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FIRST EDITION

Fuel Reference Handbook

for

Diesel & Biodiesel

A POCKET REFERENCE

Fuel testing is our specialty.

Fuel Reference Handbook For Diesel & Biodiesel

1

FIRST EDITION

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A Message from FOI Laboratories ...

To our valued customers:

We would like to take this time to thank you for your business and continued support.

With the ongoing and ever-changing pace of the fuel industry, it becomes increasingly more difficult to understand constantly updated fuel standards and regulations. From Ultra-Low Sulfur Diesel and Low Sulfur Diesel, to Biodiesel blends to meet state mandates, it becomes a challenge to continually maintain these types of fuels. This is why we created the FOI Field Manual. This handbook was designed for the purposes of providing quick assessments while out in the field. Whether pulling a sample from a 10,000 gallon above-ground tank, or speaking with your client one-on-one regarding setting up a maintenance schedule, this handbook will assist you in making the best possible selection regarding fuel analysis and information.

Mission Statement

FOI Laboratories was established for the purposes of providing a specific need within the petroleum industry, dedicated fuel testing laboratories. Applying our basic principle beliefs, FOI is dedicated to fulfilling an unprecedented commitment to service which can only be achieved by exhibiting excellent customer service, innovative technology, as well as accurate, clear, and concise analysis. Here at FOI, we pledge to our customers to always maintain the highest quality while maintaining optimal value each and every day.

FOI is committed to providing world renown fuel testing with timely, consistently accurate and actionable results with an unwavering determination to be a leader within the petroleum testing industry.

We hope this handbook will be a useful tool for you and make your job a little easier. All of us at FOI would like to thank you again for your continued support.

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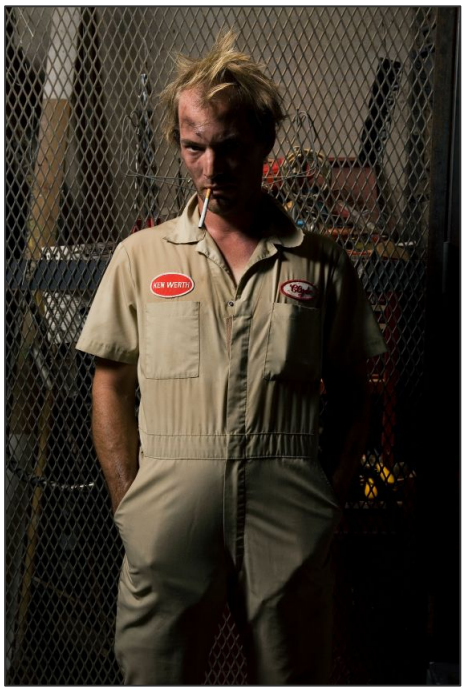
About This Manual …

The **FUEL REFERENCE HANDBOOK FOR DIESEL & BIODIESEL™,** has been developed as a quick reference guide to assist you in determining recommended testing protocols for diesel and biodiesel fuels.

Diesel fuel quality and chemistry continuously degrades by transportation, storage, oxidation, and by water & microbial contamination. Even when fuel is still clear and bright, microscopic fuel components can collect and quickly form into larger contaminating masses. Fuel analysis can point to solutions for filter plugging, loss of power or poor injector performance, and testing bulk fuel storage tanks can verify compliance with required supplier specifications.

Many of today's fuels are causing new storage condition problems. Avoid crisis management by averting the fuel-engine failure crisis. Regular fuel testing will uncover potential engine killers and identify each property that **YOUR** company can remediate.



Who's Doing Your Fuel Analysis?

Are you getting quality test results?

Chances are your fuel analysis laboratory is really an oil analysis laboratory, offering fuel testing as just another service. FOI is a full service fuel analysis, testing and research laboratory offering superior quality testing services.

Fuel testing is our specialty.

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FUEL MAINTENANCE 101

1. Sample ***every fuel tank, twice, every year***.

- Have FOI Laboratories test the fuel for a full fuel health baseline as diagnosed by your fuel maintenance professional.
- Perform a basic wellness fuel test 6 months after the full health baseline. Every year.

2. If your fuel needs reclamation, have it performed before your next fuel delivery.

- Fuel reclamation is a science. FOI Laboratories has assembled a national team of providers that treat it like one. Make sure the need and work are proven scientifically.

3. Sample and test every fuel delivery. Make sure new problems aren't being delivered to you. Good fuel gets polluted with every transfer.

- Fuel begins to degrade and become contaminated the moment it enters the pipeline from the refinery. The only certification your fuel provider has came from the refinery. You have no idea how old the fuel is or how the fuel has been contaminated by the time it gets delivered to you.
  Neither does your provider.

4. Document and manage the results of the annual testing. Whether it is an inspection or natural disaster that strikes, you are prepared.

Definition of Test Priorities

Critical - Priority 1

Critical industries are industries that must sustain 3 major components: Life, Data, & Money. Maintaining the work life of emergency generators is crucial in these industries. The test package designed for this specific category is the Premium Diagnostic package, or the LSD103, and was also created to be in accordance with JCAHO Sentinel Event Alert #37, and NFPA #110 regulations. We recommend that the LSD103 be tested for these industries at least semi-annually.

Facility Types Include: Hospitals/healthcare facilities, data centers, financial institutions, telecommunications centers.

Essential - Priority 2

Essential industries are industries that do not cover the 3 major components, but are still essential in maintaining everyday events. The test package designed for this specific category is the Essential Diagnostic package, or the LSD102, for a quarterly check-up and to complement the Premium Diagnostic package. We recommend that the LSD102 be tested for these industries at least quarterly.

Facility Types Include: Municipalities, high-rise buildings, school districts, supermarkets, state agencies, leisure and hospitality industries.

Maintenance - Priority 3

Maintenance industries are industries that cover any type of maintenance or repair. The test packages designed for this specific category are the Essential Diagnostic package and Value Assurance package, or the CEL102, to check the fuel's viability and usability. We recommend that the CEL102 be tested every two months.

Facility Types Include: Retail fuel dealers, marine services, fleet services, construction companies.

Our competitors use a frying pan to test for water in your fuel …

We think they should save the frying pan for the bacon and eggs!

Make sure you're getting reliable results for all of your fuel testing needs. FOI is a full service fuel analysis, testing and research laboratory offering superior quality testing services.

Fuel testing is our specialty.

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FOI LABORATORIES - DIESEL TEST PACKAGES

LSD103 - PREMIUM DIAGNOSTICS

INDICATORS:
The test package designed for this specific category is the Premium Diagnostic package, or the LSD103, and was also created to be in accordance with JCAHO Sentinel Event Alert #37, and NFPA #110 regulations. We recommend that the LSD103 be tested for these industries at least semi-annually.

