Solar Turbines
A Caterpillar Company

SPECIFICATION

SPECIFICATION FOR LUBRICATING OILS FOR USE IN SOLAR GAS TURBINE ENGINES

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TABLES

1.0 SCOPE - This specification establishes the types of lube oil that can be used in Solar gas turbine engines, gears and driven equipment during normal operating service. This specification also provides guidelines on use and replacement of lube oils in the field.

1.1 ENGINE PRESERVATION - The oils in this specification are suitable for preservation of the engine, gears and driven equipment for a period of up to 90 days. If storage, shipping or down time longer than 90 days is expected, special instructions for preservation shall be obtained from Solar. Information on corrosion preventive oils for long term preservation is provided in ES 9-248 and ES 9-248-1. Preservation of air/gas path surface and fuel system shall be in accordance with ES 9-249.

1.2 CONVENTIONAL OIL TYPES - The following oil types are suited for use on Solar turbomachinery provided that they are in compliance with all the requirements of this specification.

- Synthesized Hydrocarbon Oils (SHC)
- Petroleum Oils

1.3 SPECIALTY OIL TYPES - The following specialty types of lubricating oils require a complex project review and approval prior to quotation. The complex project review must examine and ensure all components that may contact the lubricating oil (such as hoses, elastomers, paint systems or sealers used to coat the internal surfaces of components) are fully compatible with the specialty oil type. Changeover to specialty oils in the field is not recommended, unless approved by Solar Engineering

- Synthetic Ester Oils
- Phosphate Ester Oils (Fire Resistant Lubricants)

1.4 USAGE - Where a Solar drawing references this specification without specifying the oil type, only synthesized hydrocarbons and petroleum oils (i.e. Conventional Oils) can be used as defined herein.

1.4.1 EXCEPTIONS - Only Mercury 50 requires the use of Class III (Synthetic Ester) Oils.

1.5 OIL MIXING - Conventional oils are miscible and can be used interchangeably in the lube system. In other words, synthesized hydrocarbons can be added to a lube oil system that is filled with a petroleum oil, as the addition of a higher performing oil type will improve the net properties of the bulk oil mixture. Conversely, the addition of a lower performing oil type such as a petroleum oil to synthesized hydrocarbon will have the net effect of lowering the bulk properties of the oil mixture. Specialty oils must not be mixed with conventional oils nor with each other.

2.0 APPLICABLE DOCUMENTS - the following documents of the issue in effect on the date of this specification from a part of this specification to the extent specified herein.

SOLAR

ES 9-248	Corrosion Preventive Oil for Long Term Preservation
ES 9-248-1	Corrosion Preventive Oil for Factory Test and Long-Term Preservation: Addendum 1 to ES 9-248
ES 9-249	Preservation, Turbomachinery, Air Side and Fuel System

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM D92	Standard Test Method for Flash and Fire Points by Cleveland Open Cup (AASHTO NO.: T48 (DIN 51 376) (IP 36/84)

ASTM D97	Standard Test Method for Pour Point of Petroleum Oils [IP 15/67(86)]
ASTM D130	Standard Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test (IP 154/86) (British Standard 4351)
ASTM D445	Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity) (British Standard 4708) (IP Designation: 71/84)
ASTM D664	Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration (British Standard 4457) (IP 177/83)
ASTM D665	Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water (IP 135/85)
ASTM D892	Standard Test Method for Foaming Characteristics of Lubricating Oils (British Standard 5092) (IP 146/82)
ASTM D943	Standard Test Method for Oxidation Characteristics of Inhibited Mineral Oils (British Standard 4388)
ASTM D974	Standard Test Method for Acid and Base Number by Color-Indicator Titration (British Standard 2634) (IP 139/86)
ASTM D1169	Standard Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids
ASTM D1298	Standard Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method (British Standard 4714) (API MPMS Chapter 9.1) (IP 160/82)
ASTM D1401	Standard Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
ASTM D6304	Standard Test Method for Determination of Water in Liquid Petroleum Products, Lubricating Oils and Additives by Coulometric Karl Fischer Titration
ASTM D2161	Standard Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
ASTM D2270	Standard Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100EC (British Standard 4459) (IP Designation: 226/91)
ASTM D2272	Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
ASTM D2422	Standard Classification of Industrial Fluid Lubricants by Viscosity System

