Supply Chain Task Group

Task: SC-18-02

White Paper on CGD of Grease Lubricants

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EXECUTIVE SUMMARY

This white paper presents an acceptable method of performing commercial grade dedication (CGD) for Oil and Greases.

The method of dedication is by comparison of selected critical characteristics to determine if the item is equal to or better than the original item. National standards (e.g., ASTM) establishes certain process controls and end product acceptance requirements. The dedication parameters must verify the selected critical characteristics by independent testing.

Critical Characteristic	**Grease Method**
Product Name	Visual
Batch Identification	Visual, material control
	Operating temperature
	Color {compare original product}
	Odor {compare original product}
	Feel {buttery}
	Thickener
Worked Penetration {Cone Penetration}	ASTM D1403/D217
Dropping Point	ASTM D566/D2265

1. PURPOSE

To establish methods to satisfy the quality assurance (QA) requirements of

- U.S. Department of Energy (DOE) O414.1D with DOE G 414.2;
- American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA) -1;
- the Office of Environmental Management, and
- Environmental Management-Quality Assurance Plan (EM-QAP)

This ensures that commercial grade items (CGI) of oil and grease lubricants are selected, purchased, and used in safety-related equipment will not degrade the safety or the qualification of the system/assembly in which they are installed.

To establish documentation to substantiate the engineering technical evaluation and verification of CG items being used in safety-related applications.

To obtain reasonable assurance via engineering evaluations that those items either already purchased or being purchased as Commercial Quality (CQ) are adequate for use in safety-related applications. Reasonable assurance consists of controlling or verifying the item's quality to an extent consistent with the item's importance to safety and/or ensuring that quality is adequately controlled by the supplier.

2. INTRODUCTION:

Greases must meet several requirements, as shown below:

Properties	Greases
Prevent metal/metal contact	x
Protect against wear	x
Protect against corrosion	x
Protect against deposits	x
Remain in place	x

In normal operation, lubricants must withstand the stresses of temperature, shear, pressure (load), and exposure to oxygen in the air. An additional stress in nuclear facilities is exposure to nuclear radiation. The overall effects of thermal and radiation exposures are similar; in that, both show thresholds below which changes in properties are not significant.

Lubricants can be incompatible with one another on mixing and have the potential to cause degradation of properties and performance. With greases, the usual result of incompatibility is breakdown of the grease gel structure to produce softness.

Different greases should not be mixed. With inadvertent mixing, compatibility risks are generally lower if products with at least the same gelling agent are involved. However, reversals do occur. Special attention should be paid to polyurea grease compatibility because this type is commonly used and there is a wide variety of polyurea thickener systems, some of which might actually be compatible with other thickener. For any polyurea grease, one should run compatibility tests for potential mixing situations just to be sure.

Grease with inadvertent mixing, possible additive interactions (other than those involving gelling agents) pose only some loss of the functions provided by the reactants. Precipitates are generally no problem (grease is already semisolid). Gelling agent interaction is a concern, depending on the application.

The method of dedication is by comparison of selected critical characteristics for design to determine if the item is equal to or better than the original. This is done by determining selected critical characteristics for design of the items with the same critical characteristics for design of the original item. National standard (e.g., ASTM) only establishes certain process controls and end product acceptance requirements. The dedication parameters must verify the selected critical characteristics by independent testing.

3. TECHNICAL REQUIREMENTS:

DETERMINATE IF THE ITEM OR SERVICE IS ELIGIBLE FOR CGI DEDICATION

The following criteria validate the item as eligible for commercial grade item dedication:

- The item being dedicated is classified as safety related by the end user.
- The item is not subject to design or specification requirements that are unique to facilities or activities licensed or regulated by DOE or the USNRC (the item is used in applications other than facilities or activities licensed or regulated by the federal government).
- The item is ordered from the manufacturer/supplier based on specifications set forth in the manufacturer's published product description.
- The item's critical characteristics can be verified.

