

# INSTRUCTIONS

GEI-28004H  
Supersedes GEI-28004G

## TYPE I INSULATING OIL TYPE II INHIBITED INSULATING OIL

### FOR USE IN TRANSFORMERS, REACTORS, REGULATORS AND OTHER ELECTRICAL EQUIPMENT

#### INTRODUCTION

General Electric approved insulating oil is used in transformers, reactors, and other electrical equipment to transfer heat, and provide a major part of the insulation. The properties of the oil contribute to long life and low maintenance requirements. The oil is compatible with all materials in the apparatus.

Only GE approved oil should be used in General Electric equipment. The use of other than General Electric Company approved oil voids standard warranties with the exception of obvious structural or mechanical defects that in no way can be related to the oil.

Deterioration of oil, which takes place principally through oxidation, is a complicated process due to the many hydrocarbon compounds involved. Oxidation produces sludge which causes a blanketing effect on cooling surfaces, thereby increasing internal temperatures and reducing the life of the equipment. GE approved Type I oil resists the tendency to oxidize. Type II inhibited oil is more resistant to oxidation than Type I oil, and under certain conditions favoring oxidation, shows a marked increase in life. A sealed oil-preservation system, such as used on a GE power transformer, reduces greatly the opportunity for the oil to oxidize.

All approved insulating oil is refined to meet specific General Electric standards and is conditioned for many years of service.

General Electric approved Type II inhibited oil is Type I oil with an inhibitor added to extend the oxidation life. Type II oil and Type I oil can be mixed in any proportion; however, dilution of the inhibited oil with Type I oil reduces the concentration and effectiveness of the inhibitor.

Whenever possible, oil is shipped in the apparatus with which it is to be used. This method of shipment prevents the entrance of moisture and air into the windings during transit, and usually eliminates the

necessity of drying the apparatus upon arrival at the destination. When shipped separately, the oil will normally be furnished in tank cars or tank trucks. For shipping small amounts of oil, hermetically sealed metal cans, or steel drums sealed with gasketed screw bungs are used.

In order to obtain the best service from GE approved Type I and Type II oil, the care and maintenance described in this leaflet should be followed.

#### DIELECTRIC STRENGTH

##### (New Oil)

The use of oil as an insulating material requires that it have a high dielectric strength. The presence of impurities in the oil, particularly moisture, may lower the dielectric strength to such a value as to make the oil unsafe for use. Type I oil, as shipped, is vendor controlled to meet a minimum dielectric breakdown voltage of 30 kv when tested by ASTM (American Society for Testing and Materials) D 877. It is emphasized that additional processing (degasification, dehydration, and filtration) is normally required for the oil to be used in certain high-voltage apparatus. Such oil must have a minimum dielectric breakdown voltage of at least 30 kv when tested according to ASTM Standard Method D 1816 for testing oil in a 40-mil gap, spherical-electrode test cell. For this purpose, ASTM D 877 is unacceptable.

**SAMPLE, AND DIELECTRIC TEST, ALL OIL BEFORE PLACING IT IN THE EQUIPMENT.** When oil is supplied in more than one container, sample and test the oil from each container. Methods of sampling and testing oil from drums and tank cars are outlined in subsequent sections.

Because oil is easily contaminated, drums and cans should be kept free of any material that might impair the quality or condition of the oil. Automotive or railway tank trucks or cars should not be used unless it is known they are maintained exclusively for transporting insulating oil.

*These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.*

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If oil as received tests 30 kv or higher (spherical-type electrodes, ASTM D1816), it is suitable for use. If the oil breakdown voltage is lower, the dielectric strength must be restored to the specified minimum value by additional processing (degasification, dehydration, and filtration).

After obtaining the desired dielectric strength, pump the oil into the apparatus following instructions furnished for the equipment being filled. A filter press, deaerator, and a 1- or 2-micron cartridge filter are recommended for transferring the oil to the apparatus.

### PERIODIC INSPECTION

Since the insulating oil in the apparatus is a major part of the insulation, it is important that a regular system of inspection and testing be followed.

Periodic checking of the oil level, the dielectric strength, and the possible formation of deposits will help prevent major faults from developing in the equipment.

