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April 11, 1988

Mr. T. E. Murley
Office of Nuclear Reactor Regulation
U.S. Nuclear Reactor Regulation
Washington, D. C. 20555

Dear Mr. Murley:

Subject: Braidwood Unit 1 and 2
Limitorque Operator Lubrication
NRC Docket Nos. 50-456 and 50-457

Reference: (1) L. O. DelGeorge Letter to T. E. Murley, Dated March 29, 1988

The purpose of this letter is to amend and supplement information documented in Reference 1. This information was discussed with members of the NRC Staff at Braidwood Station on April 4, 1988. Each of the attachments to this letter were included in Reference 1 and are being resubmitted as Attachments to this letter.

Attachment 1, entitled Lubrication Contamination Evaluation, has been revised to reflect additional validated information related to the lubrication verification program conducted at Braidwood between 1985 and early 1987. The revised Attachment also includes clarifying information on the methods for sampling and analysis of Limitorque grease undertaken recently at Braidwood Station.

Attachment 2, entitled Lubricant Acceptance Criteria, has been revised to document the acceptance range for grease penetration resistance committed to by Commonwealth Edison as part of the Braidwood lubricant evaluation.

Attachment 3, entitled Summary of Results, has been updated to reflect information available through April 8, 1988. Also included as an appendix to this Attachment is a summary

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of grease sample and analysis results currently available for all safety-related Limitorque operators at Braidwood Station. In this regard, all sampling is complete, all sensory testing is complete, all chemical analysis is complete and the remaining 1 penetration tests are expected to be complete and reports issued by 4-12-88.

Attachment 4, 10 CFR 50.49 Evaluation, has been augmented to better reflect the testing and analyses done by Commonwealth Edison which demonstrate compliance with the NRC regulation concerning environmental qualifications of electrical equipment important to safety for nuclear power plants.

Attachment 5 documents the material provided by Commonwealth Edison to the NRC Staff at the meeting of April 4, 1988.

It is our present understanding that the Office of Nuclear Reactor Regulation has the lead responsiblity for the review of this matter. If additional information is required or questions arise concerning this material, please contact me or Steve Hunsader of our Nuclear Licensing Staff.

Very truly yours,

Louis O. DelGeorge

Louis O. DelGeorge
Assistant Vice President

Attachments

cc: NRC Region III
Braidwood Resident
Mr. S. Sands

(6918z/2)

LUBRICATION CONTAMINATION EVALUATION
BRAIDWOOD UNIT 1 AND 2

INDEX

Attachment 1

Lubrication Contamination Evaluation
Braidwood Unit 1 and 2

As a result of questions raised during the NRC audit of the electrical equipment environmental qualification (EQ) program applied by Commonwealth Edison on Braidwood Unit 2 (Reference Issue 30, 31; i.e., quality of lubricant for service at time of Unit 2 initial operation), a sample lubricant inspection program was undertaken. With the agreement of the NRC, it was decided to evaluate lubricants in ten Limitorque motor operators and one pump to determine whether any of those lubricants had any construction or time related quality discrepancies. If this sample did not identify any such discrepancies, the EQ audit questions would be closed.

However, this sample did identify one of the ten Limitorque operators to have what appeared to be mixed grease. (It should be noted that Limitorque specifies Nebula EP0 and Nebula EP1 as acceptable operator greases for EQ applications. These greases are light tan in color. Another grease, Sun 50 EP, has been accepted by Limitorque as an alternate grease for non-EQ use in safety-related applications outside containment. This grease product is dark brown/black.) The possible mixing was identified by the expected tan grease having black streaks in the sample.

As a result of this observation, Commonwealth Edison agreed to a more extensive Limitorque operator lubricant sampling program to assure that safety-related operators did, in fact, contain properly qualified lubricants with no unacceptable contamination. This program entailed sampling all safety-related Limitorque operators (Braidwood Unit 1 and 2 total - 263), including those operators (Braidwood Unit 1 and 2 total - 81) on valves for which the EQ program was not applicable; i.e., are not subject to the requirements of 10 CFR 50.49. The sample would be evaluated visually for any contamination and a chemical analysis by atomic absorption spectroscopy would also be performed to identify any mixed constituents in the lubricant. This program of sampling was reviewed and accepted by the NRC (Reference 1).

At this point, it is important to note that in 1985, Commonwealth Edison undertook an extensive operator lubricant sample program that included the chemical analysis of grease samples from all safety-related operators. This sample was typically taken from the grease injection point at the top of each operator. Forty (40) operators (non E-Q) were determined by chemical analysis to have SUN 50 EP grease in the gearbox. These operators are outside containment. Use of SUN 50 EP in

this application is acceptable per a 10/29/85 Limitorque letter (Reference 2). One hundred twenty (120) operators (EQ and non-EQ) were determined by chemical analysis to have Nebula EP greases (EP0 or EP1) in the gearbox. The remaining one hundred and three (103) operators (EQ and non-EQ) had unacceptable grease (mixed or incurrect) based on chemical analysis.

Of those 103 operators, thirty (30) of the operators were removed to the Station mechanical maintenance shop where they were disassembled and degreased by the Station Mechanical Maintenance Department (MMD). They were then regreased in the shop with Nebula EP1 grease.

The remaining seventy-three (73) operators were cleaned and regreased by the Project Construction Department (PCD). For these 73 operators the majority of the grease was removed, then, the geartrain components were removed and degreased with mineral spirits, and the inside of the casing was wiped down such that all accessible areas of the casing were cleaned. The operator was then reassembled and refilled with Nebula EP0 or EP1 grease.

(See Appendix 1-1.A to this Attachment for a discussion of the cleaning and post-cleaning acceptance program used in the "1985" lubricant verification program.)

Based upon the 100% grease sample initiated in 1985, the possibility of mixed grease in the Limitorque operators was thought to be completely resolved. Therefore, the finding of apparent grease mixing in one of ten operators in the recent sampling was a surprise. However, further investigation appears to demonstrate that the original sampling and grease replacement program, though typical of industry practice at the time, might allow for findings of the type recently made. First, the 1985 samples were taken only from the top of the operator, whereas the recent samples are being drawn (where possible) from the top, middle and bottom of the operator using what is judged to be a more representative sample acquisition method (See Appendix 1-1.C). Second, the solvent cleaning of operators in place, though consistent with common accepted practice, could have left traces of the initial lubricant in the operator in "hideout" locations not identified during the cleaning. With respect to this second point, the opening and detailed inspection of operators on valves 1CC9412A, 1SI8821A, and 2RH8702A for which the recent sampling identified potential mixed greases, did not find evidence of contamination or mixing of greases internal to the operator. These supplemental detailed inspections, which were witnessed, in part, by NRC RIII personnel, support the integrity of the 1985 inspection and grease changeout program.

It is recognized that the mixing of incompatible lubricants can undermine the acceptability of the lubricant. However, examples exist demonstrating that grease mixing, depending upon the greases involved and the degree of mixing, may have no safety significance. In fact, the NRC has allowed for continued operation of plants that have identified mixed greases (Reference 3). Crucial to the determination of safety significance of a mixed grease in a Limitorque operator is the compatibility of the grease mixture. Compatibility is typically determined through "penetration testing" (Reference ASTM D217 or D1403). This point is discussed in EPRI Report NP-4916, for which the principal contributor was Dr. R. Bolt, a lubricant expert. If, as has been the case in other situations where NRC review has resulted in the temporary acceptance of a mixed grease, the composite grease can be shown to be compatible, the mixture can be accepted. The penetration test is an appropriate basis for establishing compatibility.