GREASE FUNCTIONAL REQUIREMENTS

Grease is used to lubricate various components such as bearings, as specified in procedures and manufacture's technical manuals. These usually specify particular types of grease that are acceptable or specify a National Lubricating Grease Institute (NLGI) grade number grease. The grade number is based on the worked penetration which is a measure of the hardness of a grease and its ability to stay in place. The grease must function over the temperature range of the equipment. The function of grease is to remain in contact with and lubricate moving surfaces without leaking and must maintain its properties under shear at all temperatures

GREASE SAFETY FUNCTION REQUIREMENTS:

The safety function of grease is to lubricate various components to ensure safety related equipment will operate as required by reducing friction between two surfaces in motion.

Safety related greases are rated for specific application for the parent equipment function and environment.

Grease must perform within the temperature limits or applications of the parent

4. GREASE CRITICAL CHARACTERISTICS FOR DESIGN (CCD):

The National Lubricating Grease Institute (NLGI) grade range is the most critical characteristic for design of a grease. It is based on the worked penetration of the grease. The dropping point of a grease is a parameter which indicates the temperature at which the first drop of fluid separates from a grease. It is indicative

of the temperature range of the grease. The manufacturer's formulation is critical to the design of the grease and specific service conditions.

Grease is a near solid lubricant with a makeup of normally soap emulsified with mineral or vegetable oil. Grease possess a high initial viscosity, which upon the application of shear, drops to give the effect of an oil-lubricated bearing of approximately the same viscosity as the base oil used in the grease.

CCD are defined by the manufacture. Typical Design parameters for Grease:

NLGI Grade
Operating Temperature, minimum and maximum
Penetration at 25C, unworked and worked
Dropping Point
High temperature life
Lincoln Ventmeter, psig at 30 c at 75F.30F, and 0F
Thickener, % and type
ISO Viscosity Grade and base oil equivalent
Viscosity Kinematic cSt at 40C and 100C
Viscosity Saybolt, SUS 100F and SUS 210F
Viscosity Index
Flash Point, degree C or F
Pour point, degree C or F
Texture
Color

5. GREASE CRITICAL CHARACTERISTICS FOR ACCEPTANCE (CCA):

Worked Penetration

Worked penetration is essential to the grease's performance. Worked penetration testing is defined in:

- ASTM standard Method D 217, "Standard Test Methods for Cone Penetration of Lubricating Grease".

- ASTM D1403 "Test Methods for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment" as an alternate.

This test is used to establish consistency as determined by the original design or manufacture. The results of the test determine if the lubricating grease meets the required consistency.

Dropping point

Dropping point is critical to the grease operating over the equipment's temperature range. This determines the temperature when the lubricating grease passes from

a semi-solid to a liquid state indicating the type of thickener used and a measure of the cohesiveness of the oil and thickener of grease. Dropping point is applicable only to grease that contain soap thickeners. Greases with other thickeners like synthetic types of grease do not change state. Dropping point testing is defined in:

- ASTM standard Method D 566 “Standard Test Method for Dropping Point of Lubricating Grease” and

- ASTM D2265, “Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range”

Product identification & Color

Product identification and color together provide reasonable assurance that the formulation is what was procured.

Specific verification of the formulation was not necessary since worked penetration provides adequate assurance the grease will function as intended.

ENVIRONMENTAL REQUIREMENTS

Generally, radiolysis of lubricants is not a problem in nuclear facilities. It takes radiation doses above those prevailing in normal nuclear plant operations to make appreciable changes in bulk properties of lubricants. See the following table for radiation effects on greases:

Common Greases

Radiation Dose	Effects
$<10^6$ rads	No unusual problems
10^6–10^7 rads	Things begin to happen; some greases borderline
10^7–10^8 rads	Most high-quality products usable; others not
10^8–10^9 rads	Most greases unusable
10^9–5×10^9 rads	Special products required
$>5 \times 10^9$ rads	No grease usable

The approximate 10^7 rads level is an irradiation threshold. Below it, most lubricants can tolerate irradiation. Appreciably above it, the life of most lubricants is increasingly at risk. Similar temperature thresholds exist for many lubricants. Up to a certain level, thermal effects are relatively minor but, above that threshold, the thermal component of total stress can become increasingly large. This is tied

in, of course, to the approximate doubling of chemical reaction rate by each increase of 10°C (18°F) in temperature. If the rate is very low, a doubling does not do much. When the reaction rate is appreciable, doubling has a discernible effect. The threshold is where this rate becomes apparent. This thermal effect provide the following approximation:

Operating temperature	Relubricated months
93C (200F) operation	36 months schedule
104C (220F)	18 months
121C (250F)	9 months

Thus, thermal has an effect of shortening the useful life of the lubricant up to a catastrophic event.