#### OIL LEVEL

Maintain the oil at the proper level, adding oil when necessary. The 25C level is indicated by a liquid-level gage. Check the oil level daily.

#### DIELECTRIC STRENGTH

After the first few days of operation of the equipment, test the top and bottom oil. Repeat the test after six months and after one year of operation. After one year, a periodic sampling and testing schedule should be established. The recommended time between inspections and tests depends on local climatic conditions, the load on the apparatus, and the importance of minimizing service interruptions. Intervals between tests should be one year or less depending on the preceding considerations. Accurate records of the tests should be kept. When the oil tests below 26 kv (ASTM D 1816, 40-mil gap), use suitable degasification, dehydration, and filtration equipment to restore the dielectric strength to 30 kv (D 1816, 40-mil gap). When oil is used in equipment having either an Atmosseal®, sealed-tank, automatic gas-seal, conservator, or gas-oil-seal type of oil preservation, there should be no problem in maintaining a dielectric strength of at least 30 kv (ASTM D 1816, 40-mil gap).

A water-cooled unit, or an "open-type" unit such as a furnace transformer with unsealed bar leads

through the cover, should be checked more frequently since the risk of oil contamination is greater than with an oil-to-air heat exchanger or a sealed unit.

#### DEPOSITS

The amount of deposit that accumulates in the oil is of great importance, particularly in an "open-type" transformer or transformer compartment. If a sample of oil from the bottom of the tank or compartment indicates that the oil is badly discolored or contains sediment, inspect the inside of the apparatus for sludge deposits. Sludge causes a blanketing effect on the cooling surfaces; thus increasing the internal temperature and reducing the life of the apparatus. Should there be a deposit on any surface except the tank base, untank the apparatus, filter the oil, and thoroughly clean the core and coil structure and tank by forcing clean, dry oil through the ducts and against all surfaces. Suitable pressure for this operation can be obtained from a filter press.

When oil is found to be in very bad condition, filtering may remove most of the sludge, but badly sludged oil, even after filtering, may soon form a new deposit of sludge. When such conditions occur, it is usually more economical to obtain new oil or to reclaim the old oil.

*Do not use reclaimed circuit breaker oil in a transformer or reactor.*

### HANDLING AND STORING

#### HANDLING

GE approved insulating oil, one of the best insulations available, must be handled and maintained properly to utilize fully the dielectric and cooling capabilities.

When oil is received in separate containers, the apparatus in which it is to be used and the equipment used in transferring it must be absolutely clean and dry. If the installation is outdoors, the preparation and filling of the apparatus should be done on a clear dry day; otherwise adequate protection must be provided to make certain that dirt or moisture does not enter the oil.

Cans and drums are gasketed and tightly sealed. The oil is supplied in 1-gallon, 5-gallon, or 55-gallon containers, and also in bulk shipments of 2500 gallons or more. Before opening the containers, allow them to stand for eight hours or longer until the oil is at least as warm as the surrounding air.

Use only perfectly clean metal hose or oilproof

synthetic rubber hose for oil lines. The sulphur in natural rubber will dissolve in the oil and prove harmful to the copper in the windings of a transformer.

**WARNING** – *Static charges can be developed when transformer oil flows in pipes, hoses, and tanks. Oil leaving the processing equipment may be charged to over fifty thousand volts. To accelerate dissipation of the charge in the oil, ground the processing equipment, the piping, the tank, and all bushings or windings during oil flow into any tank. Conduction through oil is slow, therefore it is desirable to maintain these grounds for at least an hour after the oil flow has been stopped.*

*Remove an explosive gas mixture from any container into which oil is flowing. Arcs can occur from the free surface of the charged oil even though the previous grounding precautions have been taken.*

It is recommended that all oil be pumped into the apparatus through a filtering system. Refer to the section on "Filtering and Degassing."

If only part of the oil in a drum is used, the remaining oil should be protected from contamination and contact with the air by reclosing the bung promptly. Use a new gasket if the old one is not in good condition.

