Exelon Generation.

200 Exelon Way
Kennett Square, PA 19348

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10 CFR 50.55a

January 4, 2019

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Limerick Generating Station, Units 1 and 2
Renewed Facility Operating License Nos. NPF-39 and NPF-85
NRC Docket Nos. 50-352 and 50-353

Subject: Relief Request I4R-18 Associated with Inaccessible Emergency Service Water and Residual Heat Removal Service Water Pump Supports

References:
1) Letter from J. Barstow (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Relief Request I4R-18 Associated within accessible Emergency Service Water and Residual Heat Removal Service Water Pump Supports," dated June 11, 2018

2) Email from V. Sreenivas (U.S. Nuclear Regulatory Commission) to T. Loomis (Exelon Generation Company, LLC), "Limerick: Request for Additional Information Relief Request (RAI) for I4R-18 Associated with Inaccessible Supports for the Fourth 10-Year Inservice Inspection Interval," dated November 27, 2018

In the Reference 1 letter, Exelon Generation Company, LLC submitted for your review a relief request associated with the Inservice Inspection (ISI) Program for Limerick Generating Station (LGS), Units 1 and 2. Specifically, this relief request is associated with inaccessible Emergency Service Water (ESW) and Residual Heat Removal Service Water (RHRSW) pump supports. In the Reference 2 email, the U.S. Nuclear Regulatory Commission Staff requested additional information. Attached is our response.

There are no regulatory commitments in this letter.

If you have any questions concerning this letter, please contact Tom Loomis at (610) 765-5510.

Respectfully,

James Barstow
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Response to Request for Additional Information for Relief Request I4R-18

cc: USNRC Region I, Regional Administrator
USNRC Senior Resident Inspector, LGS
USNRC Project Manager, LGS
R. R. Janati, Pennsylvania Bureau of Radiation Protection

Attachment

Response to Request for Additional Information for Relief Request I4R-18

RAI-1:

Please provide drawings which show the design/construction of the identified Emergency Service Water (ESW) and Residual Heat Removal Service Water (RHRSW) Pump upper and lower supports which includes materials of construction.

Response to RAI-1:

Enclosure 1 is the material parts list for the original RHRSW pumps which includes the seismic restraints. Enclosure 2 is the material parts list for the original ESW pumps which include the seismic restraints. Both parts lists identify that the seismic restraints are made from ASTM A-516 Gr. 70 material with ASTM A-193 Gr. B7 bolting. Enclosure 3 and Enclosure 4 are the design drawings of the RHRSW pump and ESW pump seismic restraints, respectively.

RAI-2:

If the drawings requested in RAI #1 do not describe the normal loads (if any) and seismic loads experienced by the identified supports, please provide a document or a discussion which describes these loads.

Response to RAI-2:

Enclosure 5 and Enclosure 6 are the RHRSW pump and ESW pump stress calculations for the seismic restraints and anchor bolting, respectively. These stress calculations include a discussion on the seismic loads and handling loads that were evaluated for the restraints.

RAI-3:

The June 11, 2018 submittal describes a calculation which shows there is a minimum safety factor of 25 based on the operating basis earthquake (OBE). Is this true of all the identified supports? Please provide a more detailed description or excerpts from the calculation supporting the safety factor of 25 for each of the identified supports.

Response to RAI-3:

Excerpts of the stress calculations have been provided in Enclosure 5 and Enclosure 6 for the RHRSW pump and ESW pump seismic restraints, respectively. The excerpts identify the calculated anchor bolt stresses and the allowable values which were used to determine the available margin or safety factor for the supports. For both the RHRSW and ESW seismic restraints, the safety factor is greater than 25 for the seismic design loads.

RAI-4:

Please discuss any protective coatings applied to these supports or other measures taken to protect the identified supports from the conditions present in their operating environment.

Response to RAI-4:

Several drawings and documents were reviewed, but no requirement or other evidence could be found that suggests any protective coatings were applied to the seismic restraints. If protective coatings were applied during initial construction, there has been no re-application of such coating to the seismic restraints.

RAI-5:

The June 11, 2018 submittal describes how 6 of the 8 pumps related to the identified supports have been replaced in the last 7 years. The submittal goes on to say that a VT-3 of the upper support of the pump was attempted and an assessment of the condition of the support was made to the best of your ability. Was this true for all 6 of the replaced pumps?

Response to RAI-5:

Yes. A VT-3 inspection of the upper support was attempted and an assessment of the condition of the support was made to the best of our ability for all pumps that were disassembled and replaced.

RAI-6:

Has LGS had any operating/maintenance experience with the identified supports which indicate a history of indications indicative of possible degradation?

Response to RAI-6:

No. Limerick Generating Station, Units 1 and 2 have not had any operating or maintenance experience that would indicate any issues with the upper or lower seismic restraint for the RHRSW or ESW pumps. During normal operation, there is a slight clearance that exists between the seismic restraints and the pump column; therefore, the seismic restraints do not touch the pump. No abnormal conditions were noted during pump disassembly that would be indicative of possible restraint degradation.

RAI-7:

Confirm that the proposed alternative would require a best effort visual examination of the upper support when any of the ESW or RHRSW pumps is disassembled and removed for maintenance.

Response to RAI-7:

As an alternative to performing a qualified VT-3 examination of the ESW and RHRSW pump seismic restraints, the station will perform a best effort visual examination of the upper seismic restraint each time the ESW or RHRSW pump is disassembled and removed for maintenance.