Our position regarding the acceptability of lubricants in Limitorque operators at Braidwood Station is based on an inspection of the operators to determine if a mixture of lubricants has occurred. In those cases where sensory tests, similar to those stated in EPRI document NP-4916, identify suspected mixing of lubricants, a penetration test will be performed. The penetration test will be used to determine if unacceptable softening or hardening of the installed lubricant has occurred. Further discussion of this inspection and testing program is provided in later sections of this document and in Attachment 2.

The concern associated with grease mixtures relates to the potential for deleterious chemical reactions between the mixed greases. Such chemical reactions cause a change in the properties of the lubricant evidencing incompatibility between the greases. This can result in softening or hardening of the lubricant, and can result in separation of complex lubricants. While such reactions can be accelerated by environmental effects such as high temperature or radiation, the changes resulting from such a reaction will be manifested after working of the mixture and time, without the additional environmental stresses on the lubricant. Appendix 1-2 to this Attachment describes the lubricant working (mixing) that occurs within a Limitorque operator. The evaluation contained in that Appendix supports our belief that whatever mixing of greases exists in Braidwood Limitorque operators, sufficient working of the material has occurred, at least of the bulk grease in the vicinity of the rotating components in the operator, to evidence a change in lubricant properties resulting from any chemical reaction if such a reaction has occurred. In addition, Appendix 1-3 to this Attachment documents the results of penetration tests (ASTM D1403) of grease mixtures that bound the conditions identified at Braidwood. These tests evidence only minor changes of the composite grease mixture (within $\pm$15 points of the penetration resistance of the base greases).

These tests were preceded by working the material (60 strokes) and allowing the material to rest at room temperature for a period of approximately 24 hours. The relatively insignificant affect of mixing the greases in question at Braidwood, evidenced by the slight change in penetration resistance for the tested mixtures, further supports our belief that aggressive chemical reaction of any mixed greases in the Braidwood operators, especially the bulk lubricant in contact with rotating parts within the operator, is not expected. Furthermore, even if such an aggressive reaction could occur, it would manifest itself in gross changes in penetration resistance of the material sampled from the vicinity of the rotating components in the operator. Such a result has not been found in the testing of laboratory or field samples.

When the incompatibility is a sharp breakdown of the grease gel structure, excessive softness occurs. The result is an increased possibility of leakage of the lubricant away from the parts to be lubricated. For Limitorque gearboxes this is not a concern since the lubricant is contained in a sealed gear case. The lubricant will not escape in quantities large enough to result in a loss of the lubrication function. In equipment such as the Limitorque operator, grease or oil is satisfactory as a lubricant. Grease is specified only to reduce the potential for leakage through the gear case seals. The base oils and their additives will perform the required lubrication function irrespective of any softening of the lubricant in the Limitorque gear case. The inspection of the Limitorque operators in question at Braidwood will reveal any such softening any operator having visible signs of leakage is being sampled with a penetration test performed. The penetration tests completed to date have typically shown penetration resistance within the range for qualified greases.

The other issue regarding incompatibility of mixed greases is hardening. This issue is addressed by the sampling of the contents of the gearboxes and the penetration testing that is further described later in this document. A change in consistency of less than or equal to 30 points, as stated in EPRI NP-4916, defines compatibility. Similar guidance is provided in Mil Spec 27617. This is judged to be conservative, especially when one considers the service environment in the sealed Limitorque gearboxes. The penetration testing will be used to detect either hardening or excessive softening by measuring the variation in penetration resistance.

This discussion on the results of mixing of lubricants is in concert with the review in Docket Nos. 50-269, 50-270, and 50-287 as well as in Dr. R. Bolt's letter to J. E. Thomas of Duke Power (Reference 4) regarding a similar issue for Oconee Station (Reference 3).

In addition to inspection of lubricants, operating equipment will exhibit other signs that lubricants have experienced a property change. Increases in noise, operating times, motor running current and temperature increases are all possible indicators. In the case of the Braidwood Limitorque operators, plant surveillances such as the signature analysis would reveal such occurrences. Operating equipment can offer great tolerance to lubrication property changes, i.e., one or two penetration grades for greases (90 points), without any significant impact on the equipment itself (NP-4916). The maintenance and surveillance program in place at Braidwood Station, along with the added testing and surveillance program described below, will preclude the possibility of degraded grease from remaining in the subject Limitorque operators.

The discussion that follows defines the actions being taken by Commonwealth Edison to resolve the issue of potential grease contamination of Limitorque operators at Braidwood Station.

1. Inspect all safety-related Limitorques (total 263) for signs of lubricant leakage from the gearbox. Any operator having signs of leakage will have a grease sample taken for penetration testing in accordance with paragraph 2c below.

2. Do a visual examination in accordance with Braidwood procedure BwFP FS-1, Rev. 0 of samples (using three point technique wherever possible) from all operators.

   a. If the sample should fail the Limitorque maintenance requirements for grease inclusions (water, grit, dirt), consistency or other sensory tests (as described in EPRI Research Report NP-4916), the operator must be evaluated for additional corrective action up to and including grease change-out.

   b. If the visual inspection of the grease sample shows no indications of grease contamination with other grease, and the grease meets the Limitorque maintenance requirements, the actuator is acceptable and no further action is required (subject to acceptable chemical analysis results). The valve will be returned to its normal routine maintenance cycle.

c. If the sample shows indications of grease contamination with other grease based upon visual observation, an approximate 20cc sample of the mixture will be pulled from the operator and sent to the lab (See Note 1) for a micro penetration test (ASTM D1403). If the test indicates that the grease has hardened or softened by more than 30 points in an ASTM worked penetration test (Reference 5), the grease in the operator will be changed out.

(See Attachment 2, Section II for further discussion.) If the test indicates the grease is acceptable (penetration resistance in the range of 295 - 400), the grease is acceptable for use for a period not to exceed 13 months. (See Attachment 2, Appendix 2-1 for a discussion of the measures to be taken to extend the grease qualification beyond 13 months for this group of operators.)

3. Perform a chemical analysis (See Note 2) of samples from all operators using atomic absorption spectroscopy to determine the composition of grease in the sample. If the grease sample shows contamination with another grease, a 20cc grease sample will be penetration tested per Paragraph 3 above.

4. All operators that show unacceptable indications of grease contamination (as described in item 2a above) or are unacceptable based on chemical analysis or penetration test results will have a grease change-out before the unit is returned to service.

Note 1 The penetration testing will be performed at Auto Research Laboratory, Inc. (Harvey, Illinois)

Note 2 The chemical analysis will be performed by the Commonwealth Edison System Materials Analysis Department (SMAD).

5. In addition to the testing described above, the following mixtures of virgin grease will be worked and ther penetration tested:

Percent*	Grease Type
100%	Nebula EP0
100%	Nebula EP1
95% / 5%	Nebula EP0 / Sun 50 EP
95% / 5%	Nebula EP1 / Sun 50 EP
75% / 25%	Nebula EP0 / Sun 50 EP
75% / 25%	Nebula EP1 / Sun 50 EP
50% / 50%	Nebula EP0 / Sun 50 EP
50% / 50%	Nebula EP1 / Sun 50 EP
25% / 75%	Nebula EP0 / Sun 50 EP
25% / 75%	Nebula EP1 / Sun 50 EP
5% / 95%	Nebula EP0 / Sun 50 EP
5% / 95%	Nebula EP1 / Sun 50 EP
100%	Sun 50 EP

No radiation testing will be done since both greases have already been qualified by Limitorque and radiation tends to soften the grease (Reference 6). Such softening will not affect the qualification of the greases in question.