TESTS REQUIRED	METHOD
Distillation	ASTM D86
Microbial Growth	Positive/Negative
Water by Karl Fisher	ASTM D6304
Flash Point	ASTM D93
Sulfur	ASTM D5453
Appearance	ASTM D4176
Stability/Accelerated Aging	DU PONT F21-61
Water & Sediment	ASTM D2709
API Gravity	ASTM D1298
Copper Strip Corrosion	ASTM D130
Cetane Index	ASTM D976

SAMPLE VOLUME REQUIRED: 500 ML

RECOMMENDED FACILITY TYPES:
Hospitals/healthcare facilities, data centers, financial institutions, telecommunications centers.

COMMENTS:

FOI LABORATORIES - DIESEL TEST PACKAGES

LSD102 - ESSENTIAL DIAGNOSTICS

INDICATORS:
The test package designed for this specific category is the Essential Diagnostic package, or the LSD102, for a quarterly check-up and to complement the Premium Diagnostic package. We recommend that the LSD102 be tested for these industries at least quarterly.

TESTS REQUIRED	METHOD
Distillation	ASTM D86
Microbial Growth	Positive/Negative
Water by Karl Fisher	ASTM D6304
Flash Point	ASTM D93
Sulfur	ASTM D5453
Appearance	ASTM D4176
Stability/Accelerated Aging	DU PONT F21-61

SAMPLE VOLUME REQUIRED: 500 ML

RECOMMENDED FACILITY TYPES:
Municipalities, high-rise buildings, school districts, supermarkets, state agencies, leisure and hospitality industries.

COMMENTS:

FOI LABORATORIES - DIESEL TEST PACKAGES

CEL102 – VALUE ASSURANCE

INDICATORS:
The test packages designed for this specific category are the Essential Diagnostic package and Value Assurance package, or the CEL102, to check the fuel's viability and usability. We recommend that the CEL102 be tested every two months.

TESTS REQUIRED	METHOD
Distillation	ASTM D86
Microbial Growth	Positive/Negative
Water by Karl Fisher	ASTM D6304
Flash Point	ASTM D93

SAMPLE VOLUME REQUIRED: 500 ML

RECOMMENDED FACILITY TYPES:
Retail fuel dealers, marine services, fleet services, construction companies.

COMMENTS:

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Industry Quick Reference Guide

360.546.3835

Industry	Priority	Tank Volume	Tank Depth	Test Pkg	Frequency	Sample Volume	# of Samples
Construction Companies	3 - Maintenance	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	CEL102	Bi-monthly Bi-monthly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Data Centers	1 - Critical	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD103	Semi-annually Semi-annually	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Financial Institutions	1 - Critical	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD103	Semi-annually Semi-annually	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Fleet Services	3 - Maintenance	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	CEL102	Bi-monthly Bi-monthly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
High-Rise Buildings	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Hospitals/Healthcare Facilities	1 - Critical	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD103	Semi-annually Semi-annually	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Leisure & Hospitality Industries	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Marine Services	3 - Maintenance	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	CEL102	Bi-monthly Bi-monthly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Municipalities	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Retail Fuel Dealers	3 - Maintenance	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	CEL102	Bi-monthly Bi-monthly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
School Districts	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
State Agencies	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Supermarkets	2 - Essential	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD102	Quarterly Quarterly	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)
Telecommunications Centers	1 - Critical	5,000 Gal or less Greater than 5,000 Gal	2 Feet or less Greater than 2 Feet	LSD103	Semi-annually Semi-annually	500 ML 500 ML	1 (Bottom only) 2 (Bottom & middle)

FAQ's for Diesel Fuel

What types of diesel fuel are available in the market?

Diesel fuel has different categories: Diesel #1, Diesel #2, Diesel #4, Diesel #6, ULSD, and LSD.

How will ULSD fuel affect air quality?

ULSD fuel enables the use for cleaner technology diesel engines and vehicles with advanced emissions control devices. Even when used in older diesel engines ULSD is believed to result in lower vehicle emissions.

How do I know which grade to use?

Most engines are designed to operate on ASTM No. 2-D grade, but some diesel engines in stop-and-go service require No. 1-D diesel fuels in order to perform satisfactorily. Follow the recommendations of the engine manufacturer and a reputable fuel supplier who recognizes that some fuels may have special or additive-derived quality features.

What are some fuel-handling causes of poor diesel engine performance?

Contamination of fuel by water and dirt entering the fuel as a result of careless fuel handing may cause poor diesel engine performance. Extreme care must be exercised. Fuel-tank caps, dispensing nozzles and hoses should be kept clean to eliminate potential sources of contamination. Regularly removing water from storage tanks, vehicle fuel tanks, and filter bowls is important. Dry storage systems will reduce fuel emulsion problems, injection system corrosion and microbial growth.

How long can I store diesel fuel?

If you keep it clean, cool and dry, diesel fuel can be stored 6 months to 1 year without significant quality degradation. Storage for longer periods can be accomplished through use of periodic filtrations and addition of fuel stabilizers and biocides.

Does diesel fuel color affect performance?

No. There is no relationship between natural diesel fuel color and such desirable diesel fuel qualities such as heat content, viscosity, cloud point, cetane number or distillation range. Diesel fuel color varies with the crude source, refinery methods and the use of dyes. However, if the fuel color darkens appreciably during storage, this could indicate oxidation and/or contamination from dirt, water, or other sources, which can cause operational problems.

Overview of FuelOnly Testing Methodologies & Procedures

ASTM D86 - Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure.

This test method covers the atmospheric distillation of petroleum products using a laboratory batch distillation unit to determine quantitatively the boiling range characteristics of such products as natural gasolines, light and middle distillates, automotive spark-ignition engine fuels, aviation gasolines, aviation turbine fuels, 1-D and 2-D regular and low sulfur diesel fuels, bio-diesel, naphthas, white spirits, kerosenes, and Grades 1 and 2 burner fuels.

The distillation (volatility) characteristics of hydrocarbons have an important effect on their safety and performance, especially in the case of fuels and solvents. The boiling range gives information on the composition, the properties, and the behavior of the fuel during storage and use. Volatility is the major determinant of the tendency of a hydrocarbon mixture to produce potentially explosive vapors.

ASTM D1298 - Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.