This examination will be performed remotely to look for evidence of structural deformation and missing, detached, or loosened support items.

RAI-8:

The June 11, 2018 submittal says a visual examination of the lower support was attempted in the past and does not discuss any future examinations of the lower seismic supports. Discuss why that is the case.

Response to RAI-8:

Future examinations of the lower seismic restraints were not proposed since this restraint is completely submerged underwater and water clarity is poor. The design of the lower seismic restraint is the same as the upper seismic restraint; however, the environmental conditions are different. The upper seismic restraint is located in the more limiting environment since it is exposed to continuous wet and dry cycles due to normal variations in Spray Pond water level.

RAI-9:

Provide an estimate of the amount of VT-3 visual examination coverage that will be obtained by the best effort examinations that will be performed on the upper support when the ESW or RHRSW pumps are disassembled and removed for maintenance.

Response to RAI-9:

A VT-3 examination is conducted to determine the general mechanical and structural condition of the components and their supports. In keeping with the intent of a VT-3 examination, the proposed best effort visual examination of the upper seismic restraint will look for evidence of structural deformation and missing, detached, or loosened support items. The best effort visual examination will be performed to the maximum extent practical within the limitations of design configuration and water quality at the time of exam.

RAI-10:

The June 11, 2018 submittal states a best effort visual examination of the upper support will be performed when the ESW or RHRSW pumps are disassembled and removed for maintenance. Please discuss the frequency of these activities in the future.

Response to RAI-10:

The D RHRSW pump was replaced the week of November 5, 2018. A VT-3 examination was attempted; however, a qualified VT-3 could not be performed due to poor water quality. A best effort visual examination of the upper seismic restraint was performed and no signs of structural deformation, missing or loose bolting, or material loss were observed.

The A ESW pump was replaced the week of December 17, 2018. A VT-3 examination was attempted; however, a qualified VT-3 could not be performed due to poor water quality. A best effort visual examination of the upper seismic restraint was performed and no signs of structural deformation, missing or loose bolting, or material loss were observed.

As of December 2018, all RHRSW and ESW pumps (4 each) have been replaced at Limerick Generating Station. The original RHRSW and ESW pumps were all in service for over 20 years prior to replacement. There are no planned activities to replace any of the RHRSW or ESW pumps. The need for any future pump replacements will be determined based on pump performance.

Enclosure 1

BYRON JACKSON PUMP DIVISION
BORG-WARNER CORPORATION
LOS ANGELES OPERATION

PROCEDURE NO. MC- 1105

LIMERICK GENERATING STATION
UNITS 1 & 2
PHILADELPHIA ELECTRIC CO.

MATERIAL OF CONSTRUCTION
TYPE 28KXL 2-STG. VCT
BECHTEL P.O. 8031-M-12, RHR SW PUMPS OAP-506, OBP-506, OCP-506, ODP-506
JOB NO. 741-S-1507/10

PREPARED BY [signature] DATE 4 Oct. 1977

ENGINEERING APPROVAL BY [signature] DATE 5 Oct 1977

QUALITY ASSURANCE APPROVAL BY [signature] DATE 5 Oct 1977

CERTIFIED
By [signature] Date June 78
Byron Jackson Pump Division
Borg-Warner Corporation

REVISIONS

REV.	DATE	BY	PARAGRAPH	CONTENT	APPROVALS ENG.	APPROVALS Q.A.
A	19 Dec. 77	LPK	Title Page Note	Added: Plant I.D. & Bechtel P.O. No. Category 2b and Category 2b & Category 3	[signature] 20 Dec 77	[signature] 12-27-77
B	14 Mar. 78	LPK	Item No. 2 Item No. 4 & 25	Was: ASTM A-276 TP 410 H.T. Was: ASTM A-276 TP 420 H.T. or ASTM A-296 GR. CA-40 H.T.	[signature] 14 Mar 78	[signature] 14 MAR 78
C	15 May 79	LPK	Item No. 50 & 51	Added: Bracket, Probe; Guard, Coupling	[signature] 15 [illegible]	[illegible]