The additional testing described in paragraph 5 will establish a supplemental basis for assessing the acceptability of mixed greases of the type possible at Braidwood. This testing is similar to that done at the Rock Island Arsenal to evaluate similar grease mixing issues (Reference 7). The results of this testing are described in Appendix 1-3.

* If grease densities are approximately the same, percent by weight. If grease densities are far different, percent by volume.

References

1. A. Bert Davis Confirmatory Action Letters to Mr. C. Reed, dated March 23, 1988 for Units 1 and 2.

2. Daniel S. Warsing (Limitorque Corporation) Letter to Dr. R. O. Bolt, dated October 29, 1985

3. Oconee Nuclear Station, Units 1, 2, and 3
   Docket Nos. 50-269, 50-270, and 50-287

4. Robert O. Bolt, Ph.D. (Bolt & Associates) Letter to Mr. J. E. Thomas (Duke Power Company), dated June 17, 1986

5. ASTM - D1403-86
   ASTM - D217-82

6. EPRI Report: "Radiation Effects on Lubricants"
   Page 6-2, Figure 6-1

7. Technical Report: "Compatibility of Lubricating Greases" (Rock Island Arsenal Laboratory) See Abstract.

(NOTE: The subject references are not provided herein. These references were transmitted to NRC by the L. O. DelGeorge Letter to T. E. Murley, Dated March 29, 1988.

Appendix 1-1

Braidwood Limitorque Lubrication Activities

The purpose of this section of the report is to describe the sampling and operator regreasing activities conducted at Braidwood from 1985 through early 1987. That activity is discussed in Section A of this Appendix. In addition, a discussion is provided in Section B of this Appendix of the method for acquiring a representative sample of grease in the lubrication evaluation now being conducted at Braidwood (1988). Finally, Section C of this Appendix discusses the current methods employed at Braidwood to clean and regrease Limitorque operators.

Appendix 1-1

Original (1985-1987) Grease Sample/Changeout Program for Safety-Related (Class 1E) Limitorque Valve Operators

From late 1985 to early 1987, Braidwood Station undertook an extensive Limitorque Grease Sampling/Changeout Program. We took this action in response to various discoveries in the nuclear industry of "mixed" main gear case greases. This grease sampling program is documented by Nuclear Work Requests (NWR's) A04015 and A05077. Details of this program are as follows:

The Station Mechanical Maintenance Department (MMD) obtained one grease sample from the main gear case grease for each of the two hundred sixty-three (263) Safety Related (Class 1E) Limitorque Valve operators thirteen (13) Unit Common, one hundred twenty-five (125) Unit One, and one hundred twenty-five (125) Unit Two. Generally, the grease sample was taken from the most convenient grease plug, usually at the top. MMD obtained the grease samples (generally two to three grams each) with new wooden tongue depressors (each used once only), scraped the grease samples into new plastic petri dishes, and labeled the petri dishes with the appropriate valve tag numbers. MMD then sent the grease samples to the CECo System Materials Analysis Department (SMAD) for chemical analysis. SMAD determined the composition of the grease samples (by using a combination of infra-red spectroscopic analysis and atomic absorption analysis) and sent the results back to Braidwood. The Station Technical Staff reviewed and evaluated the SMAD analysis results to determine which of the grease sample compositions were unacceptable (any "mixed" greases, and any grease other than Exxon Nebula EP0/EP1 for EQ applications). One (1) Unit Common Limitorque, fifty-eight (58) Unit One Limitorques, and forty-four (44) Unit Two Limitorques were determined to have unacceptable grease samples. (These results are detailed in Table A).

For Unit Common and Unit One, Tech Staff generated fifty-nine (59) NWR's to changeout the main gear case grease to Exxon Nebula EP0/EP1. For thirty (30) of these Limitorques, MMD performed the grease changeout in the following manner:

> MMD had the project construction department (PCD) remove the Limitorque operators from their valves and take them to the Station Maintenance Shop. MMD, in accordance with the NWR instructions and approved procedures (ie: BwMP 3305-045), disassembled the operators in the shop, degreased them (using VARSOL #3 solvent), repacked them with new Exxon Nebula EP1 grease, and reassembled them back together. The Station Quality Control Department inspected the disassembled operators after the cleaning was complete and verified

acceptable cleanliness prior to reassembly. After the operators were reassembled, Quality Control verifiedthat Exxon Nebula EP-1 grease was installed and that the level of the grease was acceptable. With respect to the "spring packs" they were not disassembled for degreasing, but instead were thoroughly brush cleaned with Solvent as integral units. PCD then took the regreased operators back to the valves and reinstalled them.

The remaining twenty-nine (29) Limitorques were too difficult to remove from their valves and take to the shop. For these, PCD performed the grease changeout in the field.

For Unit Two, Tech Staff generated correspondence from the Station to PCD which identified the forty-four (44) Limitorques requiring grease changeout. PCD performed the grease changeouts in the field for all forty-four (44) of these Limitorques.

The field grease changeout (73 Limitorque operators total) was performed in the following manner:

The operator was completely disassembled in accordance with the limitorque manual. All parts were degreased with solvent, the "spring packs" were disassembled for degreasing then reassembled. The operator housing was cleaned and wiped out with solvent (mineral spirits). The cleaned parts and operator housing were force air dried. Phillips Getschow Co. (PGCo) Quality Control inspected the parts and operator housing for cleanliness prior to regreasing and reassembly. The operators were regreased with Exxon Nebula EP-0 or EP-1 and reassembled. Exxon Nebula EP-1 was predominantly used when regreasing. P.G.Co Field Change Orders (FCO's) were used to document the work.

Appendix 1-1

TABLE A

"ORIGINAL BRAIDWOOD STATION SAFETY RELATED CLASS 1E LIMITORQUE GREASE SAMPLE AND CHANGEOUT PROGRAM (1985-1987)"

	Calcium: No Changeout		Lithium: No Changeout		Mix/Wrong Grease: MMD Changeout		Mix/Wrong Grease: PCD Changeout		TOTALS		
	EQ	SR Non EQ	EQ	SR Non EQ	EQ	SR Non EQ	EQ	SR Non EQ	EQ	SR Non EQ	SR All
Unit 0	None	8	None	4	None	1	None	----	None	13	13
Unit 1	37	11	None	19	27	2	27	2	91	34	125
Unit 2	50	14	None	17	--	--	41	3	91	34	125
Totals	87	33	None	40	27	3	68	5	182	81	263

APPENDIX 1-1

BRAIDWOOD GREASE SAMPLING (1988)

Grease samples were taken from each accessible port on all 263 Limitorque operators. The grease sample was extracted from the Limitorque operator by inserting a nylon tie wrap approximately 6"-8" into the operator, twisting the tie wrap to collect the grease and then withdrawing the tie wrap which is then encased with grease. The grease was then transferred to a petri dish. The petri dish was marked with the appropriate valve number and sample port location (i.e. top, middle, bottom).

A demonstration given on April 4, 1988 was witnessed by the following NRC personnel: Mr. D. R. Muller of NRR, Mr. F. J. Witt of NRR, Mr. E. J. Brown of AEOD and Mr. A. S. Gautam of Region III. One of the fuel handlers who had taken actual samples in the field demonstrated the sampling technique using a Limitorque operator training aid which has a clear window in the case. All members were able to visually observe how the tie wrap penetrates completely into the case, thereby obtaining a truly representative sample of the grease contained in the Limitorque operator.

Appendix 2-1

Limitorque Operator Grease Replacement

The Limitorque Operators with unacceptable grease are being removed from the applicable valve by the Project Construction Dept. The Limitorque Operator is then being dissassembled by the Mechanical Maintenance Dept.

