**GEH-2733C**
Rev 04/2008

# Instructions
# Water-cooled Capacitors

## GENERAL SAFETY INSTRUCTIONS

The objective of these instructions is to help make capacitor users aware of application and handling practices which will aid them in the use of capacitors. The guides cover good practices in receiving, handling, installation, fusing, field testing and disposal of capacitor units. The guides do not address themselves to the requirements of national and/or local codes, nor to requirements of insurance underwriters, which may be applicable to any given capacitor application. Compliance with codes and insurance underwriters' requirements demand individual consideration on the part of capacitor users for each particular situation and should not be assumed to have been achieved simply by complying with the suggestions contained in these instructions.

## PROTECTION AGAINST SHOCK

Power must be switched off before doing any work on capacitors or equipments. To be certain that the capacitors have been disconnected from the power source, **it is necessary to make a visual check for an open-contact disconnect**. After being disconnected, the capacitors or equipments should then be shorted and grounded as follows:

Capacitors for shunt or series application on power systems have internal discharge resistors (so indicated on the nameplate) which are designed to reduce the voltage, after the power is switched off, to 50 volts or less in ten minutes if an underground or submersible type, in **five minutes** for all others rated over 600 volts, and in **one minute** for all others rated 600 volts or less. After the indicated time, the capacitor or equipment should be shorted and grounded by utilizing an insulated grounding stick or equivalent and then the capacitor terminals should be connected together and to the case and grounded before handling.

Other types of capacitor units such as d-c energy storage, d-c filter and pulse forming applications, and certain types of induction heating capacitors units do not have internal resistors. With these types of units, the disconnecting, shorting and grounding procedures indicated above must be accomplished by **utilizing an external discharge resistor of at least** the resistance in ohms equal to the maximum charge voltage that may have been on the capacitor. The shorting connection between terminals should be left on until the unit is reconnected in the circuit.

## EXPLOSION HAZARD

The correct application of capacitor fuses will greatly minimize the possibility of case rupture; but since considerable stored energy may be available upon the occurrence of a fault inside a capacitor, it is possible to get explosive case rupture in any application, even with proper fusing. For three-phase capacitors fused only on two terminals or single-phase two-bushing units fused on only one terminal, and applied on delta or ungrounded wye systems, an internal ground fault from the unfused phase to case might result in case rupture. These remote possibilities must be considered when locating the capacitors or equipments.

If capacitors or equipments are not supplied with fuses, following the fusing guides recommended in NEMA Standard CP-1; ANSI Standard C-55.1; the General Electric Handbook Section 6212; or refer to the nearest General Electric Sales Office.

## HANDLING OF FAILED CAPACITORS

Some failed capacitors may be found considerably bulged due to internal pressure from gassing prior to circuit clearing. Such units should be handled very carefully. A failed capacitor should be shorted with suitable insulated shorting sticks, to discharge any residual charge. It is further recommended that a bulged capacitor be permitted to cool before handling. This will lower the internal pressure, reducing the possibility of case rupture with leakage of gasses and liquid during subsequent handling.

In handling capacitors which have liquid leaking out, avoid contact with the skin, and prevent entry into sensitive areas such as the eyes. Close-fitting protective goggles should be worn when handling units which are leaking or might suddenly squirt impregnant while being handled. Contact with the skin is taken care of by simply washing off thoroughly with soap and water as soon as possible. However, the eyes can be quite irritated by some impregnants, so they should be flushed with large amounts of water as soon as possible and then examined by a physician.

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## COMBUSTIBLE IMPREGNANT FIRE HAZARD

Units contain a Class IIIB combustible liquid which could possibly ignite if there is a case puncture or rupture in the presence of an electrical arc. Capacitors containing these materials should be suitably protected from mechanical damage and located where a possible fire could be contained and would result in minimum damage and hazard to the surrounding environment.

## DISPOSAL OF CAPACITORS OR IMPREGNANT

The dielectric liquid has been formulated to be environmentally compatible. Good practice demands that the liquid be handled in a manner appropriate for the handling of hazardous chemical liquids, and that loss of the liquid into the environment should be avoided or minimized. The preferred method of liquid disposal is by incineration. If feasible, the solid portion of the capacitor, the roll pack, should be incinerated, and the capacitor case should be disposed of in a waste disposal site approved for hazardous industrial waste.