PARTS LIST

ITEM NO	REF. NO.	CATEGORY	QTY	PART DESCRIPTION	MATERIAL
1	334	3	1	Spirolox Ring	AISI 302
2	678	3	7	Gib Key	ASTM A-582, Tp. 416 H.T.
3	104	2(b)	1	Suction Bell Bearing	ASTM B-271, Al. 932
4	217	2(b)	1	Shaft Sleeve	ASTM A-276, Tp. 410 H.T. or ASTM A-296, GR. CA-15 H.T.
5	086	1	1	Suction Bell	ASME SA-216, GR. WCB
6	244	3	1	Sand Cap	ASTM B-584, Al.932
7	039	2(b)	1	Impeller Liner	ASTM B-148, Al. 952
8	078	1	1	Series Case	ASME SA-216, GR. WCB
9	747	2(b)	2	"O" Ring	Nitrile
10	176	2(a)	2	Impeller	ASTM B-148, Al. 952
11	207	2(b)	2	Case Wear Ring	ASTM B-271, Al. 932
12	226	2(b)	2	Thrust Collar	ASTM A-296, CA-15 (Cent. Cast
13	256	2(b)	1	Split Ring	ASTM A-276, Tp. 410 H.T.
14	076	1	1	Top Case	ASME SA-216, GR. WCB
15	676	2(b)	2	Key	ASTM A-582, Tp. 416 H.T.
16	256-1	2(b)	1	Split Ring	ASTM A-276, Tp. 410 H.T.
17	422	1	1	Lower Column - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Tubing	ASTM A-519, GR. 1018 or ASTM A-519, GR. 1022
18	747-1	2(b)	4	"O" Ring	Nitrile
19	167	2(a)	1	Pump Shaft	ASTM A-276, Tp. 410 H.T.
20	256-2	2(b)	3	Split Ring	ASTM A-276, Tp. 410 H.T.
21	401	2(a)	3	Coupling	ASTM A-276, Tp. 410 H.T.
22	676-1	2(b)	6	Coupling Key	ASTM A-582, Tp. 416 H.T.
23	334-1	3	11	Spirolox Ring	AISI 302
24	167-1	2(a)	2	Shaft	ASTM A-276, Tp. 410 H.T.
25	217-1	2(b)	5	Shaft Sleeve	ASTM A-276, Tp. 410 H.T. or ASTM A-296, GR. CA-15 H.T.
26	397	2(b)	5	Bearing	ASTM B-271, Al. 932
27	420	1	1	Middle Column - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Tubing	ASTM A-519, GR. 1018 or ASTM A-519 GR. 1022
51	801	3	1	Guard, Coupling	ASTM A-36 or Equivalent

ITEM-NO.	REF. NO.	CATEGORY	QTY	PART DESCRIPTION	MATERIAL
28	420-1	1	1	Upper Column - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Tubing	ASTM A-519, GR. 1018 or ASTM A-519, GR. 1022
29	404	2(a)	1	Shaft	ASTM A-276, Tp. 410 H.T.
30	465	1	1	Discharge Head - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Forging	ASME SA-181, GR. II or ASME SA-105
31	747-2	2(b)	1	"O" Ring	Nitrile
32	747-3	2(b)	1	"O" Ring	Nitrile
33	233	2(b)	1	Throttle Bushing	ASTM B-271, Al. 932
34	217-2	2(b)	1	Shaft Sleeve	ASTM A-276, Tp. 420 H.T. or ASTM A-296, GR. CA-40 H.T.
35	050	3	1	Stuffing Box	ASME SA-216, GR. WCB
36	747-4	2(b)	1	"O" Ring	Nitrile
37	230	3	1	Throat Bushing	ASTM B-271, Al. 932
38	236	3	1	Cage Ring (OPTIONAL)	ASTM B-271, Al. 932
39	480	3	5	Packing Ring	John Crane
40	111	3	1	Gland	ASTM B-271, Al. 932
41	334-2	3	1	Spirolox Ring	AISI 302
42	676-2	2(b)	1	Key	ASTM A-582, Tp. 416 H.T.
43	529	2(a)	1	Drive Half Coupling	ASTM A-36 or AISI 1020-1045
44	256-3	2(b)	1	Split Ring	ASTM A-276, Tp. 410 H.T.
45	532	2(b)	1	Adjusting Plate	ASTM A-36 or AISI 1020-1045
46	530	2(a)	1	Pump Half Coupling	ASTM A-36 or AISI 1020-1045
47	676-3	2(b)	1	Key	ASTM A-582, Tp. 416 H.T.
48	816	3	1	Pipe (Bleed-off)	ASTM A-106 GR.B
49	814, 814-1, 531	3	3	Fittings-90° EL, 45° EL, Union	ASTM A-105
50	239	3	1	Bracket, Probe	ASTM A-36 or Equivalent

NOTE: All 410 H.T. Mat'l shall have minimum tempering temperature of 1100°F.

RESPONSE TO RAI 1 →

Category 1 fasteners are ASME SA-193 GR. B7 others are Category 2b and are ASTM A-193 GR. B7
Category 1 nuts are ASME SA-194 GR. 7 others are Category 2b and ASTM A-194 GR. 7
The sole plate and seismic restraints are ASTM A-516 GR. 70 and Category 3

CATEGORY DEFINITIONS:

Category 1............Pressure boundary parts and attachments
Category 2............Critical non-pressure boundary parts.
(a)............Parts that if failed would cause the pump's function to be significantly and abruptly impaired.
(b)............Parts that if failed would cause the pump's function to be impaired over a period of time and failure of which is remote.
Category 3............Non-critical, non-pressure boundary parts.

Enclosure 2

BYRON JACKSON PUMP DIVISION
BORG-WARNER CORPORATION
LOS ANGELES OPERATION

PROCEDURE NO. MC- 1104

LIMERICK GENERATING STATION
UNITS 1 & 2
PHILADELPHIA ELECTRIC CO.