Excess grease is wiped off of the parts and then the parts are cleaned with Varsol. After the parts have been cleaned, the Quality Control Dept. inspects each part for cleanliness prior to reassembly. Following the cleanliness inspection, the Limitorque Operator is reassembled and greased with Exxon Nebula EP-1. Quality Control verifies that the reassembled operator has been greased with Exxon Nebula EP-1 and that the level of the grease is acceptable.

The reassembled Limitorque Operator is then reinstalled on the applicable valve by the Project Construction Dept. Once the valve Limitorque Operator has been reterminated it is stroke tested, a current signature is taken and, if applicable, a leak rate test performed.

Appendix 1-2

Lubricant Mixing in Limitorque Operators

Each Limitorque operated valve has been operated open and/or closed on average 26 times. This is based upon

	5 full strokes*	(Construction) limit switch setting, control circuitry testing and motor current readings)
	2 full strokes	valve timing (during start-up testing)
	4 full strokes	pre-operational testing program
	2 full strokes	valve signature program
Total	13 full strokes	
	(26 open/closed operations)	

The motor of a valve operator runs at 1750 RPM, the gear train runs at approximately 400 RPM, and the worn gear runs at approximately 3 RPM.

On the average a valve takes about 30 seconds for an open or close operation. This is based upon Byron/Braidwood Environmental Qualification evaluations for voltage and frequency variations concerning motor heat rise.

Thus, each valve operator has at least experienced 39 revolutions of the worn gear.

(26 operations) x (1/2 min/operation) x (400 rev/min) = 5200 rev

* A full stroke of the valve means one open operation and one close operation.

Clearly, this number of revolutions would provide a mixing of the grease in the vicinity of the gears. This mixing of the grease in the Limitorque gear area will assure that in those cases where mixed greases are present, a sufficient mixing of the lubricants will occur. This working of the grease will assure that different grease types, if present, will have already chemically reacted with each other.

The testing performed to date on mixtures of 98% Nebula EP0/2% Sun 50 EP and 95% Nebula EP0/5% Sun 50 EP have resulted in penetration values of 399 for both mixtures (See Appendix 1-3). These test samples are representative of the state of the mixed grease in the immediate area of the Limitorque gear boxes in that both are homogenous mixtures. The resulting penetration valves in the test samples do represent what would be expected to be present in those operators with mixed greases.

Similar results have been obtained for mixtures of 98% Nebula EP1/2% Sun 50 EP and 95% Nebula EP1/5% Sun 50 EP, with tested valves of 332 for both mixtures (See Appendix 1-3).

These results are also consistent with the penetration results for samples extracted from Braidwood operators with suspected grease mixtures.

Appendix 1-3

Supplemental Grease Mixture Testing

As described in Attachment 1, a program of supplemental grease mixture penetration testing has been performed to provide additional insight on the potential affects of mixing Nebula EP0 and EP1 with Sun 50 EP. The results of that testing are provided in Table 1-3a (See also Figure 1-3a) and Table 1-3b (See also Figure 1-3b). These results evidence only minor changes in penetration resistance as a function of mix ratio. This is demonstrated by comparison of the resultant penetration resistance for the grease mixtures with the penetration resistance for the two constituents (note that the grease densities for the Nebula EP0 and EP1 and the Sun 50 EP are similar).

These results demonstrate only minor deviations from the analytically predicted penetration resistance, and are well within ± 30 penetration points of the prediction for the trace constituent mixes (i.e. 2% or 5%).

Table 1-3a

Nebula EPO/Sun 50 EP

MIXTURE Constituents	Penetration Resistance (1) Test(2)
100% EPO / 0% Sun	384
98% EPO / 2% Sun	399
95% EPO / 5% Sun	399
75% EPO / 25% Sun	339
50% EPO / 50% Sun	309
25% EPO / 75% Sun	287
5% EPO / 95% Sun	268
2% EPO / 98% Sun	268
0% EPO / 100% Sun(3)	268

(1) Note test repeatability is in the range of ± three points

(2) Based on penetration test (ASTM D1403)

(3) The tested value for Sun 50 EP is below the handbook range for the grease (330 - 350)

(6918z/21)

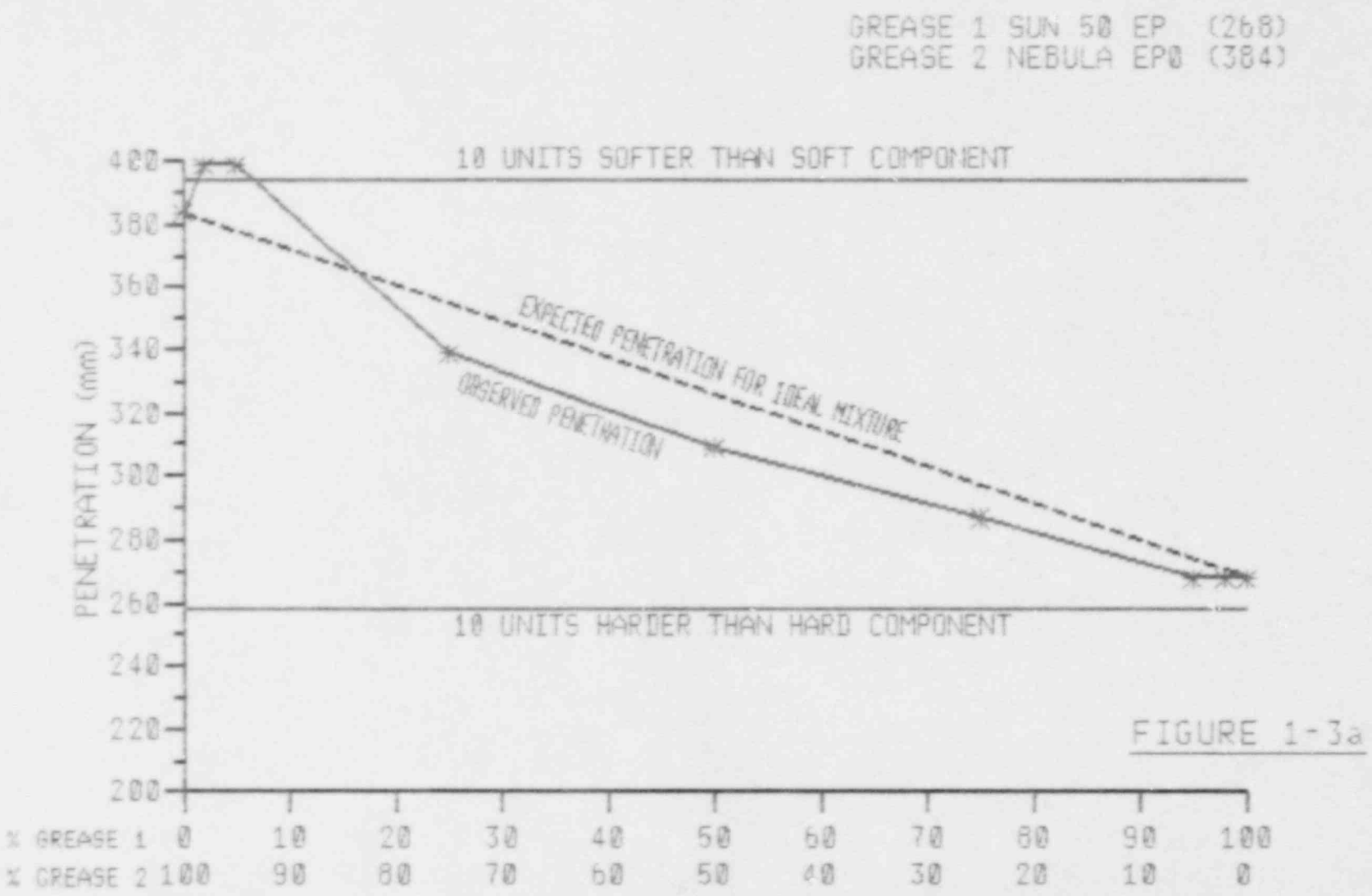

GREASE 1 SUN 50 EP (268)
GREASE 2 NEBULA EP0 (384)
10 UNITS SOFTER THAN SOFT COMPONENT
EXPECTED PENETRATION FOR IDEAL MIXTURE
OBSERVED PENETRATION
10 UNITS HARDER THAN HARD COMPONENT
PENETRATION (mm)
400
380
360
340
320
300
280
260
240
220
200
% GREASE 1 0 10 20 30 40 50 60 70 80 90 100
% GREASE 2 100 90 80 70 60 50 40 30 20 10 0