ASTM D3427	Standard Test Method for Gas Bubble Separation Time of Petroleum Oils
ASTM D3605	Standard Test Method for Trace Metals in Gas Turbine Fuels by Atomic Absorption and Flame Emission Spectroscopy
ASTM D4172	Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method)
ASTM D4293	Standard Specification for Phosphate Ester Based Fluids for Turbine Lubrication
ASTM D4308	Standard Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter
ASTM D4628	Standard Test Method for Analysis of Barium, Calcium, Magnesium, and Zinc in Unused Lubricating Oils By Atomic Absorption Spectrometry
ASTM D5182	Standard Test Method for Evaluating the Scuffing (Scoring) Load Capacity of Oils
ASTM D7843	Standard Test Method for Measuring the Color of Insoluble Deposits in In-Service Turbine Oils using Membrane Patch Colorimetry.
ASTM E659	Standard Test Method for Autoignition Temperature of Liquid Chemicals

MILITARY

MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

OTHER

ISO 4406	Hydraulic Fluid Power - Fluids - Method for Coding Level of Contamination by Solid Particles

3.0 NEW OIL REQUIREMENTS

3.1 SYNTHESIZED HYDROCARBON OILS (ISO VG 32 and 46)

3.1.1 GENERAL - Synthesized hydrocarbons (SHC) are oils that are derived from other chemical compounds; they include polyalphaolefins (PAO, also referred to as olefin oligomers), alkylated aromatics and other products. Additives are blended in, as necessary, in order to meet all the requirements of this specification. Two viscosity grades are allowed for use, ISO VG 32 and ISO VG 46. SHC's must be chemically compatible and miscible with petroleum oils.

3.1.2 ACCEPTANCE REQUIREMENTS - In order for a synthesized hydrocarbon to be suitable for use on Solar equipment, all the physical and chemical property limits in Table 1 must be complied with.

3.1.3 CLASSIFICATION REQUIREMENTS - In addition, an oil shall be assessed for compliance with the classification requirements in Table 1A. In order for an oil to be classified for use as an SHC on Solar packages, it has to meet the Class I requirements in Table 1A. Class I oils are generally expected to be higher performing and more oxidation resistant than petroleum (Class II) oils.

3.1.4 ADDITIVES IN SHC's - Additives blended with the oil shall be thermally stable, water inseparable and uniformly distributed throughout the oil at all temperatures up to 284°F (140°C).

3.2 PETROLEUM OILS (ISO VG 32 and 46)

3.2.1 GENERAL - Petroleum oils, also known as mineral oils, shall consist of refined paraffinic base stock oils that have been blended with suitable additives to meet the physical and chemical property requirements specified in Table 1. Two viscosity grades are allowed for use, ISO VG 32 and 46. In addition, this type of oil must be chemically compatible and miscible with synthesized hydrocarbons.

3.2.2 ACCEPTANCE REQUIREMENTS - In order for a petroleum oil to be suitable for use on Solar equipment, all the physical and chemical property limits in Table 1 must be complied with.

3.2.3 CLASSIFICATION REQUIREMENTS - In addition, an oil shall be assessed for compliance with the classification requirements in Table 1A. In order for an oil to be classified for use as a petroleum oil on Solar packages, it has to meet the Class II requirements in Table 1A.

3.2.4 ADDITIVES IN PETROLEUM OILS - Additives blended with the oil shall be thermally stable, water inseparable and uniformly distributed throughout the oil at all temperatures up to 284°F (140°C).

3.3 SYNTHETIC ESTER OILS

3.3.1 REQUIREMENTS - These oils shall comply with the requirements of MIL-PRF-23699 Class CI and are classified as a Class III oil for use on Solar packages.

3.4 PHOSPHATE ESTER OILS (ISO VG 32 and 46)

3.4.1 GENERAL - Phosphate esters are also known as fire resistant lubricants and they shall be comprised of phosphate esters blended with the necessary additives to meet the physical and chemical property requirements of Table 1.

3.4.2 ACCEPTANCE REQUIREMENTS - In order for a phosphate ester oil to be suitable for use on Solar equipment, the physical and chemical property limits in Table 1 must be complied with.

3.4.3 CLASSIFICATION REQUIREMENTS - In addition, an oil shall be assessed for compliance with the classification requirements in Table 1A. In order for an oil to be classified for use as a phosphate ester oil on Solar packages, it has to meet the Class IV requirements in Table 1A.