An alternate method of disposal to be considered is the incineration of the liquid and disposal of the solid reminder, consisting of the roll pack and the capacitor case, in a waste disposal site approved for hazardous industrial waste.

Disposal of whole capacitor, including the liquid, in a site approved for hazardous industrial waste, is a third method which may be considered for the disposal of the capacitors.

## APPLICATION

Water-cooled capacitors are for operation in an enclosed environment at higher kvar, and/or at higher frequencies than that of units used in power distribution systems. Cooper tubing for circulation of cooling water and other features for dissipation of losses, are built into the assembly of each individual capacitor. Any number of capacitor units may be connected into a group with suitable arrangement of supporting racks, bus connections, water connections, and control or switching equipment. The high kVA ratings in a single unit make it desirable to sectionalize, having several bushing terminals for some applications. Refer to the nameplate or the connection diagram included with shipment for internal connections.

## RECEIVING

Check the capacitor when received to make sure that no damage occurred during shipment. Minor damage such as small dents will not harm the unit's performance, but units with large dents, leaks, or broken bushings should not be installed. See the section on "Maintenance" for the method of handling units with leaks. In case of major damage, file a claim against the carrier and also notify the nearest Sales Office of the General Electric Company for instructions regarding the disposition of the capacitor. Also check the nameplate rating with the order and the proposed application, making a report of any discrepancy to the General Electric Company.

***CAUTION:*** *Water-cooled capacitors can be large and heavy. Appropriate care should be used in handling. Capacitors with brackets should be lifted with BOTH brackets. Attempting to lift a capacitor by one bracket is dangerous and could cause damage to the capacitor and injury.*

***DO NOT LIFT THE CAPACITORS BY BUSHINGS, EXTENDED ENDS OF THE COOLING COIL TUBING, OR ALLOW THE TUBING TO BE BENT.***

## INSTALLATION

### MOUNTING

The capacitor units should be mounted side-by-side on a firm supporting structure in as clean an atmosphere as is possible under plant conditions. The preferable mounting is with bushings on top, although mounting with bushings in any position is satisfactory with proper support for the weight of the capacitor. The arrangement of supporting angles, blocks, or insulators must be such that ample bearing surface is provided and that the broad sides of the capacitor case are not clamped under pressure, thus causing excessive internal pressure with expansion of the impregnant at operating temperatures.

Electrical connection to the capacitor units may be made by placing a solid bus bar directly across the terminals of individual units, with reasonable clearance in holes to eliminate the possibility of placing severe mechanical strain on the terminals. Heavy bus must be supported by insulators from the equipment frame rather than being solely supported by the capacitor terminals. Bus bars should be water-cooled or of sufficient size to limit their temperature to 75 C so as not to contribute to the temperature rise of the unit.

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***CAUTION: TIGHTENING THE TERMINAL NUTS TO MORE THAN 15 FOOT-POUNDS IS NOT REQUIRED OR RECOMMENDED: EXCESSIVE TORQUE CAN BREAK GASKET SEALS OR STRIP THREADS ON GROUND BAR OR BUSHING TERMINALS.***

When capacitors are mounted in hangers, it is recommended that both the capacitor case and the hanger (if it is metal) be grounded to eliminate the minor shock which may be obtained from the small charging current between the line terminals and the case. Stainless-steel cases have an unpainted surface under the mounting bracket so that contact is made between the capacitor case and hanger, thus facilitating grounding by means of a single conductor to the hanger.

When making aluminum to copper connections, the slow galvanic action caused by the contact of different metals can be avoided by coating the aluminum conductor at the point of contact with an oxidation preventative such as Penotrox A (Burndy Co.) or No-ox-id (Dearborn Chemical Co.).

Capacitors having one terminal or mid-tab in electrical connection with the case should be mounted on insulators. Where a number of such units are to be connected to the circuit as a single group, this can be accomplished by mounting the units directly on angles, which are, in turn, supported by insulators. Where certain individual units are disconnected with adjoining units remaining energized, simulation must be provided between cases. In such instances, porcelain supports for each unit are recommended with ample clearance between capacitor cases for the voltage rating.

Capacitor installations should be guarded by suitable enclosures, guardrails, or elevation in accordance with the National Electrical Code.