FIGURE 1-3a

Table 1-3b
Nebula EP1/Sun 50 EP

MIXTURE Constituents	Penetration Resistance (1) Test(2)
100% EP1 / 0% Sun	328
98% EP1 / 2% Sun	332
95% EP1 / 5% Sun	332
75% EP1 / 25% Sun	313
50% EP1 / 50% Sun	298
25% EP1 / 75% Sun	287
5% EP1 / 95% Sun	264
2% EP1 / 98% Sun	264
0% EP1 / 100% Sun(3)	268

(1) Note test repeatability is in the range of ± three points

(2) Based on penetration test (ASTM D1403)

(3) The tested value for Sun 50 EP is below the handbook range for the grease (330 - 350)

GREASE 1 SUN 50 EP (268)
GREASE 2 NEBULA EP1 (328)

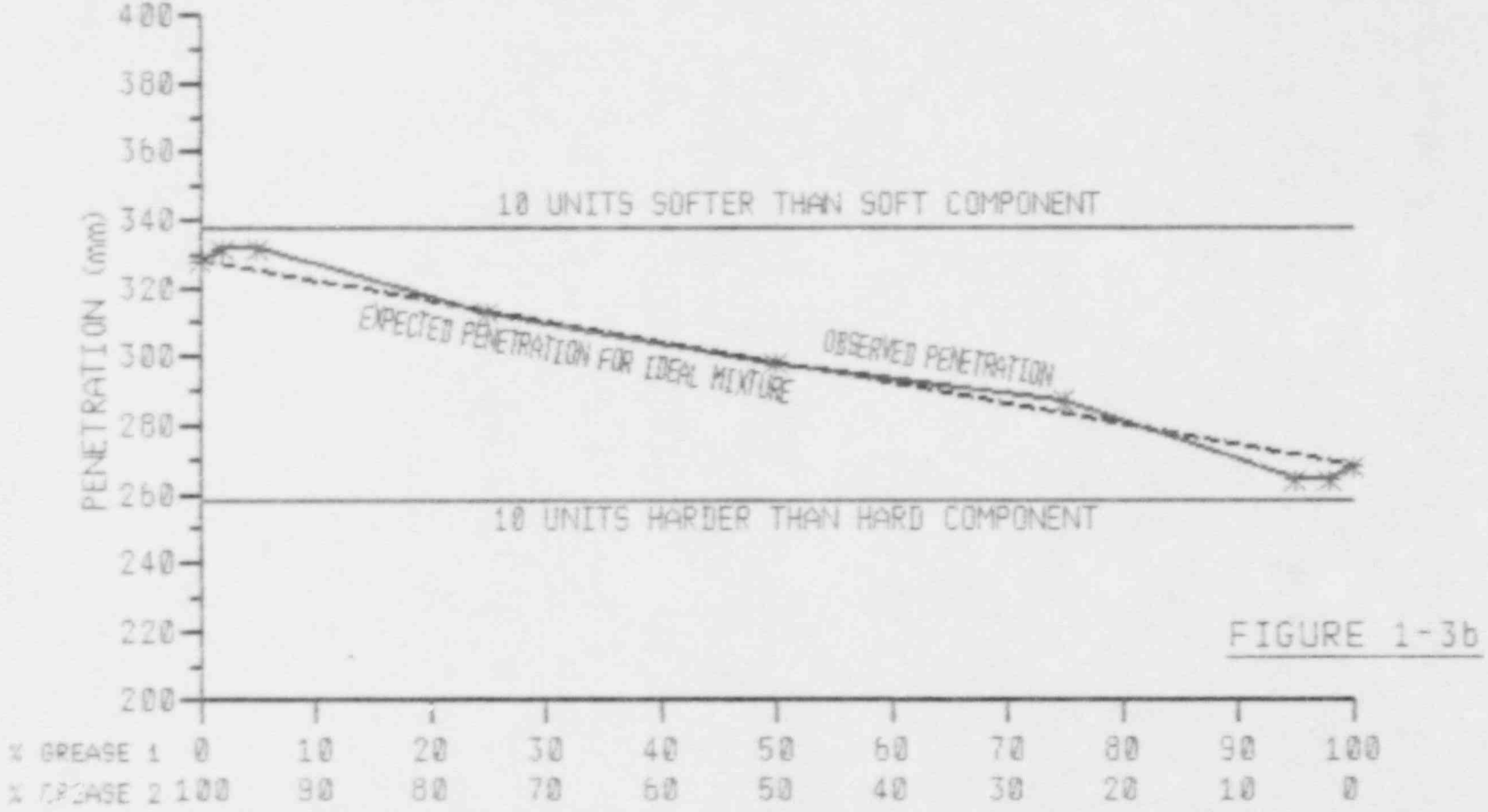


FIGURE 1-3b

Appendix 1-4

Limitorque Hydraulic Lockup

While it was recognized by the NRC Staff at the meeting of April 4, 1988, that the issue of Limitorque hydraulic lockup is distinguished from the mixed grease question now being evaluated for Braidwood Station, the matter was discussed at length and that discussion is documented here for information only. In addition, the NRC Staff reviewed the method for cleaning and results of cleaning the Limitorque spring pack, which is associated with the hydraulic lockup issue.

Hydraulic locking in the spring packs of Limitorque operators is a concern which dates back to 1973. The hydraulic locking found was due to grease being trapped behind the spring cartridge cap of the spring pack assembly. Limitorque had addressed the 1973 concern by: (1) recommending backfitting of older model operators with a spring cartridge cap cover relief tube kit and (2) a redesign of the spring cartridge sleeve to include a machined notch in new model operators. Braidwood Limitorque operators are of the redesigned spring cartridge sleeve type. Two new types of hydraulic locking have since (1987) been identified in the spring pack assemblies of Limitorque operators. Limitorque did not state that the hydraulic locking was due to the type grease being used. Presently Limitorque in conjunction with the NRC AEOD (Analysis, Events, and Operations Department) and NUMARC (Nuclear Utilities Management and Resources Committee) are working to resolve these hydraulic locking problems. When a satisfactory resolution has been found, Limitorque will present its corrective actions to the industry. Commonwealth Edison will then take the appropriate corrective actions. At this time, Limitorque has not recommended specific corrective actions. This industry-wide concern is being monitored through our preventive maintenance programs, and is addressed in part by the valve signature program in place at Braidwood. When a new valve signature is compared to the base line valve signature, any change in a valve's current draw will be shown.

In addition, Commonwealth Edison has reviewed INPO SER 20-17 for Braidwood Station and continues to monitor Limitorque operators discussed in that Significant Event Report.

Attachment 2
Lubricant Acceptance Criteria

I. All operators for which both the visual inspection of the lubricant sample and the chemical analysis of the lubricant sample meet the applicable acceptance criteria are acceptable, with no further remedial action required.