This test method covers the laboratory determination using a glass hydrometer, of the density, relative density (specific gravity), or API gravity of crude petroleum, petroleum products, or mixtures of petroleum and non-petroleum products normally handled as liquids, and having a Reid vapor pressure of 101.325 kPa (14.696 psi) or less. Values are measured on a hydrometer at either the reference temperature or at another convenient temperature, and readings corrected to the reference temperature by means of the Petroleum Measurement Tables; values obtained at other than the reference temperature being hydrometer readings and not density measurements. Values determined as density, relative density, or API gravity can be converted to equivalent values in the other units at alternate reference temperatures by means of the Petroleum Measurement Tables.

Accurate determination of the density, relative density (specific gravity), or API gravity of petroleum and its products is necessary for the conversion of measured volumes to volumes or masses, or both, at the standard reference temperatures during custody transfer.

ASTM D2709 - Standard Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge.

This test method covers the determination of the volume of free water and sediment in middle distillate fuels having viscosities at 40°C (104°F) in the range of 1.0 to 4.1 mm 2/s to 4.1cSt) and densities in the range of 770 to 900 kg/m3. This test method is used as an indication of water and sediment in middle distillate fuels such as Grades Nos. 1 and 2 fuel oil, (Specification D 396) Nos. 1-D and 2-D diesel fuel, (Specification D 975) and Nos. 0-GT, 1-GT, and 2-GT gas turbine fuels (Specification D 2880).

Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of the fuel-handling facilities and to give trouble in the fuel system of a burner or engine. An accumulation of sediment in storage tanks and on filter screens can obstruct the flow of oil from the tank to the combustor. Water in middle distillate fuels can cause corrosion of tanks and equipment, and if detergent is present, the water can cause emulsions or a hazy appearance. Water is necessary to support microbiological growth at fuel water-interfaces in fuel systems.

ASTM D5453 - Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence.

This test method covers the determination of total sulfur in liquid hydrocarbons, boiling in the range from approximately 25 to 400°C, with viscosities between approximately 0.2 and 20 cSt (mm2/S) at room temperature. This test method is applicable for total sulfur determination in liquid hydrocarbons containing less than 0.35% (m/m) halogen(s).

Some process catalysts used in petroleum and chemical refining can be poisoned when trace amounts of sulfur bearing materials are contained in the feedstocks. This test method can be used to determine sulfur in process feeds sulfur in finished products, and can also be used for purposes of regulatory.

ASTM D93 - Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester.

This test method covers the determination of the flash point of petroleum products in the temperature range from 40 to 360°C by a manual Pensky-Martens closed-cup apparatus or an automated Pensky-Martens closed-cup apparatus.

The flash point temperature is one measure of the tendency of the test specimen to form a flammable mixture with air under controlled laboratory conditions. It is only one of a number of properties which must be considered in assessing the overall flammability hazard of a material. Flash point is used in shipping and safety regulations to define flammable and combustible materials. One should consult the particular regulation involved for precise definitions of these classifications.

ASTM D6304 - Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration.

This test method covers the direct determination of water in the range of 10 to 25 000 mg/kg entrained water in petroleum products and hydrocarbons using automated instrumentation. This test method also covers the indirect analysis of water thermally removed from samples and swept with dry inert gas into the Karl Fischer titration cell. This test method is intended for use with commercially available coulometric Karl Fischer reagents and for the determination of water in additives, lube oils, base oils, automatic transmission fluids, hydrocarbon solvents, and other petroleum products. By proper choice of the sample size, this test method may be used for the determination of water from mg/kg to percent level concentrations. Values stated in SI units are to be regarded as the standard.

Knowledge of the water content of lubricating oils, additives, and similar products is important in the manufacturing, purchase, sale, or transfer of such petroleum products to help in predicting their quality and performance characteristics. For lubricating oils, the presence of moisture could lead to premature corrosion and wear, an increase in the debris load resulting in diminished lubrication and premature plugging of filters, an impedance in the effect of additives, and undesirable support of deleterious bacterial growth.

ASTM D 6371 - Standard Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels.

This test method covers the determination of the cold filter plugging point (CFPP) temperature of diesel and domestic heating fuels using either manual or automated apparatus This test method is applicable to distillate fuels, including those containing a flow-improving or other additive, intended for use in diesel engines and domestic heating installations.

The CFPP of a fuel is suitable for estimating the lowest temperature at which a fuel will give trouble-free flow in certain fuel systems. In the case of diesel fuel used in European light duty trucks, the results are usually close to the temperature of failure.

ASTM D 2500 - Standard Test Method for Cloud Point of Petroleum Products.

This test method covers only petroleum products that are transparent in layers 40 mm in thickness, and with a cloud point below 49°C.

The cloud point of a petroleum product is an index of the lowest temperature of its utility for certain applications.

ASTM D976 - Standard Test Methods for Calculated Cetane Index of Distillate Fuels.

The Calculated Cetane Index formula represents a means for directly estimating the ASTM cetane number of distillate fuels from API gravity and mid-boiling point. The index value, as computed from the formula, is termed the Calculated Cetane Index.2 1.2 The Calculated Cetane Index is not an optional method for expressing ASTM cetane number. It is a supplementary tool for predicting cetane number when used with due regard for its limitations. The Calculated Cetane Index formula is particularly applicable to straight-run fuels, catalytically cracked stocks, and blends of the two

The Calculated Cetane Index is a useful tool for estimating ASTM cetane number where a test engine is not available for determining this property. It may be conveniently employed for approximating cetane number where the quantity of sample is too small for an engine rating. In cases where the cetane number of a fuel has been initially established, the index is useful as a cetane number check on subsequent samples of that fuel, provided its source and mode of manufacture remain unchanged.

Why pay more for fuel testing?

Are you getting the service you're paying for?

If your fuel analysis laboratory has raised your testing fees, FOI can help. We offer quality fuel testing at reasonable prices that include many things that other labs don't. FOI is a full service analysis, research and testing laboratory offering superior quality testing services.

Fuel testing is our specialty.

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FOI LABORATORIES TESTING CAPABILITIES AND EXPLANATIONS

FOI offers a comprehensive collection of diesel fuel testing services that have been designed by our chemist to detect storage integrity and classify product by ASTM and industry specifications. Our long-term storage packages help predict your product's remaining service life and product cleanliness as well as ensure compliance with diesel fuel specifications.

ANALYTICAL FERROGRAPHY

Analytical Ferrography can predict potential equipment failures or be an effective tool in determining the root cause of failure. AF is a qualitative, rather than quantitative analysis that provides digital imagery of the actual particles present. Powerful magnets trap the
ferrous particles, which are then placed on slides for microscopic analysis. Particles are analyzed based on metallic or non-metallic, alloy via heat treatment, shape, size, color, and if possible, source.