## COOLING SYSTEM

Supply and drain water pipes should be grounded and preferably should be bonded to the metal enclosure to prevent dangerous voltages to ground on these parts. Metallic connection between the live capacitor cases and external cooling water pipes must be prevented by the use of nonconductor tubing as for example, rubber hose. Such tubing should be used both on the inlet and outlet, but should be contained entirely within the enclosure above mentioned. Likewise, the water tubing connection between individual capacitors should be nonconducting where a difference of potential may exist between the two capacitor cases. The length of tubing required will depend on local conditions, such as the resistivity of water at the outlet temperature and the amount of leakage current to be permitted. Such means will prevent appreciable leakage of current, but may not provide sufficient insulation to prevent dangerous voltages from occurring on the water pipe, hence the requirement for grounding.

## WATER

The water supplied to the cooling coils must not contain contaminants that will react with or build up deposits in the copper tubing. If the water is contaminated, some method of purification must be employed, as the capacitor's life will be no longer than that of the cooling coil.

Cooling water may be supplied to any suitable pressure up to 150 psi with a minimum flow of 1.0 gallon per minute per capacitor. To prevent copper erosion due to high-velocity water, the flow should be limited to 2.5 gallons per minute. This higher flow rate is recommended for the higher kvar units and those units used in series groups. A number of capacitor cooling coils may be connected in series, provided the pressure of the water supply is sufficient to give the required water flow and the outgoing water temperature does not exceed 45 C during continuous operation at rated voltage and frequency. The approximate pressure drop for the 19L500's and 19L600's varies with water flow as follows:

| **PRESSURE DROP, PSI FOR 0.5 OD TUBING** | **WATER FLOW (GALS PER MINUTE)** |
|---|---|
| 0.3 TO 0.4 | 1.0 |
| 0.9 TO 1.1 | 1.5 |
| 1.6 TO 2.1 | 2.0 |
| 2.5 TO 3.4 | 2.5 |

*Refer to the General Electric Company concerning pressure drops for the various designs in the 19L1, 19L100, 19L400 and 19L700 series of units.*

***CAUTION: MAKE CERTAIN THAT WATER IS FLOWING IN THE COOLING COIL BEFORE ENERGIZING A CAPACITOR IN NORMAL OPERATION.***

## RATING AND LOSSES

THE NOMINAL OPERATING VOLTAGE, FREQUENCY AND KVAR OF HIGH FREQUENCY WATER-COOLED CAPACITORS **ARE GIVEN ON THE NAMEPLATE** AND ARE THE **MAXIMUM ALLOWABLE.** Low-frequency units in the 60 to 540 hertz range, have +10 percent over voltage capability, with a maximum kvar allowed of 135 percent of rated due to all causes (over voltage, overcapacity, and harmonic content). Refer to the General Electric Company for allowable duty cycles and for ratings at lower frequency and higher voltage than given on the nameplate.

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The losses in high frequency, water-cooled capacitors will vary with dielectric system and frequency, and can range from 0.2 to 1.4 watts per kvar. Each unit is thermally designed to operate satisfactorily within its rating. If further information is needed as to temperature rise and losses, contact the General Electric Company.

Water-flow indicators with electrical contacts for alarm operation are recommended for each of the capacitor-cooling water-feed lines to insure a proper flow of water at all times.

## MAINTENANCE

If water-cooled capacitors are to be left idle in a freezing temperature after they have been in operation, the cooling coil should be blow free of water with compressed air.

Capacitor bushings and bus work supports serving as insulator parts must be cleaned periodically; the frequency of the cleaning, depending upon operating conditions.

## TESTING

Field tests may be made to evaluate the operating conditions of the capacitor. Such tests are warranted only if trouble is indicated or if the unit has been damaged.

Open circuits. Internal short circuits, and kVA capacity can be tested by measuring the current taken by the capacitor when connected to a suitably protected circuit of rated voltage and good waveform.

When the case is not electrically connected to the circuit, the insulation between terminals and case can be tested by applying rated voltage between short-circuited terminals and case, from a suitably protected test source.

## WARRANTY

The following basic information must be provided with respect to warranty claims: serial number, date in service, date failed, and type of installation (i.e. pole type, stack rack), fixed or switched, conditions at the time of failure. Do not scrap an in-warranty capacitor unless authorized by manufacturer.



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