   A. The visual test will be acceptable if the sensory tests required to satisfy Limitorque lubricant maintenance requirements are satisfied and no mixture of grease products is identifiable in the sample.

   B. The chemical test will be acceptable if the primary grease constituent exceeds any secondary grease constituent by a ratio greater than or equal to 50 to 1.

II. Any operator for which either the results of the visual inspection of the lubricant or the results of the chemical analysis of the lubricant are questionable based upon identification of an anamoly will be subjected to a penetration test. If the penetration test identifies penetration resistance within a band defined as ± 30 points of the midpoint of the range for the two qualified Limitorque operator lubricants (Nebula EP0, range 355 - 385; Nebula EP1, range 310 - 340) combined, the operator lubrication is acceptable for interim use. (See Appendix 2-1.) Specifically, a penetration test result will be considered acceptable if it is within the range of 295 to 400 points in a standard penetration test. (It should also be recognized that the repeatability of such penetration tests is ± 5 points. Therefore, the acceptance range for the 100% qualified greases, accounting for test repeatability, is 305 to 390 points. Therefore, the proposed acceptance criteria is only ± 10 points outside that range.)

   A. The visual test will be categorized as having an anomaly if any trace of mixed grease product is identifiable or lubricant discoloration is apparent.

   B. The chemical test will be categorized as having an anomaly if the ratio of the primary grease constituent to the secondary grease constituent is between 50 to 1 and 20 to 1.

III. All operators for which any one of the visual, chemical or penetration test results are rejectable will be regreased prior to criticality of either Braidwood 1 or 2.

A. The visual test result will be rejectable if the sensory tests required to satisfy Limitorque maintenance requirements cannot be satisfied. (As described in item 2a of Attachment 1).

B. The chemical test result will be rejectable if the ratio of the primary grease constituent to the secondary grease constituent is less than or equal to 20 to 1.

C. The penetration test will be rejectable if the penetration test result is less than 295 or greater than 400 points.

Appendix 2-1

Group 2 Acceptable Valves Interim Activities

Those valve operators found acceptable for use as defined in Attachment 2, Item II shall meet the following acceptance criteria: (i.e. group 2 acceptance criteria)

a) Operators containing calcium based grease will have a calcium to lithium ratio between 50:1 (98%) and 20:1 (95%), and have penetration test results from 295mm to 400mm.

b) Operators with lithium based grease will have a calcium to lithium ratio between 1:20 (5%) and 1:50 (2%), and have penetration test results from 310mm to 370mm.

Valves accepted by the above criteria will be subject to the following additional actions:

1. Unit 1 valve operators accepted via the group 2 acceptance criteria will remain in service until the first scheduled refueling outage, currently estimated to occur in May of 1989. During the refueling outage these valve operators will be degreased, cleaned and regreased using approved site procedures.

2. Unit 2 valve operators accepted via the group 2 acceptance criteria will remain in service until the first refueling outage, at which time the valve operators will be degreased, cleaned and regreased. In addition the Unit 2 valve operators will receive an interim review during the scheduled Unit 2 surveillance outage, currently estimated to take place in January of 1989. The following activities will be performed on the unit 2 group 2 accepted valve operators.

   a) The operators will be visually checked for signs of lubricant leakage.

   b) The valve operator will be monitored as the valve is stroked for abnormal noise levels.

   c) Current signature analysis will be performed and compared to baseline current signatures.

If any of the three activities indicates a significant change in the lubricant performance, one of the following actions will be taken. A penetration test will be performed on the lubricant to determine if the lubricant is acceptable for continued operation to the first refueling outage, or the operator will be degreased, cleaned and regreased in accordance with approved site procedures. In addition, if significant deterioration of grease in three or more Unit 2 operators is identified, a supplemental Unit 1 evaluation will be undertaken promptly. This Unit 1 activity will be promptly reported to the NRC.

(6918z/26)

REFERENCES: 1) March 29, 1988 Letter L. O. DelGeorge to T. E. Murley, Attachment 2, Page 9

2) NRR and Region III NCR Meeting at Braidwood site April 4, 1988 with CECo

Attachment 3
Summary of Results (4-8-88)

Background:

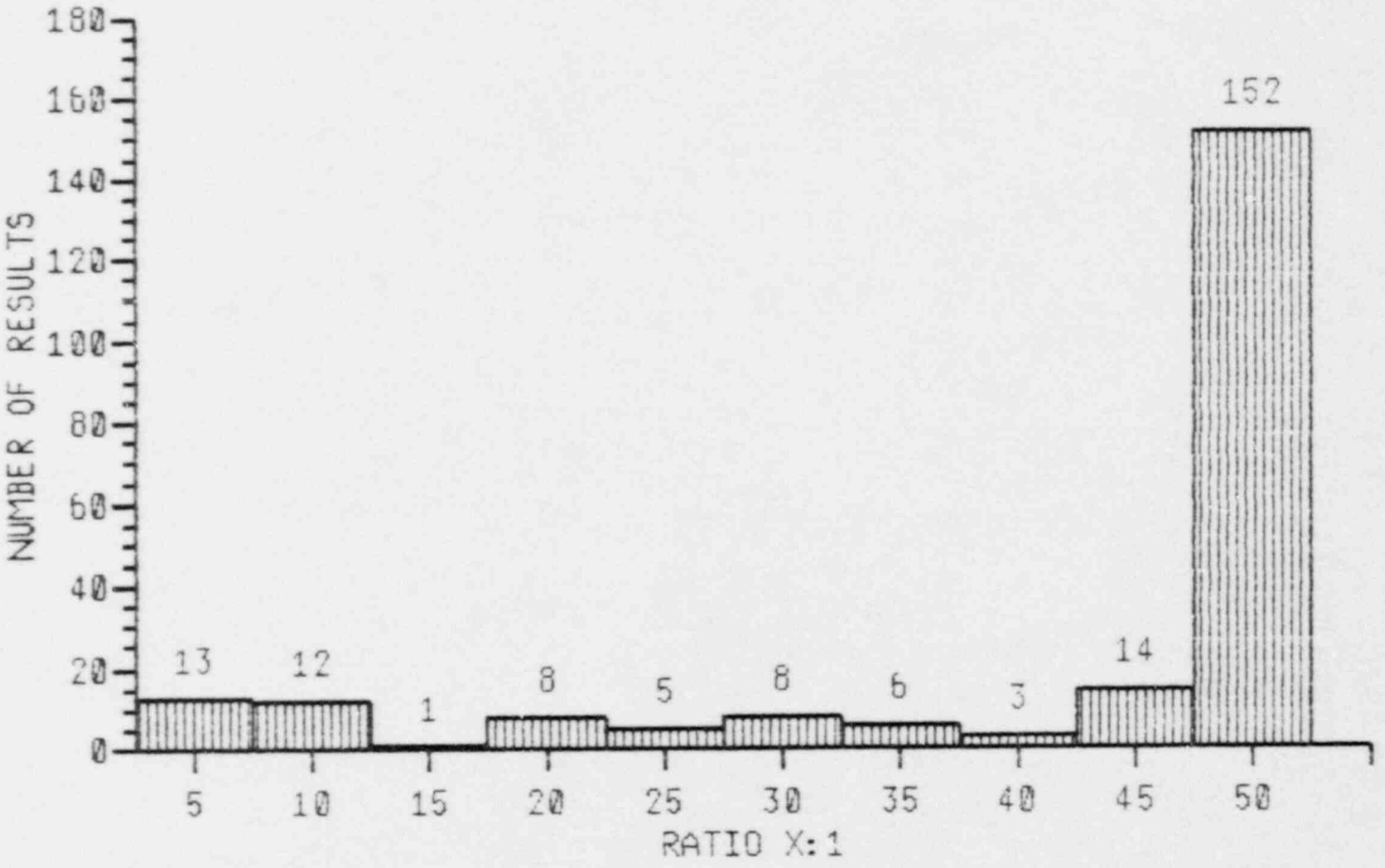
Total of Safety Related (S/R) Limitorque Operators	263
Total S/R Operators in Harsh Environments	182
Total Grease Samples Taken (Complete 4-05-88)	263
Total Visual Inspections Completed (Complete 4-05-88)	263
Total Chemical Tests Completed (Complete 4-06-88)	263
Total Penetration Tests Completed (Completion Est. 4-12-88)	121*

NOTE: A detailed summary of test results is provided as an Appendix to this Attachment (Appendix 3-1).