Greases are not subject to seismic considerations. This item is considered to be seismically rugged for nuclear facilities. Verification of the critical characteristics for acceptance listed in the evaluation are sufficient without requirement of seismic qualification needed. Essentially a Like-for-Like evaluation.

Although harsh applications affect the useful life of both grease and oils, the approach to dedication is identical; although the selection of products need to address elevated parameters. Thus additional testing for harsh environments, which is common for most items, will not be required.

6. VERIFICATION IS BY METHOD 1, SPECIAL TESTS and INSPECTION

The dedication parameters must verify the selected critical characteristics by independent testing.

Grease

Characteristic	**Method**
Product Name	Visual
Batch Identification	Visual, for material control
Color	Visual per manufacture
Worked Penetration	**ASTM D1403/D217*** *: D217 is the reference method; ASTM D1403 is acceptable alternative method and preferable for this purpose as a smaller sample of grease is required.

Dropping Point	ASTM D566/D2265 Manufacture provides minimum temperature

Product identification and color together provide reasonable assurance that the formulation is what was procured.

Sampling

Sampling shall be based upon standard statistical methods with supporting engineering justification and shall consider lot/batch traceability, homogeneity, and the complexity of the item. One generally accepted source for developing sampling plans is EPRI Final Report TR-017218-R1, "Guideline for Sampling in the Commercial-Grade Item Acceptance Process," which provides an enhanced methodology for the use of sampling in accepting and dedicating CGIs. Use of this EPRI guide provides useful information in establishing the basis for the sampling plan, but users of this report should consider the document in total and clearly document the rationale for the selected sampling method.

7. SOURCES OF DESIGN PARAMETERS

First and foremost, the selection of the proper lubricant should be based on the equipment manufacturer's recommendations.

The Safety Data Sheet for the product provides the "Typical Test Data" sheet which identify the design parameters; wherein, the related ASTM test and acceptance range can be determined.

Prior tests performed on the grease or oil being replaced.

Grease penetration is defined by Standard National Lubricating Grease Institute (NLGI) grease consistency classes (grade definitions) are as follows:

NLGI Grade No.	ASTM (D 217) Penetration, 60 Stroke, Worked, 25°C (77°F), 0.1 mm
000	445–475
00	400–430
0	355–385
1	310–340
2	265–295
3	220–250
4	175–205
5	130–160
6	85–115

The following is a historical example of SRI Grease 2:

Source	WORKING PENETRATION	Dropping Point
2SRI-2	280	243C/470F
NLGI	265-295	450F

Manufactures over time may change absolute value, but remain within the ASTM ranges.

8. SUMMARY

The following characteristics are to be verified:

Characteristic	Grease Method
Product Name	Visual
Batch Identification	Visual, material control Operating temperature Color {compare original product} Odor {compare original product} Feel {buttery} Thickener
Worked Penetration {Cone Penetration}	ASTM D1403/D217
Dropping Point	ASTM D566/D2265

9. . REFERENCES

1. EPRI Final report 1019518, December 2009, Nuclear Maintenance Applications Center: Lubrication Guide, Revision 4 (Formerly 1003085 which replaced EPRI NP-4916 Lubrication Guide R3, and EPRI NP-4735 Radiation Effects on Lubricants)

2. CHEVRON SRI GREASE 2, GR-110, 18 DECEMBER 2014, PRODUCT DESCRIPTION

3. ASTM standard Method D 217 Standard Test Methods for Cone Penetration of Lubricating Grease

4. ASTM D1403, Test Methods for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment

5. ASTM standard Method D 566 Standard Test Method for Dropping Point of Lubricating Grease

6. ASTM D2265 Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range