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OPERATION AND MAINTENANCE INSTRUCTIONS FOR DRY TYPE TRANSFORMERS

EN

INDEX

1.0 INTRODUCTION

1.1 General

A transformer manufactured by STS, is designed, manufactured and tested with the latest technology and with strict quality control so as to ensure a long and problem free service.

This manual must be read carefully before unpacking the equipment. It contains important information including safe handling, installation and maintenance instructions.

This guide covers general recommendations for the operation and maintenance of dry type transformers. The successful operation of these transformers is dependent on proper unloading, installation and maintenance. Dry type transformers require little maintenance as compared to other types of transformers, but appropriate attention will ensure their expected service life. Conditions of operation determine the extent of maintenance required. A periodic inspection program should be established to monitor the effects of the conditions on the transformers.

In addition to this guide, STS should be consulted for specific recommendations on special conditions. Please do not hesitate to contact us for any question or comment.

DANGER: Lethal voltages will be present inside all transformer enclosures, and at all connection points. Installation and maintenance must be performed only by experienced and qualified personnel accustomed to working with such electrical equipment. De-energize the transformer before performing any maintenance or service work.

1.2 Caution Notes

- No transformer should have rated service voltage applied to it until all preliminary work and tests and checks have been satisfactorily completed.
- No high voltage tests to be applied to any transformer without contacting STS.
- A transformer which has been installed and then removed from service for a long time should be rechecked as when first installed prior to re-energising and placing the transformer back into service.

1.3 Health and Safety

-The equipment covered by this publication must be selected for a specific application, and must be installed, operated and maintained by qualified personnel who understand any hazards which may be involved. This publication has been

written for such qualified personnel exclusively, and is not intended to be a substitute for adequate training in safety procedures for this type of equipment.

- Lethal voltages will be present inside all transformer enclosures, and at all connection points. Installation and maintenance must be performed only by experienced and qualified personnel accustomed to working with such electrical equipment. De-energize the transformer and lock out/ tag out the main switch feeding the transformer before performing any maintenance or service work.

- Materials and Components that are liable to be exposed or handled in normal operation and maintenance and which present any hazard to health are covered here.

- In addition to the instructions given in this manual, IEC/ANSI/equivalent standards and local regulations must also be referred to for other details regarding the design, materials and performance. A list of standards applicable to distribution and power transformers is given as below;

a- Dry Type Transformers IEC 60076-11

b- Guide for installation
and Maintenance of Dry-Type Transformers ANSI C57.94 IEC:60905

- Additional Information or suggestion will be given on request to STS.

2.0 RECEIVING

2.1 Arranging for Shipping

Dry Type transformers are not sensitive to natural humidity. Domestic transportation over short distances on covered vehicles generally does not required packaging. For long distance or overseas transportation, the transformers are wrapped in protective covering and placed in containers or wooden crates. Packaging details are decided in each individual order either according to customer specification or by STS, based on the transport route.

For road transportation only pneumatic suspension vehicles shall be used.

For lashing, yellow painted lifting lugs shall be used.

Acceleration of truck must not exceed 1 G in driving direction and 0,5 G in transverse axis.

2.2 Inspection

When received, new transformers must be inspected for damage during shipment. Examination should be made before removing them from trucks or containers; and, if any damage is evident or any indication of rough handling is visible, a claim should be filed with the carrier at once and the manufacturer notified.

Subsequently, covers or panels should be removed and an internal inspection made for damage or displacement of parts, loose or broken connections, dirt or foreign material, and for the presence of water or moisture. If the transformer is moved or if it is stored before installation, this inspection should be repeated before placing the transformer in service.

2.3 Unloading and Handling of Transformer

The transformers are designed with provisions for lifting, jacking, or rolling. These provisions will vary in detail depending upon the weight, size and mechanical configuration of the unit. The weight distribution should be studied by examining the inside of the transformer. Spreader bar must be used in order not to crush the enclosure.

Enclosed transformers with lifting lugs on the enclosure may be lifted with appropriate slings. Larger units will have provisions for lifting from the base frame or from the top core clamps. Lifting from base frame may require use of spreader bar to avoid damage to the enclosure panels.

Transformers must be protected against shocks and jerks while transport and unloading.

Units lifted from the top core clamps will sometimes require that the top cover or part of the cover be removed. Rigging crew must be experienced in lifting and moving of heavy electrical equipment.

Danger: Dry type transformers must be maintained in an upright position when being moved. No attempt to handle a transformer in any other position should be made without first contacting the manufacturer.

Because of their high centre of gravity, dry type transformers are subject to tipping over during handling. Care during handling will prevent equipment damage and/or personnel injury.

Core and coil units must be lifted using only the lifting device/holes provided on the core clamps. Care should be taken to prevent damage to bus work, wiring and termination assemblies during lifting. When lifting, increase tension gradually; do not jerk, jar or otherwise move the transformer abruptly.