DIRECT READ FERROGRAPHY

Direct Read Ferrography is a quantitative analysis of ferrous particles present in used oil. It provides an index of large ferrous >5# particles to small ferrous <5# particles. Because it can identify the amount of ferrous wear occurring within a unit, it is most helpful in illustrating developing trends.

ACID NUMBER

Acid Number is the amount of acid present. Numbers higher than that of new lubricant is an indication of oxidation or contamination of some kind.

BASE NUMBER

Base Number measures a lubricant's alkaline reserve, or ability to neutralize acid. When Acid Number and Base Number approach the same number, the oil should be changed or "sweetened," meaning more new oil should be added.

CHLORINE

Chlorine is one of a group of five chemically-related nonmetallic elements - chlorine, bromine, fluorine, iodine and astatine. In certain oils, chlorine compounds are used as EP additives to prevent sliding metal surfaces from seizing under extreme pressure. These compounds react chemically with the metal to form an inorganic film to prevent the welding of opposing asperities (microscopic projections on metal surfaces that result from normal surface-finishing processes) and the consequent scoring (distress marks or long, distinct scratches on sliding metallic surfaces in the direction of motion) that is so destructive to these metal surfaces under high loads.

ELEMENTAL ANALYSIS (24 METALS BY ICP)

Elemental Analysis by ICP (inductively-coupled plasma) detects up to 24 metals, measuring less than 5# in size that can be present in used oil due to wear, contamination or additives. Wear Metals include iron, chromium, nickel, aluminum, copper, lead, tin, cadmium, silver, titanium and vanadium. Contaminant Metals include silicon, sodium, potassium, molybdenum, antimony, manganese, lithium and boron. Additive Metals include magnesium, calcium, barium, phosphorous and zinc. Elemental Analysis is instrumental in determining the type and severity of wear occurring within a unit. Consult the POLARIS Wear Metals Guide for quick reference to possible wear metal sources.

FIRE POINT

Fire Point is the minimum sample temperature at which vapor is produced at a rate sufficient to sustain combustion for at least 5
seconds.

FLASH POINT

Flash Point is the lowest temperature at which the vapors of a combustible liquid will ignite momentarily in air. Low diesel fuel flash points indicate contamination by more volatile fuels such as gasoline. For Flash Point by Pensky Martens and Flash Point by Cleveland Open Cup, refer to ASTM Guidelines for minimum flash point requirements.

FTIR

FTIR (Fourier Transform Infrared Spectroscopy or Full Spectrum Scan) is a test where infrared light absorption is used for assessing levels of soot, sulfates, oxidation, nitro-oxidation, glycol, fuel and water contaminants.

FUEL DILUTION

Fuel Dilution is the amount of raw, unburned fuel that ends up in the crankcase. It lowers an oil’s viscosity - creating friction-related wear almost immediately - and also decreases unit load capacity. POLARIS reports fuel dilution in % of volume.

GLYCOL

Glycol is a test used to check an oil for contamination from a glycol product such as antifreeze or water/glycol in an oil environment.

NITRATION

Nitration indicates excessive "blow-by" from cylinder walls and/or compression rings. It also indicates the presence of nitric acid, which speeds up oxidation. Too much disparity between oxidation and nitration can point to air to fuel ratio problems. As oxidation/nitration increases, so will total acid number and viscosity, while total base number will begin to decrease.

OXIDATION
Oxidation measures the breakdown of a lubricant due to age and operating conditions. It prevents additives from performing properly and therefore allows acid content and viscosity to increase.

PARTICLE COUNT
Particle Count is the measurement of all particles that have accumulated within a system, including those metallic and non-metallic, fibers, dirt, water, bacteria and any other kind of debris. It is most useful in determining fluid and system cleanliness in such filtered systems as hydraulics, turbines, compressors, auto/power shift transmissions, recirculation systems and filtered gear systems with a fluid viscosity of less than ISO 320.

PARTICLE QUANTIFYING
Particle Quantifying (Ferrous Density) exposes a lubricant to a magnetic field. The presence of any ferrous metals causes a distortion in the field, which is represented as the PQ Index, an arbitrary unit of measurement that correlates well with DR ferro large. Although PQ does not provide a ratio of small to large ferrous particles, if the PQ Index is smaller than FE ppm by ICP, it's unlikely there are any particles larger than 5 microns present. If the PQ Index increases dramatically while the ICPs FE ppm remains consistent or goes down, larger ferrous particles are being generated and further testing or diagnostics are recommended.

pH
pH is a measure of oil's alkalinity or acidity. It indicates the intensity of acid-forming or base-forming materials present.

SOOT
Soot is also reported in % of volume and can indicate reduced combustion efficiency. Soot can be caused by over-fueling, air restrictions, blow-by, excessive engine brake use and/or excessive exhaust backpressure.

STRONG ACID NUMBER
Strong Acid Number is the quantity of strong acid or strong base, expressed in equivalent numbers of milligrams of KOH, required to neutralize strong acid (pH 4/g) constituents.

STRONG BASE NUMBER
Strong Base Number is the quantity of strong acid or strong base, expressed in equivalent numbers of milligrams of KOH, required to neutralize base (pH 11/g) constituents.

VISCOSITY
Viscosity measures a lubricant's resistance to flow (fluid thickness) at temperature and is considered an oil's most important physical property.

Depending on lube grade, viscosity is tested at 40 and/or 100 ° Centigrade and reported in Centistokes.

VISCOSITY INDEX
Viscosity Index represents an oil's change in viscosity with respect to changes in temperature. The viscosity index of an oil is determined experimentally by testing its viscosity at 40°C and 100°C.

WATER
Water in oil decreases lubricity, prevents additives from performing properly and furthers oxidation. Its presence can be determined by Crackle (hot plate) or FTIR (full spectrum scan) and is reported in % of volume.

WATER BY KARL FISCHER
Water by Karl Fischer measures water by titration and is reported in either ppm (parts per million) or % by volume.

DIESEL FUEL ANALYSIS

ASH
Ash can result from oil, water-soluble metallic compounds or contamination (dirt or rust). By knowing the amount of ash forming material
in a product, it can be determined if a product is suitable for a given application.

AEROBIC BACTERIA
Aerobic Bacteria testing determines the presence of bacteria and how many colonies there are.

API GRAVITY
API Gravity is the measure of a diesel fuel's density, or weight per volume. The higher the API Gravity, the less dense the fuel. API Gravity can provide valuable information about a fuel's composition and performance characteristics including power economy, low temperature properties and smoking tendencies.