3.4.4 ADDITIVES IN PHOSPHATE ESTERS - Additives blended with the oil shall be thermally stable, water inseparable and uniformly distributed throughout the oil at all temperatures up to 284°F (140°C).

4.0 USED OIL REQUIREMENTS

4.1 OIL DETERIORATION - Regardless of the type of oil used, the physical and chemical properties of lube oil are expected to deteriorate over time. As the rate of deterioration depends on many factors (such as engine model, maintenance practice, duty cycle, cleanliness of process gases in boost compressor applications, oil type, etc.), the useful life of lube oils cannot be specifically defined. Based on industry experience, guidelines and standards for the physical and chemical condition of in-service oils are provided here.

Table 1. Acceptance Requirements of New Lube Oils

ASTM	Property	Requirements For New Lube Oil	
D2422	Viscosity Grade	ISO VG 32 (S150)	ISO VG 46 (S215)
D92	Flash Point, COC, °F (°C) Minimum	390°F (199°C)	390°F (199°C)
	Fire Point, COC, °F (°C) Minimum	440°F (227°C)	450°F (232°C)
D130	Copper Corrosion at 212°F (100°C), 3 hours.	Class 1b	Class 1b
D665	Rust Prevention, Procedure B (Procedure A for Class IV)	Pass	Pass
D892	Foam Limits, Milliliters, Maximum Sequence I Sequence II Sequence III	 50/0 50/0 50/0	 50/0 50/0 50/0
D943[1]	Oxidation Resistance, Hours to 2.0 Neutralization Number, Minimum	2000 hours	2000 hours
D1401	Water Separability (Emulsion Test)	40-40-0 (30)	40-40-0 (30)
D4628	Zinc, Weight Percent, Maximum	0.005 wt.%	0.005 wt. %
E659	Autoignition Temp., °F (°C) Minimum	590°F (310°C)	590°F (310°C)
D4172	Wear Preventive Characteristic, Scar Diameter (167°F or 75°C, 1200 rpm, 88.1 lb or 40 kg, 1 hr.), Millimeters, Maximum	0.90 mm	0.90 mm
	Particle Contamination	ISO 4406 Code 16/14/12	ISO 4406 Code 16/14/12
D5182	FZG Visual Method, Failure Load Stage, Minimum	6	7
D3427	Gas Bubble Separation (Air Release) at 122°F (50°C), Minutes, Maximum	5	6
D2272	Rotating Pressure Vessel Oxidation Test (RPVOT), Minutes	(to be reported)	(to be reported)
D4308 or D1169	Electrical Conductivity, pS/m at 32°F (0°C) or Resistivity, MΩAm at 68°F (20°C)	(to be reported)	(to be reported)

[1] - The oxidation stability requirements of MIL-PRF-23699 and ASTM D4293 shall apply to Class III and Class IV oils respectively, in lieu of the ASTM D943 requirement.

4.1.1 CORRECTIVE ACTION - If the physical condition of an in-service oil (per paragraph 4.2) is deteriorated while its chemical condition (per paragraph 4.3) appears to be acceptable, corrective action taken should include checking for possible source(s) of solid/water contamination, check/replace filter elements and, if necessary, oil reconditioning to remove particulate matter and water.

4.2 PHYSICAL CONDITION OF IN-SERVICE OILS - The physical condition of an in-service oil can be determined by inspecting it for color, odor, viscosity, water content and particle contamination. In general, such physical deterioration (as defined by these five properties) can be reversed by reconditioning the oil provided that physical deterioration is not accompanied by chemical deterioration as defined in paragraph 4.3. Functional guidelines/limits for the physical condition of lube oil during service are provided in Table 2.