MATERIAL OF CONSTRUCTION
TYPE 24KXH 2-STG. VCT
BECHTEL P.O. 8031-M-12, ESW PUMPS OAP-548, OBP-548, OCP-548, ODP-548
JOB NO. 741-S-1503/06

PREPARED BY Ronald Sperry DATE 20 SEP 77

ENGINEERING APPROVAL BY [signature] DATE 4 Oct 1977

QUALITY ASSURANCE APPROVAL BY [signature] DATE 4 Oct 1977

CERTIFIED
By [signature] Date [illegible] 78
Byron Jackson Pump Division
BORG WARNER CORPORATION

REVISIONS

REV.	DATE	BY	PAGE	CONTENT	APPROVALS ENG.	APPROVALS Q.A.
A	19 Dec. 77	RS	1 3	Added Plant I.D. and Bechtel P.O. Revised Notes	[signature] 20 Dec 77	[signature] 12-27-77
B	17 March 78	RS	2	Item No. 2 was ASTM A-276 Tp. 410 HT. Item No. 4 & 25 was ASTM A-276 Tp. 420 HT or ASTM A-296 GR. CA-40 HT	[signature] 20 Mar 78	[signature] 4-14-78
C	15 May 79	LPK	2 & 3	Added: Item No. 50 & 51	[signature] [illegible]	[signature] [illegible]

PARTS LIST

ITEM NO	REF. NO.	CATEGORY	QTY	PART DESCRIPTION	MATERIAL
1	334	3	1	Spirolox Ring	AISI 302
2	678	3	7	Gib Key	ASTM A-582, Tp. 416 H.T.
3	104	2(b)	1	Suction Bell Bearing	ASTM B-271, Al. 932
4	217	2(b)	1	Shaft Sleeve	ASTM B-276, Tp. 410 H.T. or ASTM A-296, GR. CA-15 H.T.
5	086	1	1	Suction Bell	ASME SA-216, GR. WCB
6	244	3	1	Sand Cap	ASTM B-584, Al.932
7	039	2(b)	1	Impeller Liner	ASTM B-148, Al. 952
8	078	1	1	Series Case	ASME SA-216, GR. WCB
9	747	2(b)	2	"O" Ring	Nitrile
10	176	2(a)	2	Impeller	ASTM B-148, Al. 953
11	207	2(b)	2	Case Wear Ring	ASTM B-271, Al. 932
12	226	2(b)	2	Thrust Collar	ASTM A-296, CA-15 (Cent. Cast)
13	256	2(b)	1	Split Ring	ASTM A-276, Tp. 410 H.T.
14	076	1	1	Top Case	ASME SA-216, GR. WCB
15	676	2(b)	2	Key	ASTM A-582, Tp. 416 H.T.
16	256-1	2(b)	1	Split Ring	ASTM A-276, Tp. 410 H.T.
17	422	1	1	Lower Column - Pipe - Plate - Tubing	ASME SA-106, GR. B ASME SA-516, GR. 70 ASTM A-519, GR. 1018 or ASTM A-519, GR. 1022
18	747-1	2(b)	4	"O" Ring	Nitrile
19	167	2(a)	1	Pump Shaft	ASTM A-276, Tp. 410 H.T.
20	256-2	2(b)	3	Split Ring	ASTM A-276, Tp. 410 H.T.
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22	676-1	2(b)	6	Coupling Key	ASTM A-582, Tp. 416 H.T.
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24	167-1	2(a)	2	Shaft	ASTM A-276, Tp. 410 H.T.
25	217-1	2(b)	5	Shaft Sleeve	ASTM A-276, Tp. 410 H.T. or ASTM A-296, GR. CA-15 H.T.
26	397	2(b)	5	Bearing	ASTM B-271, Al. 932
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51	801	3	1	Guard, Coupling	ASTM A-36 or Equivalent

D BR

ITEM-NO.	REF. NO.	CATEGORY	QTY	PART DESCRIPTION	MATERIAL
28	420-1	1	1	Uppor Column - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Tubing	ASTM A-519, GR. 1018 or ASTM A-519, GR. 1022
29	404	2(a)	1	Shaft	ASTM A-276, Tp. 410 H.T.
30	465	1	1	Discharge Head - Pipe	ASME SA-106, GR. B
				- Plate	ASME SA-516, GR. 70
				- Forging	ASME SA-181, GR. II or ASME SA-105
31	747-2	2(b)	1	"O" Ring	Nitrile
32	747-5	2(b)	1	"O" Ring	Nitrile
33	233	2(b)	1	Throttle Bushing	ASTM B-271, Al. 932
34	217-2	2(b)	1	Shaft Sleeve	ASTM A-276, Tp. 420 (H)T. or ASTM A-296, GR. CA-40 H.T.
35	850	1	1	Stuffing Box	ASME SA-216, GR. WCB
36	747-4	2(b)	1	"O" Ring	Nitrile
37	230	3	1	Throat Bushing	ASTM B-271, Al. 932
38	236	3	1	Cage Ring	ASTM B-271, Al. 932
39	480	3	5	Packing Ring	John Crane
40	111	3	1	Gland	ASTM B-271, Al. 932
41	334-2	3	1	Spirolox Ring	AISI 302
42	676-2	2(b)	1	Key	ASTM A-582, Tp. 416 (H)T.
43	529	2(a)	1	Drive Half Coupling	ASTM A-36 or AISI 1020-1045
44	256-3	2(b)	1	Split Ring	ASTM A-276, Tp. 410 (H)T.
45	532	2(b)	1	Adjusting Plate	ASTM A-36 or AISI 1020-1045
46	530	2(a)	1	Pump Half Coupling	ASTM A-36 or AISI 1020-1045
47	676-3	2(b)	1	Key	ASTM A-582, Tp. 416 (H)T.
48	816	3	1	Pipe (Bleed-off)	ASTM A-106 GR. B
49	814, 814-1, 531	3	3	Fittings-90° EL, 45° EL. Union	ASTM A-105
50	239	3	1	Bracket, Probe	ASTM A-36 or Equivalent

D BR

NOTES: All Heat treated 410 will have a minimum tempering temperature of 1100°F.