### STORING

Store full or partially full oil drums or cans in a closed room. Keep the bungs tight. If necessary to store oil outdoors, protect the containers from the weather and direct contact with water. Regardless of the storage location, all drummed oil should be stored with the bungs *down* so that the bungs are under a positive oil pressure. In the event the drums cool and the bungs are in an upright position, vacuum created inside the drums may force outside air and water into the drums; thus leading to contamination of the oil.

Do not open or unseal the drums or cans until the oil is actually needed. Any change in temperature while the containers are open will cause an exchange of air between the containers and the room with the possibility of moisture entering the oil. Partially emptied drums must be resealed tightly and stored in the same manner as explained previously.

When the oil is shipped in the apparatus, exercise care to see that dirt or moisture does not enter the tank. A transformer or reactor tank filled with oil must not have the cover removed any longer than necessary for repairs or inspection. In any case, the oil must be tested for dielectric strength before energizing the equipment.

### SAMPLING

It is recommended that the ASTM standard methods for sampling (latest revision of D 923) be followed when sampling insulating oils. **THE ACCURACY OF TEST RESULTS MAY BE SERIOUSLY AFFECTED IF THE OIL SAMPLES ARE NOT OBTAINED AND HANDLED CORRECTLY BEFORE TESTING.** Observe the following procedures which experience has indicated are essential to obtain representative oil samples.

#### SAMPLING FROM TRANSFORMER OR REACTOR

1. Use glass receptacles, if possible, so that if any free water is present it can be readily observed. General Electric, chemically-cleaned, one-quart, amber-glass, screw-cap sample bottles are recommended. If metal containers are used, be sure they are free from rust, solder flux, and other contaminants. For the GE Laboratory Oil Testing Service, described later, only the General Electric sample bottles furnished are acceptable.

2. Thoroughly rinse the sample containers that have been used previously with Stoddard solvent, trichloro-trifluoroethane, or other cleaning agent that completely dissolves the liquid residue, until the containers are entirely clean. Invert and drain the containers to remove excess solvent, and then wash with a detergent or strong soap solution. Rinse thoroughly with clean water, then rinse with distilled water and dry in an oven at 105C to 110C for at least one hour. After drying, store the containers uncapped in a dry, dustfree cabinet or compartment at a temperature of not less than 38C (100F). If they are not stored in a hot cabinet, cap the containers immediately after drying.

3. Take samples when the oil and sample containers are at least as warm as the surrounding air. Insulating oil is not hygroscopic, but cold oil may condense enough moisture from a humid atmosphere to adversely affect the insulating properties. **TAKE SAMPLES FROM OUTDOOR APPARATUS ON A CLEAR DRY DAY ONLY**, and guard against contamination by wind blown dust, etc.

4. Before taking a sample from the apparatus, carefully clean the valve and allow enough oil to run out so that any contamination that may have collected in the valve will be removed. Take the sample from the small valve provided for that purpose.

5. Rinse the container several times with the same oil as the sample to remove any contamination that may have collected in the container. Do not mix these rinsings with the oil samples.

6. Carefully seal the container to prevent leakage or exposure of the oil to the atmosphere. Use a glass stopper, clean cork, or screw cap to seal the glass receptacle. If a cork is used or if the screw cap contains a cork disk insert, the cork should be covered with tin or aluminum foil. A composition cork gasket covered by tin or aluminum foil should be used when the oil sample is placed in a metal container. **DO NOT** use a rubber composition stopper.

### SAMPLING FROM DRUMS

1. Obtain samples from drums after the oil has remained undisturbed and has settled for at least eight hours, and when the oil is at least as warm as the surrounding air. If the drums are outdoors, **TAKE SAMPLES ON A CLEAR DRY DAY ONLY**, and guard against wind blown dust, etc. Take samples with a "thief" which has been cleaned and stored in the same manner as outlined for sample bottles. Rinse the "thief" several times with the oil to be sampled. The sample should be taken about  $\frac{1}{8}$  inch from the bottom. Observe the sampling precautions previously outlined.

2. Clean and wash the glass thief in the same manner as a bottle, and dry at a temperature not less than 100C.

### SAMPLING FROM TANK CARS

Observe the same precautions as in sampling from drums. While industry standards for sampling tank car oil by means of a tank car thief are covered by the latest revision of ASTM D 923, from a practical standpoint satisfactory samples can be obtained from the bottom valve of the tank car. The valve exterior should be thoroughly wiped off and a few quarts of oil should be discharged to clean the valve interior before taking the sample.