If the transformer cannot be lifted by a crane, it can be skidded or moved on rollers. Care should be taken not to damage the base or tip it over. When rollers are used on transformers without structural base, skids should be used to distribute the stress over the base.

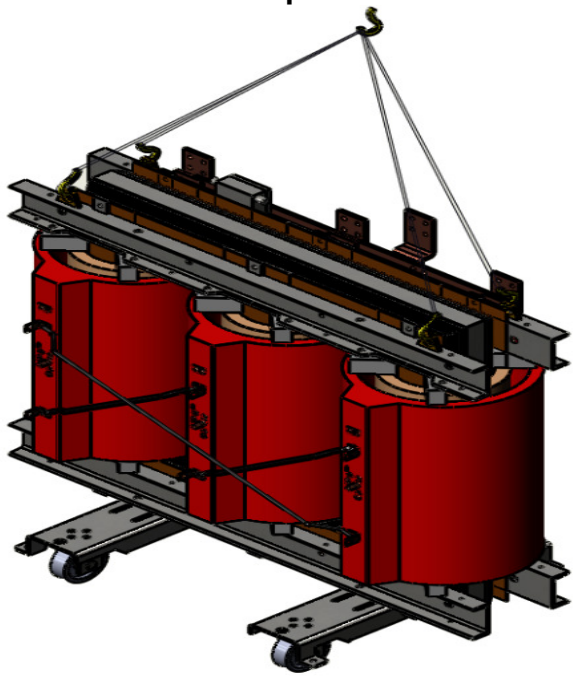
Care must always be taken to prevent any foreign material from falling into or onto the coils. Hardware, connecting parts, tools, or any foreign material should not be allowed on top of the core and coil assembly. Foreign material lodged in a coil duct can cause electrical failure or overheating.

2.4 Storage

Temporary storage during transportation or prior to installation must be done only in rainproof storage areas. Plastic coverings should be fitted over the Transformer in such a way that condensed water is prevented from forming, for example by rear ventilation. The same applies to transformers already installed in enclosures. Storage temperatures must be in the same range of allowed operational temperature range, this can change from project to project. However, unless otherwise defined, storage temperature must be between -25 C / + 60 C degree.

3.0 INSTALLATION

3.1 Location and Site Preparation



Major factors to be considered when locating dry type transformers are: personnel safety, accessibility, ventilation, atmospheric conditions, and sound level.

When planning the installation, a location should be selected that will comply with all safety codes, and will not interfere with the normal movement of personnel, equipment, and material. The location should not expose the transformer to possible damage from cranes, trucks, or moving equipment.

Danger: Damage to the enclosure may reduce the insulation clearances to an unsafe level.

As an added safety precaution, thought should be given to the possibility of personnel inserting rods, wire, etc., through the ventilation openings of the enclosure and thus coming into contact with live parts. An appropriate personnel barrier such as a fence may be necessary.

The installation will be simplified if an outline drawing is requested. By studying the overall, mounting and terminal dimensions, it is possible to plan the installation with an orderly arrangement of connections.

Core and coil units (without enclosure) usually have mounting and terminal dimensions to suit the customer's enclosure. That enclosure must give protection to the coils and have adequate clearance and sufficient ventilation openings. The manufacturer should always be consulted to determine these requirements. Top covers may be designed for cable entry or exit with bolt-on cover plates; (that conduits, bus ducts, etc., must be independently supported as top cover is not designed for these loads.)

Ventilated dry type transformers can be designed for installation indoors or outdoors. They will operate successfully where the humidity is high, but under this condition it may be necessary to take precautions to keep them dry if they are shut down for appreciable periods. For locations where severe atmospheric conditions prevail, cast resin type transformers are recommended.

Transformer room must be metallic dust free. Metal dusts must not come in contact with transformer directly. If this is not possible, necessary ingress protection (IP Class) must be requested by customer.

Locations where there is dripping water must be avoided. If this is not possible, suitable protection should be provided to prevent water from entering the transformer case. Precautions should be taken to guard against accidental entry of water, such as might be obtained from an open window, by a break in a water or steam line, or from use of water near the transformers.

Transformer room should be without condensation. If there is any possibility of condensation, anti-condensation heaters should be requested by customer.

CAUTION: Adequate ventilation must be provided for Dry Type air-cooled Transformers.

Adequate ventilation is essential for the proper cooling of these transformers. Clean dry air is desirable. Filtered air may reduce maintenance if the location has a contamination problem. When transformers are installed in vaults or other restricted spaces, sufficient ventilation must be provided to hold the air temperature within established limits when measured near the transformer inlets. This usually will require approximately 3 cubic meters of air per minute per kilowatt of transformer loss. The area of ventilation openings required depends on the height of the vault, the location of openings, and the maximum loads to be carried by the transformers. For self-cooled transformers, the required effective area should be at least 0.1 square meters each of inlet and outlet per 100 kVA of rated transformer capacity, after deduction of the area occupied by screens, gratings, or louvers.