Category 1 fasteners are ASME SA-193 GR. B7 others are Category 2b and ASTM A-193 GR. B7

RESPONSE TO RAI 1 → Category 1 nuts are ASME SA-194 GR. 7 others are Category 2b and ASTM A-194 GR. 7

The sole plate and seismic restraints are ASTM A-516 GR. 70 and Category 3

CATEGORY DEFINITIONS:

Category 1............Pressure boundary parts and attachments

Category 2............Critical non-pressure boundary parts.

(a)............Parts that if failed would cause the pump's function to be significantly and abruptly impaired.

(b)............Parts that if failed would cause the pump's function to be impaired over a period of time and failure of which is remote.

Category 3............Non-critical, non-pressure boundary parts.

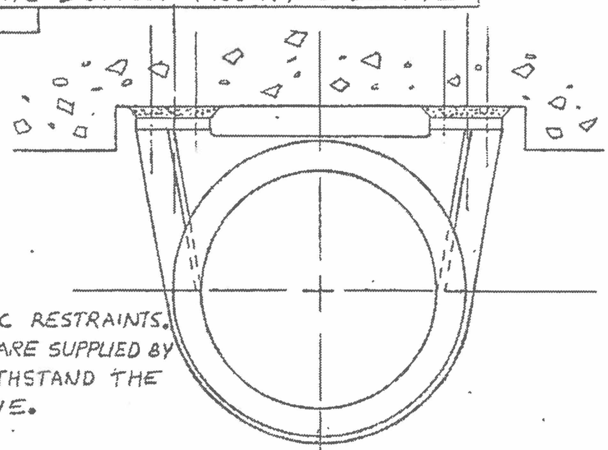
Enclosure 3

741-S-1507

REV A 23 AUG 77 R.S.

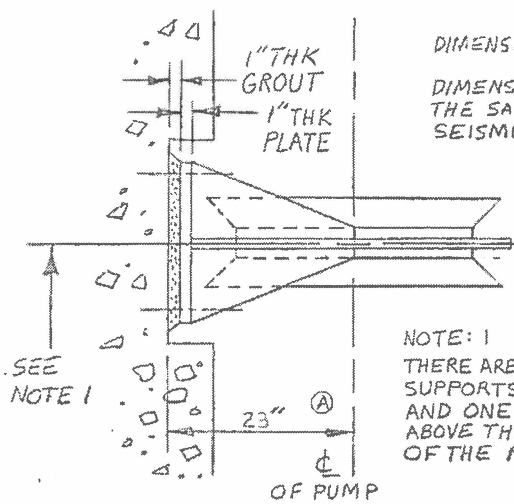
BYRON JACKSON SEISMIC SUPPORT MOUNTING DETAIL

BY R.K. 20 JUN 77



MAXIMUM ANCHOR BOLT LOADS	
TENSILE LOAD PER BOLT (LBS)	SHEAR LOAD PER BOLT (LBS)
7,188 Ⓐ	1,438 Ⓐ

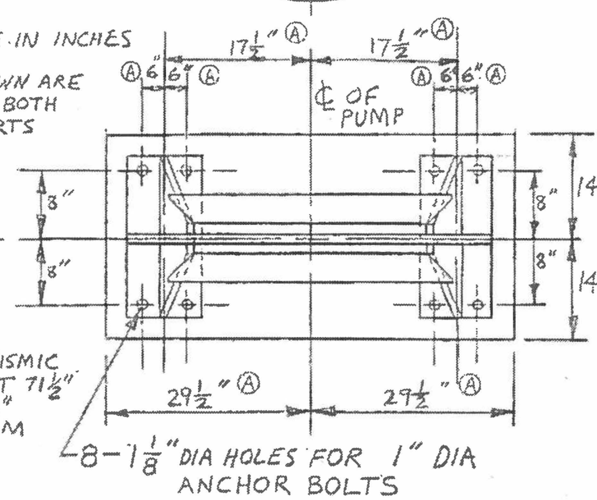
BYRON JACKSON WILL SUPPLY THE SEISMIC RESTRAINTS. THE ANCHOR BOLTS AND FOUNDATIONS ARE SUPPLIED BY OTHERS AND SHOULD BE DESIGNED TO WITHSTAND THE MAXIMUM ANCHOR BOLT LOADS SHOWN ABOVE.



DIMENSIONS ARE IN INCHES

DIMENSIONS SHOWN ARE THE SAME FOR BOTH SEISMIC SUPPORTS

NOTE: 1
THERE ARE TWO SEISMIC SUPPORTS, ONE AT 71½" AND ONE AT 169½" ABOVE THE BOTTOM OF THE PIT.