BACTERIA, FUNGI, AND MOLD
Bacteria, Fungi and Mold are indications that fuel storage tanks have not been properly maintained. Water can build up at the bottom of storage tanks and create an excellent breeding ground for biological growth.

BTU (PER GALLON)
BTU (per gallon) is a conversion from BTU per pound.

BTU (PER POUND)
BTU (per pound) is the quantity of heat required to raise the temperature of one pound of water 1°F at 60°F and at a pressure of one atmosphere.

CETANE INDEX
Cetane Index is a measure of a diesel fuel's ignition quality. The limit for a #2 diesel fuel is a Cetane Index of at least 40.

CLOUD POINT
Cloud Point is the temperature at which wax crystals begin to form.

COLD FILTER PLUG POINT
Cold Filter Plug Point determines the temperature of a fuel at which wax crystals form to the extent that they plug fuel filters.

DENSITY
Density is a quality indicator for fuels where it affects storage, handling and combustion. Measures density of a fluid.

DISTILLATION
Distillation temperature is the temperature at which 90% of the fuel volume can be distilled off. This temperature is directly related to the fuel's volatility and therefore, its Cetane Index, density, flash point and viscosity as well. A #2 diesel fuel's minimum distillation temperature is 282° C - its maximum is 338° C.

FLASH POINT
Flash Point is the lowest temperature at which the vapors of a combustible liquid will ignite momentarily in air. Low diesel fuel flash points indicate contamination by more volatile fuels such as gasoline. For Flash Point by Pensky Martens and Flash Point by Cleveland Open Cup, refer to ASTM Guidelines for minimum flash point requirements.

LUBRICITY
Lubricity is a measure of the ability to affect friction between and wear to surfaces in motion under load. Diesel fuel injection components have some reliance on the lubricating properties of diesel fuel. Lack of lubricity in a fuel can shorten the life of fuel system components.

POUR POINT
Pour Point is the lowest temperature at which fuel will still pour. Using ASTM D 97, which measures the pour point of any petroleum product (such as diesel fuel), pour point is the lowest temperature at which movement of the test specimen is observed.

SPECIFIC GRAVITY
Specific Gravity is the ratio of the mass of a given volume of product and the mass of an equal volume of water, at the same temperature. It can be determined by a hydrometer, a graduated float weighted at one end that provides

a direct reading of specific gravity depending on the depth to which it sinks in the liquid.

SULFUR
Sulfur content will affect SOx emissions and can have adverse effects on many NOx and PM emission reduction devices. The amount of sulfur allowed in diesel fuel is regulated by the government. Bulk delivery of diesel fuel should be tested to include sulfur levels.

THERMAL STABILITY
Thermal Stability is a percentage range assigned to a fuel based on its tendency to produce asphaltenes at high temperatures.
Asphaltenes are tar-like, resinous substances most often responsible for clogging fuel filters. Fuel with a Thermal Stability of 80% or greater should not cause filter clogging. Fuels between 60% and 80% could have a marginal affect and values less than 60% will significantly reduce filter life.

WATER & SEDIMENT
Water & Sediment in fuel can cause corrosion, wear, bacterial growth and premature fuel filter clogging. The amount of water in fuel should not exceed 500 ppm (0.05%). Sediment should be no greater than 100 ppm (0.01%).

COOLANT ANALYSIS

ANTIFREEZE %
Antifreeze % (Ethylene or Propylene Glycol) levels should range between 40% and 60% to ensure proper freeze point protection. A high percentage of glycol can cause additive drop out and shorten coolant life.

BOIL POINT
Boil Point is calculated from glycol %, boil point indicates at what temperature a coolant will boil at sea level.

CALCIUM CARBONATE
Calcium Carbonate can be calcium from source water and contributes to the hardness of the water.

CARBOXYLIC ACID
Carboxylic Acid testing determines if the amount of carboxylic acid required by an organic acid coolant is present, or if there is
contamination from a conventional coolant.

CONTAMINANTS
Contaminants include Nitrites, Nitrates, Chlorides & Sulfates. Nitrites and Nitrates are metal-protecting chemicals in Supplemental Coolant Additive packages. Chlorides and Sulfates are outside contaminants. Chlorides can come from

source water or air leaks. Sulfates can also come from source water or combustion gas leaks. Both have the potential to form acids.

CORROSION INHIBITORS

Corrosion Inhibitors are chemicals in Supplemental Coolant Additive packages that are designed to lay a protective film on various metals to inhibit corrosion.

ELEMENTAL ANALYSIS BY ICP

Elemental Analysis by ICP identifies metals that are typically the product of corrosion such as iron, aluminum, copper, lead, tin, zinc and silver. Also included are inhibitor additives such as silicates, molybdenum/molybdates, phosphorus/phosphates and boron/borates.

FREEZE POINT

Freeze Point is the temperature at which the liquid solidifies. Freeze point is a function of the glycol concentration in the engine coolant.

GLYCOLATES, ACETATES, FORMATES & OXYLATES

Glycolates, Acetates, Formates and Oxylates are acids that form as a result of coolant degradation.

NITRATE

Nitrate is an inhibitor for aluminum and solder corrosion protection. The conversion from nitrite to nitrate can indicate an electrical ground problem within the cooling system.

NITRITE

Nitrite is an inhibitor for cast iron, steel and liner cavitation protection. Excessive levels can lead to solder corrosion.

pH

pH is a measure of the coolant's acidity or alkalinity. Whereas a coolant's neutralization number is related to the quantity of acid- or base forming materials in a solution, pH indicates their intensity. Coolant pH range should remain between 7.5 and 11 to provide adequate corrosion protection.

RESERVE ALKALINITY

Reserve Alkalinity testing determines the base or alkaline reserve in a fluid. It can be done on many fluid types but is most commonly used for metalworking fluids.

SCA NUMBER

SCA Number (Supplement Coolant Additive) Number represents the level of coolant additive required for adequate liner pitting
protection. A level of 2.5 is ideal for extending coolant life. SCA can be in the form of an additive that is added to the coolant or from a water filter time release system.

SPECIFIC CONDUCTANCE
Specific Conductance is a coolant's ability to resist carrying an electrical current between dissimilar metals. Excessive levels can be due to improper source water, high metal corrosion or over-treatment with SCAs.

TOTAL DISSOLVED SOLIDS
Total Dissolved Solids such as inhibitor chemicals, silicates, contaminants and water hardness compounds can lead to water pump leakage. TDS levels should not exceed 4%. If leakage occurs, drain coolant and flush pump with tap water.