## TESTING

### DIELECTRIC STRENGTH

The industry recognizes two methods. ASTM D 877 is recommended for the routine acceptance of new, unprocessed oil from a vendor but **IS NOT** recommended by the General Electric Company for testing insulating oil processed into apparatus or contained in apparatus made by the Power Transformer Products Department. It will not detect satisfactorily, to the required degree, the presence of moisture and particulate contamination. ASTM Method D 1816 is the recommended method for this purpose. It is coming into wider use because of greater sensitivity to soluble moisture (below 60 parts per million) and to suspended solids. It has

been successfully used in our factories for over ten years.

Low dielectric tests may be caused not only by moisture but also by other foreign materials in suspension such as fine metal particles, conducting dust, lint, cellulosic fibers, or carbonized oil.

For testing, refer to ASTM standard test method D 1816 using spherical-type electrodes at a 40-mil gap setting.

A test cell with spherical-type electrodes can be purchased from the General Electric Company. The test cell is a cubical container made from a high dielectric strength, transparent material. The electrodes are mounted rigidly from opposite sides with the gap centered. The cell is equipped with a motor-driven stirrer. Since the cell is transparent, breakdown can be observed. The cell will fit a standard GE a-c test set equipped with a test chamber.

For transformer oil testing, a 35 kv (minimum), 2 kva test set will be needed. Information on test sets can be obtained from the nearest GE Electric Utility Sales Office.

When testing, certain precautions must be observed.

1. The spacing of the spherical electrodes is critical and should be checked for proper adjustment prior to use.

2. The test cell and electrodes must be **CLEAN, DRY, AND FREE OF CORROSION**.

3. The temperature of the oil sample must be at room temperature which should be over 20C and preferably under 30C.

4. The oil in the sample container must be thoroughly mixed *without* introducing air into the oil.

New or restored oil should withstand at least 30 kv (average of five breakdowns by ASTM D 1816 procedure) to be acceptable. Oil in apparatus should withstand at least 26 kv (average) to be acceptable for continued use.

### Electrode Spacing

With the electrodes locked firmly in position, check the gap with a standard round gage. The spacing should be 0.040 inches.

Avoid touching the electrodes or gage with the fingers after cleaning as described in the next section. If it is necessary to readjust the electrodes, the spacing should be checked again after relocking.

### Cleaning Equipment

Since the test cell and electrodes must be clean and

dry, they should be wiped with dry, lint-free tissue paper or a clean, dry chamois. It is important to avoid touching the cleaned electrodes and other parts with the fingers or with portions of the tissue or chamois that have been in contact with the hands. After wiping, the cell should be rinsed thoroughly with a dry hydrocarbon solvent such as Stoddard solvent or water-white kerosene. Do not use solvents such as benzol. Flush the test cell with new, dry, filtered oil and make a test of voltage breakdown on a sample of the same oil. If breakdown is in the proper range for oil of this quality, the test cell is suitable for testing.

#### **Preparing The Sample**

Obtain a sample of the oil to be tested and store in a tightly stoppered, dry, bottle. Refer to the section on "Sampling."

Just before testing, invert the sample bottle gently two or three times to re-entrain into the oil any impurities that may have settled out. Too rapid agitation is undesirable as it introduces air into the liquid; thus causing misleading test results.

Immediately after mixing, pour a small portion of the sample into the cell and rinse. Then, slowly fill the cell.

Replace the cell cover and energize the stirring motor. The sample must be stirred for three minutes before proceeding with the test; then stirred continuously during the test.

#### **Temperature**

The temperature of the sample when tested must be the same as the room temperature and in no case should the room temperature be less than 20C (68F). Testing at lower temperatures is likely to give variable results which may be misleading.

#### **Applying Voltage**

Test at commercial power frequencies.

Apply and increase the voltage at the rate of 0.5 kv per second until breakdown occurs. Occasional momentary discharges may occur which do not trip the circuit interrupter. These should be disregarded.