LIMERICK · RHR

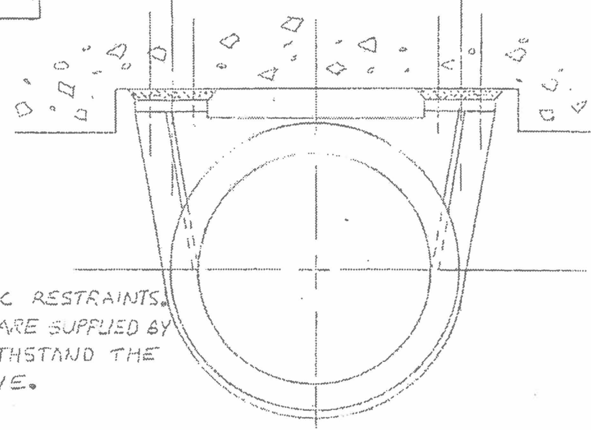
Enclosure 4

741-S-1503

REV A 23/[illegible]

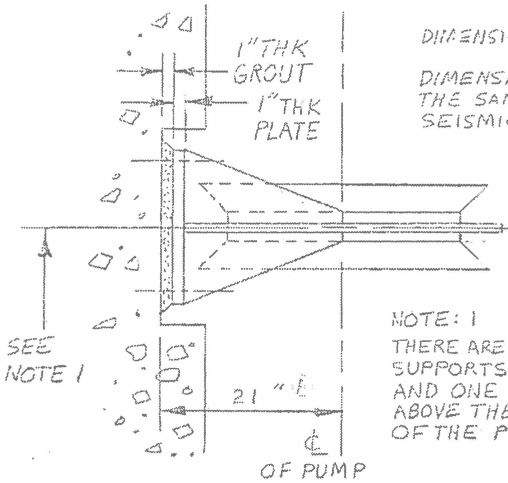
BYRON JACKSON SEISMIC SUPPORT MOUNTING DETAIL

BY R.K. 30 JA 77



MAXIMUM ANCHOR BOLT LOADS	
TENSILE LOAD PER BOLT (LBS)	SHEAR LOAD PER BOLT (LBS)
5,513 (A)	1,225 (A)

BYRON JACKSON WILL SUPPLY THE SEISMIC RESTRAINTS. THE ANCHOR BOLTS AND FOUNDATIONS ARE SUPPLIED BY OTHERS AND SHOULD BE DESIGNED TO WITHSTAND THE MAXIMUM ANCHOR BOLT LOADS SHOWN ABOVE.

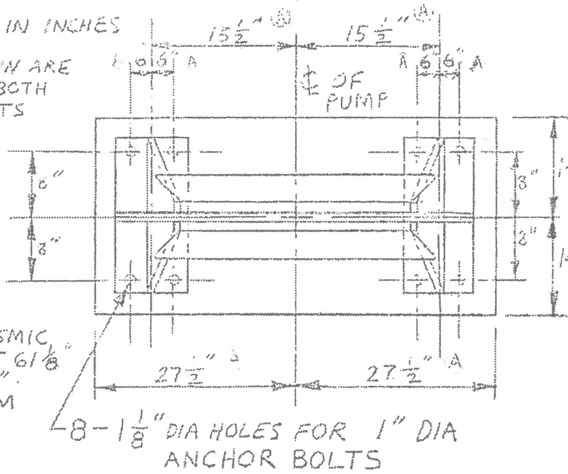


DIMENSIONS ARE IN INCHES

DIMENSIONS SHOWN ARE THE SAME FOR BOTH SEISMIC SUPPORTS

NOTE: 1

THERE ARE TWO SEISMIC SUPPORTS, ONE AT 61⅛" AND ONE AT 159⅛" ABOVE THE BOTTOM OF THE PIT.



D-1

LIMERICK ESN

Enclosure 5

6.11 Seismic Restraint and Seismic Restraint Anchor Bolts

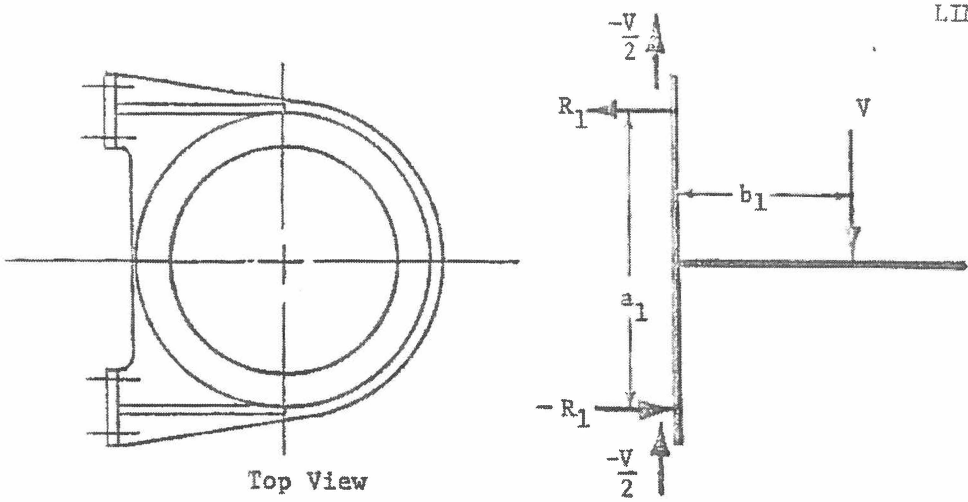
The seismic restraints are designed for two loading conditions. One loading condition relates to the seismic qualification of the equipment and the other relates to the possibility of severe loads incurred during the handling of the equipment.