TOTAL HARDNESS
A source water's hardness is determined by the amounts of calcium and magnesium present.

VISUALS
Visual inspection identifies outside contamination sources or coolant degradation. Oil and fuel contamination can destroy rubber seals and changes in color may indicate changes in chemical composition or possible mixing of formulations. Foaming causes loss of heat transfer. Odor helps confirm the source of contamination and/or degradation sources.

SPECIALTY TESTING

4 BALL WEAR TEST
4 Ball Wear Test (ASTM D 2266) determines a lubricant's anti-wear properties under boundary lubrication (metal to metal contact). Three steel balls are clamped together to form a cradle upon which a fourth ball rotates on a vertical axis. The balls are immersed in the oil sample at a specified speed, temperature and load. At the end of a specified test time, the average diameter of the wear scars on the three lower balls is measured.

CARBON RESIDUE
Carbon Residue (Conradson/Ramsbottom) is the percent of coked material remaining after a sample of lubricating oil has been exposed to high temperatures under ASTM D189 (Conradson) or ASTM D 524 (Ramsbottom). Results are reported as a percentage of the weight of the original sample. As far as the affect of residue on performance, one opinion is that the type of carbon is of greater importance than the quantity. Since compounded oils contain metallic additives that generally leave a residue, other testing should be done to also identify the type of residue rather than just the amount.

COPPER CORROSION
Copper Corrosion testing evaluates a fluid's tendency to corrode cuprous metals. Results are based on the matching of corrosion stains and are often reported on a pass or no-pass basis. Non-corrosiveness should not be confused with rust

inhibiting, which is the protection of a surface from a particular contaminant, such as water, rather than the lubricant itself.

DENSITY

Density is a quality indicator for fuels where it affects storage, handling and combustion. Measures density of a fluid.

FOAM

Foam testing determines the foaming characteristics of a lubricant or fuel oil by blowing air through a sample at a specified temperature and measuring the volume of foam produced as described in ASTM D 892. Foaming can result from excessive agitation, improper fluid levels, air leaks, contamination or cavitation - the pitting or wearing away of a solid surface as a result of the collapse of a vapor bubble. Foaming can cause sluggish hydraulic operation, air binding in oil pumps and tank or sump overflow.

GRAVIMETRIC SOLIDS

Gravimetric Solids - a filter patch is tare weighted and sample is passed through the filter and then re-weighed to get a % Solids result.

MICROPATCH

MicroPatch requires a prepped sample be passed through a .8# absolute filter then examined through a microscope. Results are
interpreted and prepared on a separate report with digital imagery similar to an Analytical Ferrograph.

PHOTO MICROGRAPH

Photo Micrograph is similar to Micro Patch except only photos are taken. There is no interpretation or separate report.

PENTANE INSOLUABLES

Pentane Insoluables (coagulated/uncoagulated) identifies contaminants in used oil. The oil is first diluted with pentane so it loses its solvency for certain oxidation resins (light yellow to dark brown solid or semi-solid materials composed of carbon, hydrogen and oxygen). This dilution also causes the precipitation of such extraneous materials as dirt, soot and wear metals or pentane insoluables.

RPVOT

RPVOT (Rotary Pressure Vessel Oxidation Test) measures the oxidation stability of a turbine oil. The sample is placed in a container, which is then placed in a heated bath, charged with oxygen and pressurized while a constant elevated temperature is maintained. Oxidation stability is expressed in terms of the time required to achieve a specified pressure drop.

RUST
Rust results from the chemical reaction between water present in a lubricant and metal.

SULFATED ASH
Sulfated Ash is a test used to indicate the concentration of known metallic additives in new oils.

TRAMP OIL PERCENT
Tramp Oil Percent is the amount of undesired oil scum in a system, such as lubricants or hydraulic fluids that mix with rolling oil systems in cold mill areas.

TOLUENE INSOLUBLES
Toluene Insoluables (coagulated/uncoagulated) are the solids remaining after oxidation resins, or pentane insoluables, have been diluted with toluene. Insoluble resins are the difference in weight between the pentane insoluables and the toluene insoluables.

WATER SEPARABILITY
Water Separability Characteristics by ASTM D-1401 measures a fluids ability to shed water. It is also commonly referred to as a Demulsification test.

Joint Commission on Accreditation of Healthcare Organizations

Sentinel Event Alert

Preventing adverse events caused by emergency electrical power system failures

Health care facilities are highly dependent on reliable sources of electrical power. Therefore, electric power is a mission-critical resource. Each health care facility must assess the risk of electrical power failure – at various degrees of magnitude and impact severity – and make plans to deal with such an emergency. Planning and implementation of risk reduction approaches to addressing electrical power failure are the responsibility of the facility engineer, as well as organization management, the risk manager, incident command leaders, and the medical staff. By assuming access to emergency electrical power systems and implementing contingency plans for clinicians to follow during both short-term and sustained losses of power, health care organizations can reduce the risk of adverse patient care events.

A power failure can range in magnitude and impact from a relatively modest curtailment of power caused by a local power disruption to a catastrophic regional blackout caused by a violent storm or terrorist attack. As reflected in numerous media reports, clinical operations were negatively affected when normal power was lost during the Houston floods of 2001, the northeastern United States blackout in 2003, and major hurricanes Charlie, Francis, Ivan and Jean in 2004 and Katrina and Rita in 2005. Three incidents relating to failures of emergency electrical power systems are in the Joint Commission's Sentinel Event Database (reporting period from January 1995 to the present). These range from single unit failures to entire large medical centers, and each was associated with one or more patient deaths.

Meeting NFPA codes and standards only a start

Each health care facility must have an emergency power testing program that includes generator load testing and Emergency Power Supply System (EPSS) maintenance. The National Fire Protection Association (NFPA) establishes codes and standards on the minimum design, installation, and testing of these systems in the National Electric Code (NFPA 70), the Standard on Health Care Facilities (NFPA 99), and the Standard for Emergency and Standby Power Systems (NFPA 110). EPSSs meeting the NFPA codes and standards are designed for immediate life safety – in other words, to complete surgical or other procedures where lives are in balance or to evacuate the building in case of fire. These systems should be designed to "hold out" until normal power is restored.

However, recent experiences demonstrate that emergency power systems that meet these standards are not always sufficient during major catastrophes. This is because they can only support the power needs of a small percentage of the needed equipment and systems, or they are unable to supply power for an extended period of time. For example, in the wake of hurricane Katrina, many health care organizations did not have sufficient emergency power to cool or ventilate their facilities. In other instances, evacuation of patients was delayed because only one or two elevators could be operated. To assure optimal safety during catastrophes, health care organizations are encouraged to go beyond the minimum NFPA life safety requirements and to conduct thorough vulnerability analyses of their facilities.