#### **Number of Tests**

To determine the dielectric strength, make six breakdowns on each sample maintaining at least 1-minute intervals between applications of voltage for successive breakdown tests. During these intervals and while voltage is being applied, the stirrer must be operating.

Record the first breakdown, but otherwise disregard it. The remaining five are examined for statistical consistency, as specified in Method D 1816; then are averaged to determine the dielectric breakdown voltage. If the five breakdowns do not meet the specified criterion for statistical consistency, make five additional breakdowns on the sample and use the average of all ten as the dielectric breakdown voltage of the sample.

To avoid erroneous data that may be caused by sampling difficulties, it is advisable to take duplicate samples for each determination. The two dielectric breakdown voltage results should fall within a range of two kv. A wider spread indicates possible sample contamination regarding the lower value. This should be resolved before any decision regarding disposition of the oil is made.

#### **COLOR**

The color test is only an indicator, not an accurate test in itself since darkening of the oil during oxidation does not indicate necessarily that any particular condition exists. Discoloration is a rough (but not infallible) indication of oxidation which should be verified by making an acidity (neutralization) test. In general, the best indication that a color test can give is that the condition of the oil is doubtful and further tests should be made. The standard laboratory method for determining the color of oils is ASTM Method D 1500. A field test is available as described in ASTM D 1524 using a small color comparator which is excellent for field use.

#### **ACIDITY (NEUTRALIZATION)**

The acidity test is one of the most satisfactory indicators of oxidation in the oil. This is true because some of the oxidation products are of an acid nature and thus can be detected by measuring the acidity of the oil. The main hazard of oxidation is the deposition of sludge. Sludge occurs after the oxidation products held in solution finally saturate the oil, and any additional products formed settle out in solid form. The acidity test indicates fairly accurately how far oxidation has progressed. The standard laboratory methods for determining acid number are covered by ASTM Methods D 974 and D 664. ASTM Method D 1534 may be useful for determining the approximate acidity of used oils.

#### **SLUDGE**

For a laboratory test method for "Sediment and Soluble Sludge in Service-Aged Insulating Oils" refer to ASTM Method D 1698. An ASTM test that

may be of use for observation in the field is covered in ASTM Method D 1524.

However, visual observation of sludge in the sample bottle is adequate for most practical purposes. The observation should be made on a sample of oil which has stood overnight. Any light, tan to brown flocculent sediment or suspended material is probably sludge. Solubility in acetone adds confirmation and distinguishes sludge from cellulose fibers and extraneous sediment which is not soluble.

**RECORDS**

A permanent record of the tests should be kept by apparatus serial number so that a clear picture of the rate of change in the condition of the oil will be available.

**TESTING SERVICE**

For convenience in sampling and testing insulating oil, the General Electric Company will, upon receipt of an order through a sales office, furnish one-quart containers in which a sample of the oil can be sent to the GE Laboratory for analysis. Two types of testing are available: 1, Routine Maintenance tests recommended yearly for transformer oils which previously were in satisfactory condition; and 2, Comprehensive tests for transformer filtered, or reconditioned oils, or where a problem is suspected, and at three to five year intervals in place of yearly routine tests.

Orders for sample bottles should be sent to the Dielectric Materials Laboratory, Building 11-312, General Electric Company, 100 Woodlawn Avenue, Pittsfield, Massachusetts 01201. A complete report covering the following tests will be furnished.

<u>ROUTINE</u>	<u>COMPREHENSIVE</u>
Dielectric Strength	All Routine Tests plus:
Color	Power Factor at 25 C and 100 C
Acidity	Pour Point
Visual Condition	Interfacial Tension
Viscosity	Corrosive Sulfur
Specific Gravity	
Water Content	

Reliable tests are dependent on the samples reaching the laboratory in the same condition as they were when in the apparatus sampled. Therefore, in obtaining and handling the samples, follow the technique outlined under "Sampling."

To assist the laboratory in furnishing the most useful recommendations from the results of tests, a request for testing oil should:

1. State why the tests are desired.
2. Give the serial number and rating of the apparatus from which the samples were taken.
3. State whether or not the samples represent the oil originally furnished with the apparatus, and if not, when the oil was replaced.
4. State the temperature and weather conditions at the time the samples were taken.
5. Give any other information that might have a bearing on the condition of the oil.
6. State to whom the report should be sent.

