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March 29, 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 Unit 2
Limitorque Operator Lubrication
NRC Docket Nos. 50-456 and 50-457

The purpose of this letter is to document information provided to the NRC Staff in telephone meetings on March 25, 1988 and March 28, 1988 concerning the ongoing Commonwealth Edison program to validate the adequacy of Limitorque operator lubrication at Braidwood Units 1 and 2. This program was undertaken to resolve the concern created recently upon the discovery by Commonwealth Edison of trace amounts of a grease product not qualified for harsh environment service in a Limitorque operator subject to harsh environment requirements. Although all safety-related Limitorque operators were sampled in 1985/1986 to ensure proper lubrication products were installed, the recent sample anomaly has resulted in an extensive program, described in attachments to this letter, to resolve all reasonable concerns related to the qualification of the affected Limitorque operators.

Attachment 1 to this letter, entitled Lubrication Contamination Evaluation, discusses the background to the issue and describes the sampling and testing program underway to identify unacceptable lubricants.

Attachment 2 to this letter provides a summary of the logic to be used to evaluate the acceptability of an operator based upon the sampling and testing program.

Attachment 3 to this letter provides a summary of the sampling and testing results compiled through March 28, 1988.

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Attachment 4 to this letter discusses the applicability of 10 CFR 50.49 to the lubrication issue being addressed herein.

It is our understanding that the NRC Region III Staff has lead responsibility for coordinating the review of this issue. We further understand that the NRR Staff is providing technical expert support on matters related to lubricant adequacy. The materials provided in this letter are intended to facilitate that technical review.

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

Attachment 1

Lubrication Contamination Evaluation
Braidwood Unit 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 motor 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, the result of 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 qualified by Limitorque 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 visual inspection of grease samples from all safety-related operators. This sample was taken from the grease injection point at the top of each operator. Forty valves were determined by visual observation 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 fourteen valves were determined by visual observation to have Nebula EP0 grease in the gearbox. The remaining 109

valves (S/R, EQ and non-EQ) had indications of mixed greases by visual examination.

Of those 109 valves, 43 of the operators were removed to the mechanical maintenance shop where they were disassembled and degreased. They were then regreased in the field with Nebula EPO grease.

The remaining 66 valves were maintained by Project Construction Department (PCD). These 66 operators were drained of grease, the geartrain components were removed and degreased in a bucket, 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 EPO grease.

Based upon this 100% 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 sample was taken only from the top of the operator, whereas the recent samples are being drawn from the top, middle and bottom of the operator. Second, the solvent cleaning of operators in place, though consistent with common accepted practice, could have left traces of the removed

lubricant in the operator in hideout locations not identified during the cleaning or in uncleaned locations at the sampling points. With respect to this second point, the opening and detailed inspection of operators on valves ICC9412A, 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. (Additional supporting information of this type is expected as more operators are opened for cleaning and regreasing.)

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 1403). 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 appropriate 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, indicate a mix of lubricants, a penetration test will be performed. The penetration test will be used to determine if softening or hardening of the installed lubricant is occurring. The samples found to have either visual indication of mixing of lubricant types or that have penetration values outside those of a non-contaminated qualified lubricants will then be subjected to periodic inspection or regreased based on defined acceptance criteria. Further, for those Limitorque gearboxes identified with mixed grease by visual or chemical test, the lubricant will be replaced as soon as practicable, but no later than startup after the first refueling outage. This overall approach is in agreement with the NRR position taken with Duke Power (September, 1986) in that the acceptability of the lubricants is established through a combination of inspection and testing on a periodic basis. This methodology will insure the adequacy of the lubricant and not compromise plant safety.

A detailed explanation of this inspection and testing program is described in later sections of this discussion and is defined in Attachment 2.

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 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 from either excessive leakage at the seals or from sampling of the contents of the gearbox. Inspections to date of the installed Limitorque operators at Braidwood have not revealed any signs of excessive leakage of the gearbox seals.

The other issue regarding incompatability of mixed greases is hardening. This issue is addressed by the sampling of the contents of the gearboxes and the penetration testing that is 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. 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 point variation in this test procedure.

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 Limitorque operators, plant surveillances such as the signature analysis of selected operators will 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.
2. Do a visual examination in accordance with Braidwood procedure BwFP FS-1, Rev. 0 of samples (using three point technique) 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. 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 actuator and sent to the lab (See Note 1) for a micro penetration test (ASTM 1403). If the test indicates that the grease has hardened or softened by more than 45 points in an ASTM worked penetration test (Reference 5), the grease in the actuator will be changed out.

In addition, one additional sample of grease will be pulled for a second penetration test after an approximately nine month period. Should this test show significant hardening or softening, the grease will be monitored on a more frequent basis until an outage of sufficient duration allows for the grease to be changed out.

3. All actuators that show visual indications of grease contamination with another grease will have a grease change-out at the next scheduled refueling outage.

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

4. 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.

5. In addition to the testing described above, the following mixtures of virgin grease will be worked and then 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.

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

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

This additional testing 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). A status of the grease sampling activity is provided as an attachment to this write up.

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.

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 anomoly will be subjected to a penetration test. If the penetration test identifies penetration resistance within $\pm$ 45 points of the range defined by qualified Limitorque operator lubricants (Nebula EP0 or EP1, Range 310 - 395), the operator lubrication is acceptable for interim use.

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 lubricant maintenance requirements cannot be satisfied.

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 range of acceptable penetration is exceeded by $\pm$ 45 penetration points.

Attachment 3

Summary of Results (3-20-88)

Background:

Total of Safety Related (S/R) Limitorque Operators	263
Total S/R Operators in Harsh Environments	182
Total Grease Samples Taken	233
(Complete 3-30-88)	
Total Visual Inspections Completed	233
(Complete 3-31-88)	
Total Chemical Tests Completed	186
(Complete 4-01-88)	
Total Penetration Tests Completed	25
(Completion Est. 4-02-88)	

NOTE: A detailed summary of test results is being prepared and will be made available to the NRC Staff on or before 8-31-88.

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. Complaince 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 only 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.