* Total of 122 required.

ATTACHMENT 3
April 8, 1988

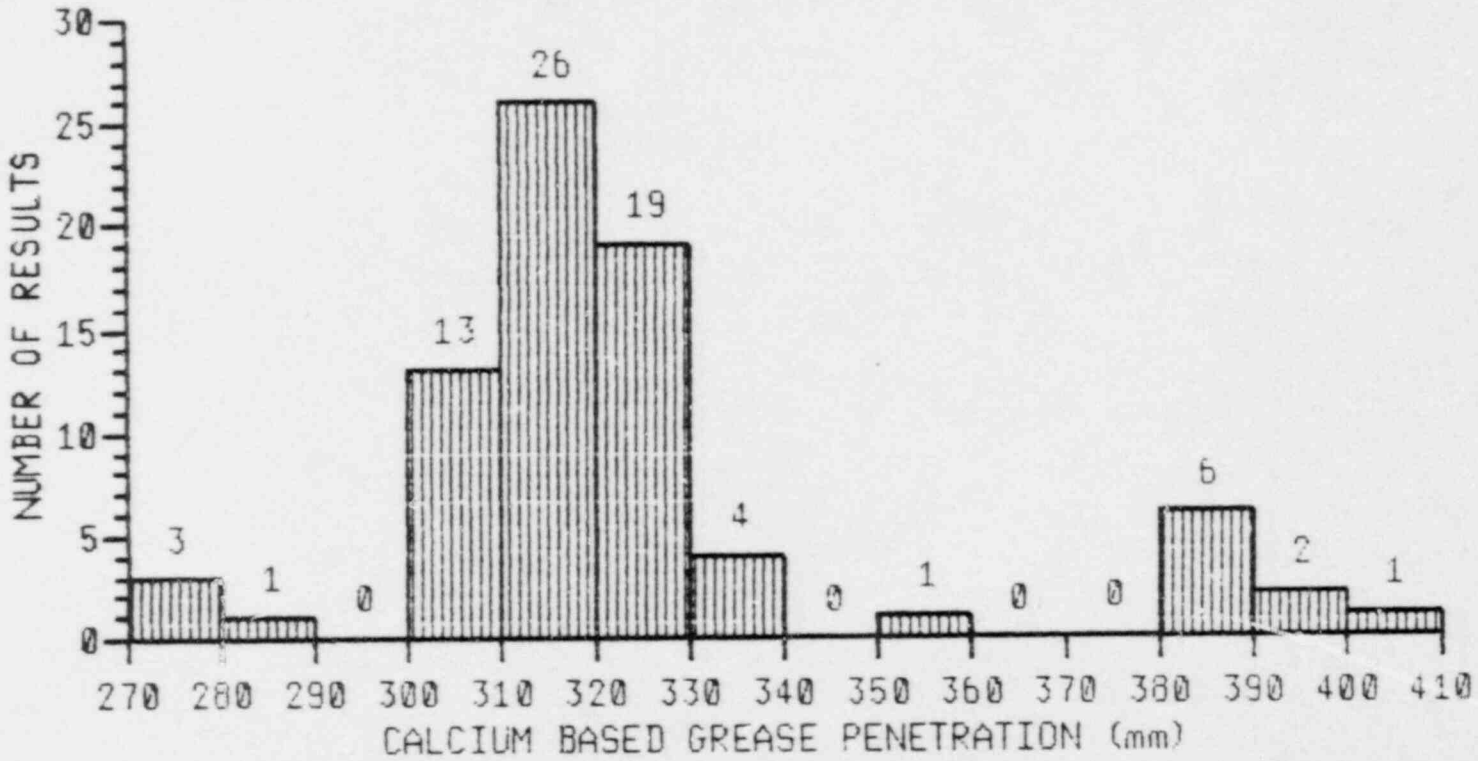
SMAD RESULTS (TO DATE)
CALCIUM BASED GREASE



ATTACHMENT 3
APRIL 8, 1988

ALI RESULTS (TO DATE)
CALCIUM

GROUP 1				1	3	1							1	
GROUP 2				9	7	11	2		1			3		
GROUP 3	3	1		3	16	7	2					3	1	1



ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

SAMPLING PROGRAM

- SAMPLES TAKEN FROM 263 LIMITORQUES
  (182 LIMITORQUES IN HARSH ENVIRONMENT)
- SAMPLES TAKEN FROM EACH ACCESSIBLE PORT ON LIMITORQUE
- EACH SAMPLE VISUALLY CHECKED FOR CONTAMINATION,
  SEPARATION & MIXING

ANALYSIS OF SAMPLES

- RATIO OF CALCIUM TO LITHIUM DETERMINED FOR EACH SAMPLE
  BY SYSTEM MATERIAL ANALYSIS DEPARTMENT (SMAD) USING
  ATOMIC ABSORPTION SPECTROSCOPY

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 1 VISUALLY ACCEPTABLE AND RATIO CALCIUM TO LITHIUM $\geq$ 50:1

  - UNIT #0 5 CALCIUM

    1 LITHIUM

  - UNIT #1 60 CALCIUM

    0 LITHIUM

  - UNIT #2 61 CALCIUM

    5 LITHIUM

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 2 RATIO CALCIUM TO LITHIUM < 50:1 BUT > 20:1 OR VISUAL COMMENT

  (1E: MIXED, CONTAMINATED)

- TOTAL GROUP 2 POPULATION

  - UNIT #0 3 CALCIUM

    1 LITHIUM

  - UNIT #1 24 CALCIUM

    8 LITHIUM

  - UNIT #2 20 CALCIUM

    7 LITHIUM

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

GROUP 2 ADDITIONAL TESTING

- EACH GROUP 2 LIMITORQUE HAD ADDITIONAL SAMPLE TAKEN FOR PENETRATION TEST

  TESTED BY AUTORESEARCH LABORATORY, INC. (ALI)

- GROUP 2 PENETRATION TEST ACCEPTANCE CRITERIA

- CALCIUM (EP0/EP1)

  295 - 400 MM

- LITHIUM (SUN 50EP)