**FILTERING AND DEGASSING**

The Atmosseal, sealed-tank, automatic-gas-seal, conservator, and gas-oil-seal types of oil preservation help to preserve the condition of the oil and prevent the entrance of water into the main tank. Consequently, filtration of oil during the service life of apparatus having these types of oil preservation is not likely to be required under normal operating conditions.

Excepting the initial filling of the apparatus or subsequent addition or handling, filtering the apparatus oil is not desirable unless careful tests show that the dielectric strength of the oil has fallen to the minimum allowable value. The reason is that the suction piping, pump, stuffing boxes, etc., unless airtight, may, during the filtering operation, introduce a relatively large amount of air into the oil. Since such a leakage is inward, the leakage is difficult to detect. The introduction of air into the oil partially defeats the purpose of the oil preservation system.

When transferring the oil from containers to the apparatus, pass the oil through a filter and degasser to remove any air, moisture, or sediment which may be present. If the oil tests 30 kv (40-mil gap, ASTM D 1816) or above, it is suitable for use. If the oil tests lower, the dielectric strength should be restored to the specified value prior to filling the apparatus.

The best method for restoring the dielectric strength is to process the oil through a filtering system capable of simultaneous filtration, dehydration, and degassification into a separate clean, dry container. This gives the total oil one pass through the process. The oil should then be sampled in the container and, if the desired dielectric strength has been attained, processed into the apparatus. If the desired dielectric strength has not been attained, additional passes through the processing system should be made before filling the electrical equipment.

If the degasser or deaerator is not available, proc-

essing can be accomplished with a blotter paper filter press and a 1- or 2-micron cartridge filter. A blotter paper filter press will usually do an acceptable job of removing solid contamination. **TO EFFECTIVELY DRY OIL WITH A FILTER PRESS ONLY, THE PAPER USED MUST BE DRY AND CHANGED FREQUENTLY.** It is particularly important that instructions covering the drying and handling of the paper be followed closely, as well as other instructions covering filtering equipment. Samples of the outgoing oil from the filter should be taken frequently and tested for dielectric strength. Whenever the dielectric breakdown voltage of the outgoing oil drops below 30 kv (ASTM test method D 1816, 40-mil gap), change the filter paper.

After obtaining the desired dielectric strength, pump the oil into the apparatus. A filtering system capable of simultaneous filtration, dehydration, and degassification is recommended for transferring the oil to the apparatus.

After the apparatus is filled with oil, let it stand for approximately 24 hours (or 48 hours if oil temperature is below 0C) to allow the oil to permeate the immersed parts. Then add additional oil to fill to the proper level, if necessary.

Restoration of the dielectric strength can be achieved without a separate container by circulating the oil from the original container through the processing equipment, and back into the original container. This method is considerably slower because unprocessed oil is continually being mixed with the processed oil.

In an oil filtering or oil storage system, carbonized circuit breaker oil should be handled separately from transformer oil.

Reclaimed circuit breaker oil should not be used in transformers or reactors.

### **INHIBITED OIL (TYPE II)**

The identification "Type II" will appear on the nameplate of apparatus filled with inhibited insulating oil. The characteristics (except for improved oxidation resistance), care, handling, and maintenance of Type II oil are the same as for Type I.

Inhibited oil is GE Type I oil with 0.15 percent by weight of inhibitor 2, 6 di-tertiary butyl para creosol (DBPC) added, which extends the oxidation life of Type I oil. Although an excellent inhibitor, it has a finite life and is used up depending on the operating conditions in the transformer. When the inhibitor becomes exhausted, the oil behavior will revert to the oxidation characteristics of the base oil.

The inhibitor does not discolor the oil, does not alter the initial chemical or physical characteristics, is heat and light stable, is extremely soluble in Type I oil, is not deteriorated by free water, is not easily removed from oil solution by fuller's earth or similar filtration procedures, and does not form pseudo-sludge by itself. When it becomes exhausted by normal oxidation, the reaction product remains oil soluble and innocuous.

**GENERAL  ELECTRIC**

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