Table 1A. Classification Requirements For New Oils

ASTM	Property	Class I (SHC)		Class II (Petroleum Oil)		Class IV (Phosphate Ester)	
D2422	Viscosity Grade	ISO VG 32	ISO VG 46	ISO VG 32	ISO VG 46	ISO VG 32	ISO VG 46
D445	Viscosity at 104°F (40°C)	28.8-35.2 cSt (136-165 SUS)	41.4-50.6 cSt (193-235 SUS)	28.8-35.2 cSt (136-165 SUS)	41.4-50.6 cSt (193-235 SUS)	28.8-35.2 cSt (136-165 SUS)	41.4-50.6 cSt (193-235 SUS)
	Viscosity at 212°F (100°C), Minimum	5.40 cSt (44 SUS)	6.04 cSt (46 SUS)	5.09 cSt (43 SUS)	6.04 cSt (46 SUS)	4.09 cSt (40 SUS)	4.8 cSt (42 SUS)
D2270	Viscosity Index	≥100		≥90		___	
D1298	Specific Gravity, 60/60°F (15/15°C)	0.83-0.88		0.83-0.88		1.10-1.20	
D664 or D974	Neutralization (Total Acid Number), Maximum	0.40 mg KOH/g		0.20 mg KOH/g		0.10 mg KOH/g	
D6304	Water (Parts Per Million Weight), Maximum	200 ppmw (0.02 wt.%)		200 ppmw (0.02 wt.%)		1000 ppmw (0.1 wt.%)	
D97	Pour Point, °F (°C)	≤-65°F (≤-50°C)		≤+15°F (≤-9.5°C)		≤0°F (≤-17.8°C)	
D92	Flash Point, COC, °F (°C) Minimum	390°F (199°C)	390°F (199°C)	390°F (199°C)	390°F (199°C)	437°F (225°C)	
	Fire Point, COC, °F (°C) Minimum	440°F (227°C)	450°F (232°C)	440°F (227°C)	450°F (232°C)	617°F (325°C)	
E659	Autoignition Temp., °F (°C) Minimum	705°F (374°C)		590°F (310°C)		1000°F (538°C)	

Class III (Synthesized Ester) - Per MIL-PRF-23699

4.2.1 COLOR (VISUAL APPEARANCE) - Darkening of in-service lube oils, regardless of type, is to be expected, although the rate at which this occurs cannot be quantified. Color darkening and increasing haziness could be indicative of (1) particulate contamination, (2) water contamination, or (3) oil oxidation. Change in oil color may or may not be accompanied by significant changes in its chemical condition as defined in paragraph 4.3.

4.2.2 ODOR - As lube oil deteriorates, intermediate compounds can be formed that can impart a strong odor. As odor is a highly subjective human sensation, such detection should be recognized as a qualitative indicator that needs to be substantiated by quantitative analytical tests to establish the chemical condition of the oil.

4.2.3 VISCOSITY - Changes in oil viscosity may be indicative of changes in oil chemistry due to contamination, high shear rates and/or excessive temperature. A decrease in viscosity can result from contamination with fuel or a less dense fluid. Viscosity increases, which is the more common phenomenon, is generally associated with oil deterioration which can be verified by checking the chemical properties of the oil.

Table 2. Guidelines/Limits for Physical Condition of In-Service Lube Oils

Property	Test Method	Limiting Condition	Recommended Action
Color	Visual observation	Rapid darkening, haziness	Check for possible source(s) of fluid contamination Check chemical properties (see para. 4.3)
Odor	Olfactory observation	Strong odor	Check for possible source(s) of contamination Check chemical properties (see para. 4.3)
Viscosity (104°F/40°C)	ASTM D445	+ 20%/-10% (compared to new oil)	Check for possible source(s) of fluid contamination Check for overtemperature Check chemical properties (see para. 4.3)
Water content	ASTM D6304	max. 2,000 ppmw	Check tank, sumps, for standing water or water leakage Centrifuge or filter oil to remove water or replace oil
Particle contamination	Automatic particle counter/ISO 4406 code	Abrupt increase in particle count	Check bearing points for excessive wear Check other sources of contamination Centrifuge or filter to remove sediments or replace oil

4.2.4 WATER CONTENT - Water contamination of in-service lube oils is of concern because it can be manifested in two ways. When excessive water is present in bulk, the tendency to separate from the oil phase will allow it to collect at the bottom of oil tanks or in stagnated areas in pipelines. In addition, depending on the emulsion characteristics of the oil, finely divided water particles can remain in permanent dispersion in the oil, thereby disrupting the hydrodynamic and corrosion properties of the oil. A maximum limit of 2000 ppm (0.2 weight percent) of water in the oil layer is the criterion to be used for oil change out or oil reconditioning to remove both standing water and water dispersed in the oil.

4.2.5 PARTICLE CONTAMINATION - Particulate matter in lube oil can be due to contamination, wear debris or oil oxidation (coking). Filters in the lube oil system, if properly installed and maintained, will remove most of the particles in the mesh size range. However, the particles that do pass through the filter mesh could continue to be in circulation and even increase in population, unless they are removed by oil conditioning processes. Unless the chemical properties of the oil have deteriorated beyond allowable limits, removal of such particles could restore the oil to service.