The Joint Commission addresses emergency electrical power systems in standards EC.7.20 and EC.7.40 and addresses emergency procedures for utility system disruptions in standard EC.7.10. To address the need to provide emergency power for an extended period of time, an additional Element of Performance (EP) for standard EC.7.40 was recently approved and will appear in the 2007 standards. The new EP requires each organization to test its emergency generators at least once every 36 months for a minimum of four continuous hours. This testing is over and beyond the current requirement to test emergency generators for 30 continuous minutes 12 times each year.

In addition, if a test(s) required by standard EC.7.40 fails, the organization is required to implement interim measures to compensate for the risk to patients, visitors, and staffs until necessary repairs or corrections are completed.

Risk reduction strategies

Important suggestions for proactively assessing a facility's vulnerabilities, helping to assure sufficient electrical power during emergencies, and facilitating the development of contingency plans for clinicians to follow in the event of short-term or sustained power loss include the following:

- Meet with your local utility provider and assess the reliability of the existing power system. Many facilities are served by overloaded power grids that have transformers and distribution equipment that date back to the 1950s. In other cases, expansions to the original power system have resulted in a "patchwork" system that may not operate reliably during periods of peak loads.

- Respond to facility brown-outs or black-outs as symptoms of marginal power supply. These may be related to the recent addition of new equipment.

- Fully test the entire emergency power supply system against the requirements of NFPA 110 to ensure minimum acceptable performance. Because appropriate testing may impact operations for periods of four hours or more, it is important that organization management, the medical staff, nursing, respiratory therapy,

and other key staff participate in the test. The test should be scheduled well in advance of carrying it out; in the same way as any disaster drill would be planned. Electricians, mechanics, and other maintenance technicians should be stationed in strategic locations throughout the facility during testing to monitor the functioning of critical equipment and to minimize response time for problems that may occur. After testing, all fuel supplies should be replenished.

- For any new construction, undertake relevant infrastructure planning as part of a master facility plan. This will assure optimal location of the generator, fuel tank, and support equipment (for example, in flood prone areas, above potential flood levels) and proper redundancy (multiple generators feeding loads versus loads dedicated to a single generator). Such planning will also permit the addition of loads over time and will identify security needs respecting access to generators and other critical equipment such as fuel tanks and radiators, which are essential to generator function.

- Assess the need for additional redundancy through portable, truck-mounted generators and develop procedures to isolate generators from problem areas and to tie in supplemental equipment not normally fed by emergency power. Also, consider designing in emergency connection panels. These might, for example, be used to hook up a truck-mounted unit during construction or renovation.

- Maintain written procedures and record all test data. Written procedures help facility managers control the testing process and require testing personnel to take responsibility for performing required tasks. Many facilities use standardized testing forms to collect test-related data. Unanticipated occurrences should be reported immediately or right after the test for analysis by the supervisor in charge of the test. Mechanical system interactions can be recorded during the test on simple data forms to facilitate both data recording and system recovery. This information can also be used for performance improvement purposes.

Joint Commission Recommendations

In addition to the current standards requirements that address emergency electrical power systems and current NFPA testing requirements, the Joint Commission recommends the following to help prevent adverse events caused by an emergency electrical power system failure:

1. Perform a gap analysis on the emergency power system that matches the critical equipment and systems needed in an extended emergency against the equipment and systems actually on the emergency power system. Use disaster scenario planning to identify critical systems that could potentially be lost (for example, potable water or elevators). This kind of planning will help assure that emergency power feeds critical systems such as water pumps in high-rise facilities; sewer pumps in low areas; heating, air conditioning and fan units in

intense climate regions; and air handlers in isolation rooms (to minimize the risk of airborne infections), in protective environment rooms, and in laboratory and pharmacy hoods.

2. Maintain a complete, labeled inventory of all emergency power systems and the loads they serve.

3. Provide competency training and testing for all operators and others responsible for system maintenance of the emergency power supply system.

4. Test generator fuel oil, track expiration dates, and replace stale fuel oil not consumed within its storage life.

5. Ensure that engineering staff communicate the capabilities and limitations of the emergency power supply system to the organization's management and clinical leaders. These communications should cover how long emergency power will be available, how long it will take the generators to provide power if and when the utility company's power is lost, and what locations within the facility will and will not be powered by the emergency power.

6. Establish contingency plans for clinicians to follow during brief or sustained losses of emergency power and include this as part of the orientation and periodic continuing educational activities for medical and other clinical staff. These plans should focus on the requirements set forth in standard EC.7.20, to wit: organizations must supply reliable emergency power to alarm systems; exit sign and exit route illumination; emergency communication systems; blood, bone and tissue storage units; emergency/urgent care areas; at least one elevator for non-ambulatory patients; medical air compressors; medical and surgical vacuum systems; areas where electrically powered life support equipment is used; and operating rooms, post-op recovery rooms, obstetrical delivery rooms, and newborn nurseries.

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NFPA 110 Update: Paying More Attention to the Business of Emergency Power Reliability

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Introduction

NFPA 110 is undergoing a long-anticipated revision. One of the documents in the 2009 revision cycle along with NFPA 99, NFPA 111 and several others, NFPA 110 has already gone through the first round of public proposals for changes. The NFPA Technical Committee (TC) on Emergency Power Supplies, which is responsible for NFPA 110 and 111, met in early 2008 to review all public proposals and also prepare committee proposals to update this increasingly important document. The NFPA 110 Report on Proposals (ROP) is being released for public comment as of this writing. The NFPA 110 ROP has been reviewed and approved by the 110 TC and the National Electrical Code® Technical Correlating Committee (NEC TCC.)1

The purpose of this white paper is not to review all of the proposals. The first part of this paper will discuss some of the existing proposals in the ROP that could have a major effect on the health care community if they survive the second round of public and TC reviews. The second part of this paper will discuss existing provisions in NFPA 110 pertaining to testing and maintenance that are intended to improve the operational reliability of an emergency power supply system (EPSS.)

Readers are urged to obtain a copy of the ROP from the NFPA website (www.nfpa.org) and review all proposed changes, including those that were rejected by the 110 TC. The commentary of the TC members during the balloting stage is also important because there were some differences of opinion within the TC about some of the final ROP wording. Readers are urged to use the opportunity built into the NFPA process for them to comment on the proposals and on the action takes by the TC during the ROP preparation stage. The closing date for receipt of further public comments for the ROP's of all standards in the 2009 revision cycle August 29, 2008.