Case 1 (Seismic Load)

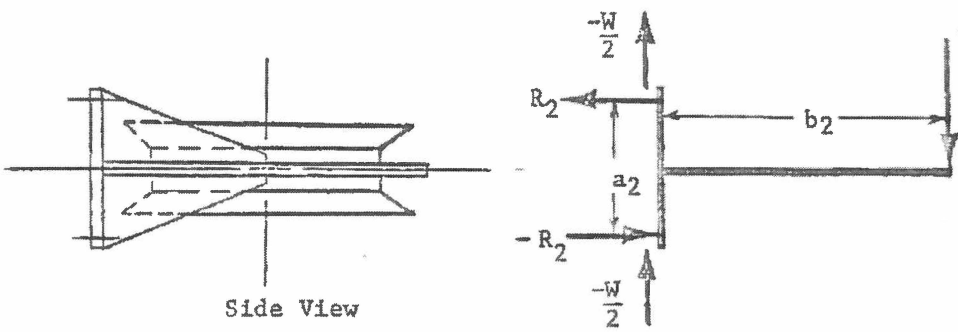
In normal operation there is a slight clearance between the pump and the seismic restraint. The restraint in this case is considered as a pinned joint, incapable of transmitting any bending moments or vertical forces from the pump. The maximum horizontal load which could be transmitted through the seismic restraint to the foundation is considered to be the shear force resulting from the DBE. In the most severe direction the seismic force has a moment arm from the center line of the pump to the foundation wall.

Case 2 (Handling Load)

The close tolerance between the pump and the siesmic restraint requires that the seismic restraints are not grouted into position until the pump is initially installed. However, if the pump is ever removed from the pit and then reinstalled there is the possibility of accidentally resting the pump weight on the restraint. This vertical load, not related to the seismic qualification of the equipment, will result in much more severe stresses in the seismic restraint and seismic restraint anchor bolts than the seismic load, because it has a greater magnitude, it has a longer moment arm, and it is applied in a "weaker" direction on the restraint.



Case 1 (Horizontal Seismic Load)



Case 2 (Vertical Handling Load)

a) Calculate the loads per bolt and stress for case 1 and case 2.

b) Material: ASTM A-193 GR. B7

Allowable: 25,000 psi

V = 2,050 lbs. (DBE Seismic Load)

W = 11,500 lbs. (Weight of Pump)

(Geometry)

a_1 = 35 in.

b_1 = 23 in.

a_2 = 16 in.

b_2 = 40 in

(Reactions)

$R_1 = \frac{b_1}{a_1} V =$ 1,347 lbs.

$R_2 = \frac{b_2}{a_2} W =$ 28,750 lbs.

c) Bolt Configuration*

N (Number of Bolts) = 8

D (Diameter of Bolts)= 1 in

n (Number of Threads per in)= 8

A_r (Root Area) = .551 in^2

d) To calculate the tensile load per bolt, assume the reactions R_1 and R_2 are resisted by 4 of the 8 bolts. In case 1, R_1 is resisted by the 4 bolts common to one mounting foot. In case 2, R_2 is resisted by the 2 uppermost bolts of both mounting feet. To calculate the shear load per bolt assume all 8 bolts resist the loads V for case 1 and W for case 2.

(Case 1)

$F_T = R_1/4 =$ 337 lb. (Tensile load per bolt)

$F_S = V/8 =$ 256 lb. (Shear load per bolt)

(Case 2)

$F_T = R_2/4 =$ 7,188 lb. (Tensile load per bolt)

$F_S = W/8 =$ 1,438 lb. (Shear load per bolt)

* The anchor bolts are not supplied by Byron Jackson

e) The stresses are calculated with the following formulas and tabulated below:

$$\sigma = \frac{F_T}{A_r}$$

$$\tau = \frac{F_S}{A_r}$$

$$\sigma_p = \frac{\sigma}{2} + ((\frac{\sigma}{2}) + \tau^2)^{\frac{1}{2}}$$ (Combined Principle Stress)

ANCHOR BOLT STRESSES

	(CASE 1) SEISMIC STRESS (PSI)	(CASE 2) HANDLING STRESS (PSI)
σ	612	13,045
τ	465	2,610
σ_p	863	13,548

f) Since the anchor bolt seismic stresses are so low and the seismic restraints are designed to be rigid enough that their participation as part of the dynamic model is insignificant, seismic stress calculations for the restraint itself are deemed unnecessary. Structural integrity, for both seismic and handling loads, is assured since the rigid restraint configuration will incur very low bending stresses, and, at each of the critical cross-sections, the restraint area exceeds the total anchor bolt area.

Enclosure 6

6.11 Seismic Restraint and Seismic Restraint Anchor Bolts

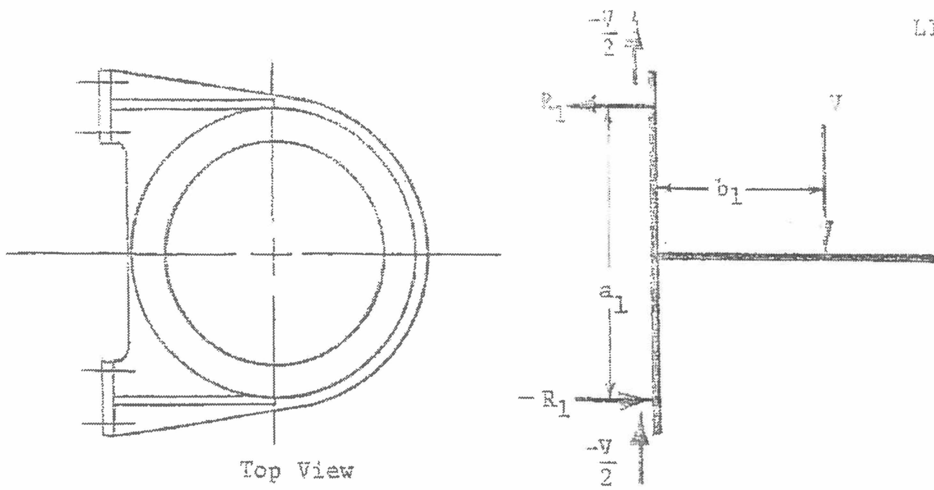
The seismic restraints are designed for two loading conditions. One loading condition relates to the seismic qualification of the equipment and the other relates to the possibility of severe loads incurred during the handling of the equipment.