4.3 CHEMICAL CONDITION OF IN-SERVICE OILS - The chemical condition of an in-service lube oil is established by analyzing it for acidity, oxidation resistance, foaming characteristics, and air release. Because of the range of values that exists among the various oils, the limits for in-service oils provided in Table 3 are to be compared to new oils, preferably from the same oil lot.

4.3.1 ACIDITY - Oil acidity is determined by obtaining its total acid number (TAN) per ASTM D664 or ASTM D974 and comparing it to that of a new, unused oil sample from the same lot, if possible. An increase in TAN is indicative of oil oxidation (or loss of antioxidant) or hydrolysis and represents irreversible oil deterioration. If other chemical properties are within Table 3 limits, and physical properties are also acceptable, continued use of such oil is possible provided that the monitoring frequency is increased.

4.3.2 OXIDATION RESISTANCE - The oxidation resistance of a lube oil is determined by conducting the rotating pressure vessel oxidation test (RPVOT) per ASTM D2272. With service, the RBOT value will decrease as the antioxidant is depleted. When the RPVOT value decreases to 25% of the new oil value (from the same lot, if possible), the oil is deemed non-acceptable for continued use and must be replaced immediately.

4.3.3 FOAMING CHARACTERISTICS - Oil foaming, as measured by ASTM D892, is a property that is controlled by the use of anti-foaming additives. As the anti-foamant is depleted either from temperature or adsorption on to surfaces and particles, the volume of foam formed and the stability of this foam will increase. As a functional guideline, once the in-service oil reaches 300/10 for Sequences I and II, the oil should be carefully assessed for continued use (see paragraph 4.3.3.1).

4.3.3.1 HIGH FOAMING TENDENCY - For high foaming oils with acceptable TAN and RPVOT values, i.e. well within Table 3 limits, the addition of an anti-foaming agent may be appropriate and the oil supplier should be consulted for correct dosage. However, because of the adverse effect of excessive anti-foamants on air bubble separation and foam stability, the air release property of the oil (see paragraph 4.3.4) should be measured before and after addition to be compared with that of new oil to ensure compliance with Table 3. If high foaming is accompanied by unacceptable or marginal TAN and RPVOT values, the oil should be replaced.

4.3.4 AIR RELEASE - The ability to allow air bubbles to separate from the oil is a critical property that can deteriorate with service or excessive silicone containing additives (such as that used to control foaming). An air release value of 10 minutes at 122°F (50°C), as determined using ASTM D3427, is provided in Table 3 as a limiting guideline (maximum) for this property. Air release must be monitored when anti-foaming agents (or any silicone containing compound) is added to an in-service lube oil.

4.3.5 VARNISH POTENTIAL – Lube oils may have tendencies to form varnish (thin, hard, lustrous, oil-insoluble deposit composed primarily of organic residue) during the engine operation. These deposits are caused by thermal degradation, oxidation and/or contamination. They have limited solubility in the base oil. They can cause filter plugging, excessive wear on parts and could lead to failure bearings or other critical components such as servomechanisms (seizing). Membrane Patch Colorimetry (MPC) test method per ASTM D7843 is typically used to assess the varnish potential of the oil. The oils showing varnish levels higher than 30 ΔE should be carefully assessed for continued use. If the varnish potential is the only issue with the oil, the filtration of the in-service oil and/or the addition of varnish controlling additives may be considered. The lube oil manufacturer must be consulted before the chemical agents are added to the oil. The solid particles and other properties of the lube oil must be checked before and after adding the chemical compounds to the in-service lube oil.

5.0 OPERATING LIMITS

5.1 USE OF VARIOUS OIL TYPES - Use of each lube oil type shall be according to paragraph 1.0, Table 4, and the viscosity and temperature limitations in the applicable functional control system specification. Package specific operating limits are contained in the hydro mechanical schematics and mechanical installation drawings issued for each package.

5.2 OIL SELECTION - In selecting the appropriate oil for use, it is required that the pour point must be at least 11°F (6°C) below the ambient air temperature surrounding the package even in the coldest season. This requirement is to ensure oil flow at the start of the pre-lube cycle.