Major Proposed Changes in NFPA 110 [Not Final Yet]

Proposed exclusion of optional standby systems

One of the major results of the disasters and terrorist attacks of the last 15 years has been an increase in the design and installation of optional standby systems.

These optional standby systems are discussed in NEC® Article 702. They include, for example, larger stand-alone EPSS's intended to provide additional emergency power for ventilation and cooling systems that are not required to have emergency power by codes, standards and Authorities Having Jurisdiction (AHJ's.)

The 110 TC decided to clarify the application of 110 to these non-required systems in response to questions from the public. The clarification is the 110 does not apply to the equipment of systems that are not classed (classified, but in NFPA language) as either Level 1 or Level 2 systems. Optional standby systems are not classed as Level 1 or Level 2 systems.

Proposed testing modifications

There have been many questions to the NFPA about the intent of the 110 testing provisions. The 110 TC reworded and reorganized the entire Initial Acceptance Testing section to clarify the TC's intent. There was some toughening of requirements, such as the new requirement to field-verify the engine start function throughout the entire EPSS. There was also the relaxation of some requirements, such as permitting an automatic transfer switch (ATS) test switch to start the acceptance test in existing occupied buildings and facilities rather than requiring a complete normal power outage for the first 2 hours of the Initial Acceptance Test as is presently required in the 2005 edition. Also included in this revision is a reduction from 2 hours to 1 ½ hours for the first portion of the Initial Acceptance Test in order to reduce engine exhaust emissions.

The 110 TC also responded to a number of questions concerning how to switch from the first portion of the Initial Acceptance Test to the second portion of that test in not more than 5 minutes by discussing in the Annex the installation of permanently installed equipment or connection points, such as spare circuit breakers or switches, for load banks and portable generators.

The annual load bank test was shortened from 2 hours from 1 ½ hours, also to reduce engine emissions.

The 3-year 4-hour load test was also rewritten and reorganized to clarify the TC's intent. This rewrite relaxes several requirements, such as permitting the use of ATS test switches rather than requiring that the normal power to the ATS's be dropped. This change was in response to concerns that a generator failure during the 4-hour test would result in a dead ATS unless the normal power source to the ATS stayed alive throughout the test, allowing the ATS to transfer back to normal power automatically. The 110 TC also responded to the joint ASHE/TJC request for a formal interpretation by allowing the 3-year test, one annual load test, and one monthly load test to be a combined test. This change also reduces engine emissions.

Finally, the 110 TC clarified in the Annex that the 110 requirement for weekly EPSS inspections does not require running the generator set weekly. Many facilities run their generator sets unloaded weekly between monthly load tests because they mistakenly believe that 110 requires that. Of course if the engine manufacturer recommends weekly running, or if a local code, standard, or AHJ requires it, those recommendations or requirements might supersede the TC's clarification. Several public proposals were rejected by the TC for a wide variety of reasons. They are not discussed in this white paper, but are available for public review, and rebuttal, in the ROP.

Reliability Requires Smart Testing and Maintenance

Emergency power supply system (EPSS) failures have occurred in large part because of the lack of smart maintenance and testing at various levels. Some facilities fall down on the regular testing and maintenance and then simply replace infrastructure equipment when its condition deteriorates too much.

NFPA 110 recognizes this and includes testing and maintenance requirements in the body of the standard and recommendations 5n the Annex. Consider this:

"Reliability and facility infrastructure health are not guaranteed simply by investing in and installing new equipment. Unexpected failures can compromise even the most robust facility infrastructure if appropriate testing, maintenance and due diligence techniques are not employed." 2

When a power system vulnerability analysis is undertaken, perhaps in response to The Joint Commission's Sentinel Event Alert Issue 37, one of the commonly-found areas of increased vulnerability is related to inadequate testing and maintenance. 3

One example of this type of vulnerability is inadequate ATS maintenance because many existing ATS's are not of the bypass-isolation type and the facility is unwilling to turn off the ATS loads during the maintenance period. A second example is when some facilities fail to operate selected ATS's every month because they view switching the ATS loads from normal to emergency power and back again as problematic. Yet another example is when circuit breakers have not been maintained since they were first installed, despite industry data to the effect that the failure rate of circuit breakers increases remarkably when they go for 5 consecutive years without maintenance. 4 5

Although The Joint Commission allows the 3-year load test to be a load bank test with a load not less than 30% of the generator set nameplate rating,6 this is not necessarily the best approach if the EPSS peak demand load is greater than the 30% TJC load bank test requirement. Why wouldn't due diligence demand that the test load be not less than the documented EPSS peak demand loading? It just makes sense if the purpose of the test is to verify the continued performance

of the EPSS to perform its intended function. The best tests are those that simulate, as closely as practical, the real operating conditions expected during a normal power outage.

1 National Electrical Code® and NEC® are both registered trademarks of the National Fire Protection Association
2 Reprinted from the "BITS Guide to Business-Critical Power" with permission, published September 2006 by the BITS Financial Service Roundtable, Washington, DC. www.bitsinfo.org.
3 Sentinel Event Alert Issue 37: "Preventing adverse events caused by emergency electrical power system failures." September 6, 2006, The Joint Commission. Also refer to the SEA-37 discussion in the September 2007 issue of Environment of Care News, The Joint Commission.
4 Callanan, Michael, Neitzel, Dennis, and Neeser, Dan, Preventative Maintenance and Reliability of Low Voltage Overcurrent Protective Devices.
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6 The Joint Commission, CAMH, EC.7.40

The present maintenance requirements in NFPA 110 are of a preventive maintenance (PM) nature; they are calendar based. There are also other possible approaches, such as predictive maintenance (PdM) and reliability-centered maintenance (RCM). The last alternative that is NOT recommended is the reactive maintenance approach, also called "run-to-failure maintenance" or "breakdown maintenance." NFPA 110 has basic testing and maintenance requirements and recommendations for the generator set itself, its batteries, its fuel oil; the EPSS transfer switches and paralleling switchgear, and circuit breakers. Readers are urged to review manufacturers' recommendations, NFPA 70B and other industry guidance to determine what proactive maintenance program will be invoked for their own facilities.

NFPA Disclaimer:
Although the author is Chairman of the NFPA Technical Committee on Emergency Power Supplies, which is responsible for NFPA 110 and 111, the views and opinions expressed in this document are purely those of the author and shall not be considered the official position of NFPA or any of its Technical Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation. Readers are encouraged to refer to the entire text of all referenced documents. NFPA members can obtain NFPA staff interpretations at www.nfpa.org.

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