeling Stiffness In #
83	VS-13	V	$9.5x10^6$	Man	1×10^6
83	VS-14	V	$9.5x10^6$	Man	1×10^6
83	$R-17_B$	L(2)	$3.3x10^5$ $2.4x10^5$(2)	Com	1×10^6 1×10^6
83	R-5	L	$1.5x10^5$	Com	1×10^6

NOTES:

1) Definitions

V = Vertical   1 = Direction 1
L = Lateral   2 = Direction 2 or two directions applicable
T = Tranlation   Man = Manual
M = Moment   Com = Computer

2) The frame stiffness values shown are estimates only. They were developed by use of manual analysis or deduced from computer output from the STRUDL analysis of the support. Effects due to bolt stiffness, coupling (off diagonal terms in a 6x6 stiffness matrix) thermal clearances, pipe wall effects and base plate flexibility were not accounted for.

TABLE II

Isometric Drawing Number	Support Number	Restraint Type	Frame Stiffness In. # or In. #/DEG	Type of Stiffness Analysis	Piping Analysis Modeling Stiffness In. # or In. #/DEG
54	R-91	V+L	$2.0x10^5$ (V) $2.0x10^6$ (L)	Man	1×10^6 1×10^6
54	R-232	V+L	$1.8x10^5$ (V) $2.4x10^5$ (L)	Com	1×10^6 1×10^6
54	R-42	V+L	$5.5x10^4$ (V) $6.0x10^4$ (L)	Com	1×10^6 1×10^6
54	R-43	V+L	$1.1x10^5$ (V) $3.1x10^5$ (L)	Com	1×10^6 1×10^6
54	A-54	A	$3.0x10^5$ (T) $5.7x10^5$ (M)	Man	1×10^6 3.49×10^6
54	R-55	V	$8.8x10^5$	Com	1×10^6

NOTES: See Notes on Table I.

ENCLOSURE I to
ATTACHMENT II

BEAVER VALLEY POWER STATION, UNIT 1

REPORT ON THE REANALYSIS OF SAFETY-RELATED PIPING SYSTEMS

FOR

BEAVER VALLEY UNIT 1
DUQUESNE LIGHT COMPANY

ORIGINAL - JUNE 15, 1979

REVISION 1 - JULY 11, 1979

Stone & Webster Engineering Corporation
Boston, Massachusetts

Current rules allow two significant departures from the original techniques utilized on Beaver Valley Unit 1.

A. An option is provided for Upset Conditions whereby the anchor displacement effect can be considered in equation 9 along with deadweight, pressure, and seismic inertia effects or they may be combined with thermal expansion effects and evaluated under equation 10.

B. For Emergency and Faulted Conditions, the codes require evaluation of only the primary portion (inertia effect) of the seismic loadings and do not require that the anchor displacement effect be considered, since it is secondary in nature. Also allowed is a Faulted Stress allowable of 2.4 S_h, which was not stated in the Beaver Valley Unit 1 licensing documents; the equivalent value utilized was 1.8 S_h.

2. State how support stiffness is being accounted for in the current reanalysis effort and whether anything different from the original analysis is being done in this respect.

Response

Reanalysis efforts are utilizing two programs, SHOCK3 and NUPIPE. If SHOCK3 is utilized, supports and restraints are modeled in the manner of SHOCK2 as rigid members, essentially allowing zero deflection in each restrained direction. When NUPIPE is utilized, representative spring stiffnesses are input in each restrained direction.

Consistent support stiffnesses are used for each problem.

3. Provide the acceptance criteria used in the design of the pipe supports, including weld and bolt sizing criteria, and indicate any deviations from criteria originally used (except criteria established in addressing I&E Bulletin 79-02). Also, state your intention to comply, prior to facility startup, with I&E Bulletin 79-02 for all cases where loading on a pipe support increases as a result of the piping reanalysis and the support reevaluation indicates that any part of the support is not within the applicable acceptance criteria.