Case 1 (Seismic Load)

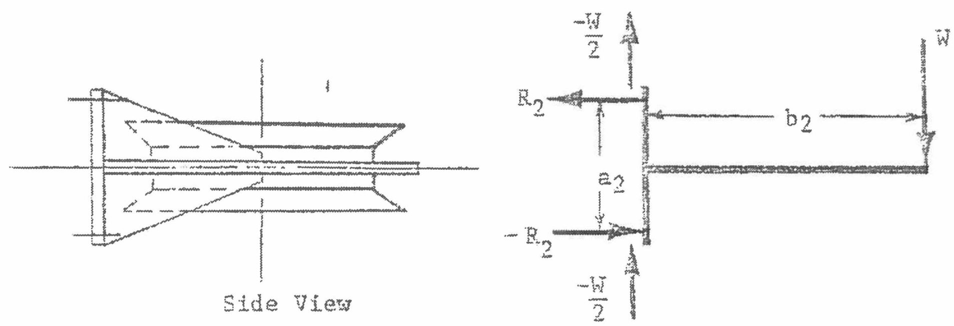
In normal operation there is a slight clearance between the pump and the seismic restraint. The restraint in this case is considered as a pinned joint, incapable of transmitting any bending moments or vertical forces from the pump. The maximum horizontal load which could be transmitted through the seismic restraint to the foundation is considered to be the shear force resulting from the DBE. In the most severe direction the seismic force has a moment arm from the center line of the pump to the foundation wall.

Case 2 (Handling Load)

The close tolerance between the pump and the siesmic restraint requires that the seismic restraints are not grouted into position until the pump is initially installed. However, if the pump is ever removed from the pit and then reinstalled there is the possibility of accidentally resting the pump weight on the restraint. This vertical load, not related to the seismic qualification of the equipment, will result in much more severe stresses in the seismic restraint and seismic restraint anchor bolts than the seismic load, because it has a greater magnitude, it has a longer moment arm, and it is applied in a "weaker" direction on the restraint.



Case 1 (Horizontal Seismic Load)



Case 2 (Vertical Handling Load)

a) Calculate the loads per bolt and stress for case 1 and case 2.

b) Material: ASTM A-193 GR. B7

Allowable: 25,000 psi

V = 1,870 lbs. (DBE Seismic Load)

W = 9,800 lbs. (Weight of Pump)

(Geometry)

a_1 = 31 in.

b_1 = 21 in.

a_2 = 16 in.

b_2 = 36 in

(Reactions)

$R_1 = \frac{b_1}{a_1} V =$ 1,267 lbs.

$R_2 = \frac{b_2}{a_2} W =$ 22,050 lbs.

c) Bolt Configuration*

N (Number of Bolts) = 8

D (Diameter of Bolts) = 1 in

n (Number of Threads per in) = 8

A_r (Root Area) = .551 in^2

d) To calculate the tensile load per bolt, assume the reactions R_1 and R_2 are resisted by 4 of the 8 bolts. In case 1, R_1 is resisted by the 4 bolts common to one mounting foot. In case 2, R_2 is resisted by the 2 uppermost bolts of both mounting feet. To calculate the shear load per bolt assume all 8 bolts resist the loads V for case 1 and W for case 2.

(Case 1)

$F_T = R_1/4 =$ 317 lb. (Tensile load per bolt)

$F_S = V/8 =$ 234 lb. (Shear load per bolt)

(Case 2)

$F_T = R_2/4 =$ 5,513 lb. (Tensile load per bolt)

$F_S = W/8 =$ 1,225 lb. (Shear load per bolt)

* The anchor bolts are not supplied by Byron Jackson

e) The stresses are calculated with the following formulas and tabulated below:

$$\sigma = \frac{F_T}{A_r}$$

$$\tau = \frac{F_S}{A_r}$$

$$\sigma_p = \frac{\sigma}{2} + \left(\left(\frac{\sigma}{2}\right)^2 + \tau^2\right)^{\frac{1}{2}}$$ (Combined Principle Stress)

ANCHOR BOLT STRESSES

	(CASE 1) SEISMIC STRESS(PSI)	(CASE 2) HANDLING STRESS (PSI)
σ	575	10,005
τ	425	2,223
σ_p	801	10,477

f) Since the anchor bolt seismic stresses are so low and the seismic restraints are designed to be rigid enough that their participation as part of the dynamic model is insignificant, seismic stress calculations for the restraint itself are deemed unnecessary. Structural integrity, for both seismic and handling loads, is assured since the rigid restraint configuration will incur very low bending stresses, and, at each of the critical cross-sections, the restraint area exceeds the total anchor bolt area.