Table 3. Limits for Chemical Condition of In-Service Lube Oils

Property	Test Method	Limits (Compared to New Oil)
Total Acid Number (TAN)	ASTM D664 or ASTM D974	0.8 mg KOH/g max. for Class I oils 0.6 mg KOH/g max. for Class II oils 2.0 mg KOH/g max. for Class III oils 0.2 mg KOH/g max. for Class IV oils
Rotating Pressure Vessel Oxidation Test (RPVOT)	ASTM D2272	25% of original (new oil) value
Foaming Characteristics	ASTM D892	**(Guideline only, see Section 4.3.3)** Sequence I - 300/10 Sequence II - 300/10
Air Release at 122°F (50°C)	ASTM D3427	**(Guideline only, see Section 4.3.4)** 10 minutes max.
Varnish Potential*	ASTM D7843	**(Guideline only, see Section 4.3.5)** 30 ΔE For Class I and II oils.

*MPC scale (ΔE)
- ≤ 15 Normal for in-service lube oil
- 15 to 30 Higher risk of varnish
- ≥ 30 Take action per Paragraph 4.3.5

Table 4. Lube Oil Usage

Oil Class	Viscosity Grade	Ambient Temperature
Class I (Synthesized Hydrocarbons)	ISO VG 32 ISO VG 46	-54°F to +115°F (-48°C to +46°C) -54°F to +140°F (-48°C to +60°C)
Class II (Petroleum Oils)	ISO VG 32 ISO VG 46	+26°F to +110°F (-3°C to +43°C) +26°F to +135°F (-3°C to +57°C)
Class III (Synthetic Esters)	MIL-L-23699	-54°F to +110°F (-48°C to +43°C)
Class IV (Phosphate Esters)	ISO VG 32 ISO VG 46	+11°F to +110°F (-12°C to +43°C) +11°F to +110°F (-12°C to +43°C)

5.3 OIL TEMPERATURE AT START-UP - Before start-up, the temperature of the oil in the entire lube system, such as tank, lines, cooler, filters, "P" traps, etc. shall be at or above the temperature limits given in the applicable functional control system specification to ensure that the oil entering the engine will have the desired viscosity. Tank heaters and auxiliary pumps may be used to ensure proper oil temperature in the system prior to package start-up.

6.0 ELECTRICAL CONDUCTIVITY/RESISTIVITY OF LUBE OILS

6.1 BACKGROUND - In some applications, flammable gas mixtures may exist in the vicinity of the oil. To avoid incendive sparks (sparks that have enough energy to ignite flammable gases) caused by static electricity the oil must be able to conduct electricity. Grounding of lubricating system components is also required.

6.2 GUIDELINE FOR ELECTRICAL CONDUCTIVITY/RESISTIVITY - A minimum conductivity of 50 (picomho/meter or picoSiemens/meter, pS/m) is generally recognized as being adequate to prevent formation of incendive sparks in Class I and II oils. Due to the inherently higher polarity, and hence higher conductivity, of Class IV oils, maximum conductivity or more commonly minimum resistivity is specified for these oils. A minimum resistivity of 50 (mega ohm meter) MΩAm at 68°F (20°C) is required for Class IV oils.

6.2.1 LOW CONDUCTIVITY OILS - If the conductivity of a lube oil is reported to be less than 50 pS/m at 32°F (0°C), or the lowest ambient temperature at start-up, the lube oil manufacturer should be asked to submit the following to Solar and the equipment operator:

a) Define a commercially available additive, which may be used to enhance conductivity. (Dupont manufactures an additive called Stadis 425, which may be acceptable.)

b) Specify the concentration of additive in new oil which is needed to achieve 50 (pS/m) at 32°F (0°C) or the lowest ambient temperature at start-up.

c) Define the impact of the additive on all of the properties specified in this specification.

7.0 QUALITY ASSURANCE

7.1 PRODUCT QUALITY AND LIABILITY - The equipment operator shall be ultimately responsible for ensuring that the product that is delivered to the site and used in the package, regardless of brand name, meets the requirements of this specification.

7.1.1 VERIFICATION TESTING - As Solar has no control over, and is not necessarily cognizant of changes in, lube oil formulation, processing, blending, and labeling, it is recommended that the equipment operator verify that each batch of oil shipped to the site meets specification requirements. Verification testing is especially useful when a new lube oil supplier is being developed and when new or improved lube oils are being considered for use. Verification could involve conducting all or selected test(s) from Table 1, as determined by operator's previous experience and specific application.