  310 - 370 MM

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ALI RESULTS

- UNIT #0

  CALCIUM

1	ACCEPTABLE	1 NON EQ
2	RESULTS PENDING	2 NON EQ

  LITHIUM

1	ACCEPTARLE	1 NON EQ

- UNIT #1

  CALCIUM

14	ACCEPTABLE	13 EQ 1 NON EQ
10	RESULTS PENDING	9 EQ 1 NON EQ

  LITHIUM

7	ACCEPTABLE	7 NON EQ
1	RESULT PENDING	1 NON EQ

- UNIT #2

  CALCIUM

19	ACCEPTABLE	16 EQ 3 NON EQ
1	RESULT PENDING	1 EQ

  LITHIUM

6	ACCEPTABLE	6 NON EQ
1	RESULT PENDING	1 NON EQ

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ALI RESULTS

- UNIT #0
  - 4 CALCIUM RESULTS PENDING
  - 1 LITHIUM ACCEPTABLE
- UNIT #1
  - 10 CALCIUM ACCEPTABLE
  - 18 CALCIUM RESULTS PENDING
  - 11 LITHIUM RESULTS PENDING
- UNIT #2
  - 11 CALCIUM ACCEPTABLE
  - 9 CALCIUM RESULTS PENDING
  - 3 LITHIUM ACCEPTABLE
  - 5 LITHIUM RESULTS PENDING

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 3 RATIO CALCIUM TO LITHIUM $\leq$ 20:1

- UNIT #0	1 CALCIUM	1	NON EQ
	2 LITHIUM	2	NON EQ
- UNIT #1	21 CALCIUM	19	EQ
		2	NON EQ
	12 LITHIUM	12	NON EQ
- UNIT #2	27 CALCIUM	27	EQ
	5 LITHIUM	5	NON EQ

ATTACHMENT 3
APRIL 8, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

REWORK OF GROUP 3 LIMITORQUE

- EACH LIMITORQUE IS BEING DISASSEMBLED AND THE EXCESS GREASE WIPED OFF AND THEN CLEANED IN VARSOL.

- SPRING PACK IS BEING CLEANED AS AN ASSEMBLY USING VARSOL IN A BATH PARTS CLEANER.

- EACH LIMITORQUE REASSEMBLED WITH EP1 GREASE.

Attachment 4
10 CFR 50.49 Evaluation

10 CFR 50.49(a) states:

"Each holder of or each applicant for a license to operate a nuclear power plant shall establish a program for qualifying the electrical equipment defined in paragraph (b) of this section."

10 CFR 50.49(f) states, in part

"Each holder of electrical equipment important to safety must be qualified by one of the following methods:
. . . (4) Analysis in combination with partial type test data that supports the analytical assumptions and conclusions"

Edison has established a program that addresses the environmental qualification of mixed grease at Braidwood Station. Compliance with 10 CFR 50.49(f) can be demonstrated by that which is presented in this letter and its Attachments. Attachment 1 provides references to a summary of the test data that supports the conclusion that the grease will function in a radiation environment. Attachment 1 also provides a summary of the testing that will be performed to supplement the existing test data. Upon completion of this testing, we will perform the final analysis that will determine those valve actuators that can be qualified. This approach will fully implement 10 CFR 50.49(f) (4) and demonstrate environmental qualification.

It should also be recognized that the subject lubricant is not itself electrical equipment. However, it is considered to be a part of the EQ program, as defined in 10 CFR 50.49, since it must fulfill its intended function which is to lubricate. As such, full grease qualification testing, as defined in IEEE 323-74, is not specifically required for lubricants and can be accomplished through a program of testing of the type described in Attachment 1. Therefore, it is judged that the test data and analysis being conducted will demonstrate compliance with 10 CFR 50.49.

Based on that test data and analysis, the following specific qualification conclusions have been reached.

1. Any qualified Limitorque operator for which visual inspection identifies no signs of lubricant leakage, and lubricant sampling identifies no sensory anomaly (i.e., material contamination, separation or mixture) and, based on chemical analysis, demonstrates the chemical composition of the lubricant to be the lubricant specified (constituent

ratio $\geq$ 50 to 1) is acceptable for use by Limitorque as part of the Braidwood EQ program, and is considered qualified.

2. Any qualified Limitorque operator for which visual inspection or lubricant sampling (mixture suspected or constituent ration between 50 to 1 and 20 to 1) identifies an anomaly but for which penetration resistance is acceptable (i.e., within the range 295 - 400) is considered qualified. However, that qualification is for a limited period not to exceed 13 months without further lubricant evaluation).

3. Any qualified Limitorque operator for which visual inspection or lubricant sampling or penetration identifies an unacceptable lubrication anomaly, will be considered unqualified until the anomaly is rectified. This can be accomplished by cleaning out the lubricant and regreasing the operator.

Attachment 5

Handouts: Braidwood Station Lubrication Evaluation
Meeting, April 4, 1988

(6918z/31)

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

SAMPLING PROGRAM

- SAMPLES TAKEN FROM 263 LIMITORQUES
  (182 LIMITORQUES IN HARSH ENVIRONMENT)
- SAMPLES TAKEN FROM EACH ACCESSIBLE PORT ON LIMITORQUE
- EACH SAMPLE VISUALLY CHECKED FOR CONTAMINATION, SEPARATION & MIXING

ANALYSIS OF SAMPLES

- RATIO OF CALCIUM TO LITHIUM DETERMINED FOR EACH SAMPLE BY SYSTEM MATERIAL ANALYSIS DEPARTMENT (SMAD) USING ATOMIC ABSORPTION SPECTROSCOPY

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 1 VISUALLY ACCEPTABLE AND RATIO CALCIUM TO LITHIUM $\geq$ 50:1

  - UNIT #0 5 CALCIUM

    1 LITHIUM

  - UNIT #1 56 CALCIUM

    0 LITHIUM

  - UNIT #2 62 CALCIUM

    5 LITHIUM

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 2 RATIO CALCIUM TO LITHIUM < 50:1 BUT > 20:1 OR VISUAL COMMENT

  (1E: MIXED, CONTAMINATED)

- TOTAL GROUP 2 POPULATION

  - UNIT #0 4 CALCIUM

    1 LITHIUM

  - UNIT #1 28 CALCIUM

    11 LITHIUM

  - UNIT #2 21 CALCIUM

    8 LITHIUM

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

GROUP 2 ADDITIONAL TESTING

- EACH GROUP 2 LIMITORQUE HAD ADDITIONAL SAMPLE TAKEN FOR PENETRATION TEST

  TESTED BY AUTORESEARCH LABORATORY, INC. (ALI)

- GROUP 2 PENETRATION TEST ACCEPTANCE CRITERIA

- CALCIUM (EPO/EP1)

  (310 - 385) $\pm$ 45

- LITHIUM (SUN 50EP)

  (330 - 350) $\pm$ 45

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ALI RESULTS

- UNIT #0
  - 4 CALCIUM RESULTS PENDING
  - 1 LITHIUM ACCEPTABLE
- UNIT #1
  - 10 CALCIUM ACCEPTABLE
  - 18 CALCIUM RESULTS PENDING
  - 11 LITHIUM RESULTS PENDING
- UNIT #2
  - 11 CALCIUM ACCEPTABLE
  - 9 CALCIUM RESULTS PENDING
  - 3 LITHIUM ACCEPTABLE
  - 5 LITHIUM RESULTS PENDING

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

ANALYSIS RESULTS

- GROUP 3 RATIO CALCIUM TO LITHIUM $\leq$ 20:1

  - UNIT #0 0 CALCIUM

    2 LITHIUM

  - UNIT #1 21 CALCIUM

    9 LITHIUM

  - UNIT #2 25 CALCIUM

    4 LITHIUM

ATTACHMENT 5
April 4, 1988

LIMITORQUE GREASE SAMPLE PROGRAM

REWORK OF GROUP 3 LIMITORQUE

- EACH LIMITORQUE IS BEING DISASSEMBLED AND THE EXCESS GREASE WIPED OFF AND THEN CLEANED IN VARSOL.

- SPRING PACK IS BEING CLEANED AS AN ASSEMBLY USING VARSOL IN A BATH PARTS CLEANER.

- EACH LIMITORQUE REASSEMBLED WITH EP1 GREASE.