Ventilated dry type transformers should be installed in locations free from unusual dust or chemical fumes. Transformers should be located at least 30 to 45 centimetres away from walls and other obstructions that might prevent free circulation of air through and around each unit, unless the unit is designed for wall mounting and installed per factory recommendations. Also, accessibility for maintenance should be taken into account before locating the transformer. If the transformer must be located near combustible materials, at least the minimum separations must be maintained.

The risk of any animal coming in contact with the transformer live parts must be considered. If necessary, required protection class must be obtained. An animal between live terminals of transformer can cause flashover and serious short-circuits and will be fatal to the animal.

You must follow the steps below before energizing the transformer:

A. Remove packaging and transportation materials and clean the transformer. Special care should be given to the cooling ducts and the spaces between the windings.

B. Position the transformer free from wobble in the station. Lock the wheels. When using anti-vibration supports be sure to position them exactly in relation to the transformer.

C. Make sure there is a properly dimensioned ventilation system in the room where the transformer is installed. (Take higher load losses into account under AF (air forced) operation

D. Unpack and remove parts that have been packed separately for transportation, such as connecting leads, control boxes, temperature control relays etc., and mount them, if applicable

E. The undercarriage must not be dismantled from the bottom yoke clamping beams

F. If protection enclosures have also been delivered mount them according to the instructions enclosed with them.

G. If there is to be a long time between installation and commissioning of a transformer, and if there is a danger of the transformer becoming dirty during this time use covers (Refer to 2.4 “Storage” Section.)

H. Temperature Control Thermistors (PTC) are used in the LV windings and for each control system connected in series. Each control system (e.g. for alarm, tripping, fan control) has a separate thermistor row with different set temperatures marked by the color of the individual leads. When one thermistor reaches its set temperature, the tripping relay is operated. This way, single-phase overloads are also prevented.

The terminal strip which connects the thermistor rows with the tripping relays is generally located on the upper clamping beam. The tripping relays are sometimes packed separately when delivered, have screws and snaps for clamping and are for control panel installation.

See separate diagram for temperature control wiring in the manual of temperature control relay.

3.2 Final Inspections before Operation

Before starting, do the following:

A. Remove transportation or storage coverings, usually plastic or wooden.

B. Connect earthing properly and check for proper operation.

C. Check transformer for dirt and foreign bodies; clean again if necessary.

D. Make sure the upper coil supports are tight. The 20 mm thick artificial rubber supports must be pressed a little bit. Tighten axial clamping bolts if necessary.

E. Check the PT100 sensor in the coil to be in the correct position and not moved during transportation or installation.

F. Connect temperature control systems and check them by interrupting the sensor circuit on the terminal strip (refer to 4.4).

G. If fans are included check that propellers turn in the proper direction and that the control device works (see wiring diagram, in temperature control manual).

H. Do phase connection according to connection diagram. If the tapping connection installed by the manufacturer has to be changed to another tap position, complete according section 4.5 in this manual

I. Check the HV coils supports between core clamps are tight and coils are in correct position.

J. Check and tighten all screws/bolts in electrical connections! See Section 3.4 for torque values.

K. Check clearances:

Place all connections, power cables and control leads as well as support devices and fastenings with sufficient distance from the HV cast resin windings. We recommend clearances such as those for bare conductors, as

Um = 12 kV - 115 mm
Um = 24 kV - 215 mm
Um = 36 kV - 300 mm

If altitude is higher than 1000 mm, these clearances must be increased. Please contact STS for further information

CAUTION: STS Does not accept any liability for possible failures if these distances are not followed.

DANGER: The HV cast resin windings are insulated by a coat of cast resin, but they are not safe to touch in the sense. This means that work on the Transformer or in its immediate vicinity is only permissible when the transformer is off-circuit, locked out/ tagged out and earthed.

WARNING: All protection relays must be connected to circuit breaker before energizing the transformer.

3.3 Electrical Connection, Grounding

The leads and connectors for the electrical connection of the reactors, the round wiring and all related hardware are usually not included in the scope of supply. As much as possible, the connecting leads are to be placed in a radial direction and perpendicular to coil vertical axis, to minimize the magnetic force and the heating effect on the connectors by the magnetic field.

Connection cables are to be provided with sufficient sag, and connecting bars are to be equipped with suitable expansion elements, so as to provide adequate mechanical decoupling of the reactor terminals.

Large connection cables (for high current) can exert high static loads on the terminals. Also, long runs of cable may be subjected to large electrodynamic forces during short circuit conditions. Therefore the connecting cables must be properly supported in the vicinity of the coil to minimize the forces and moments on the terminals.

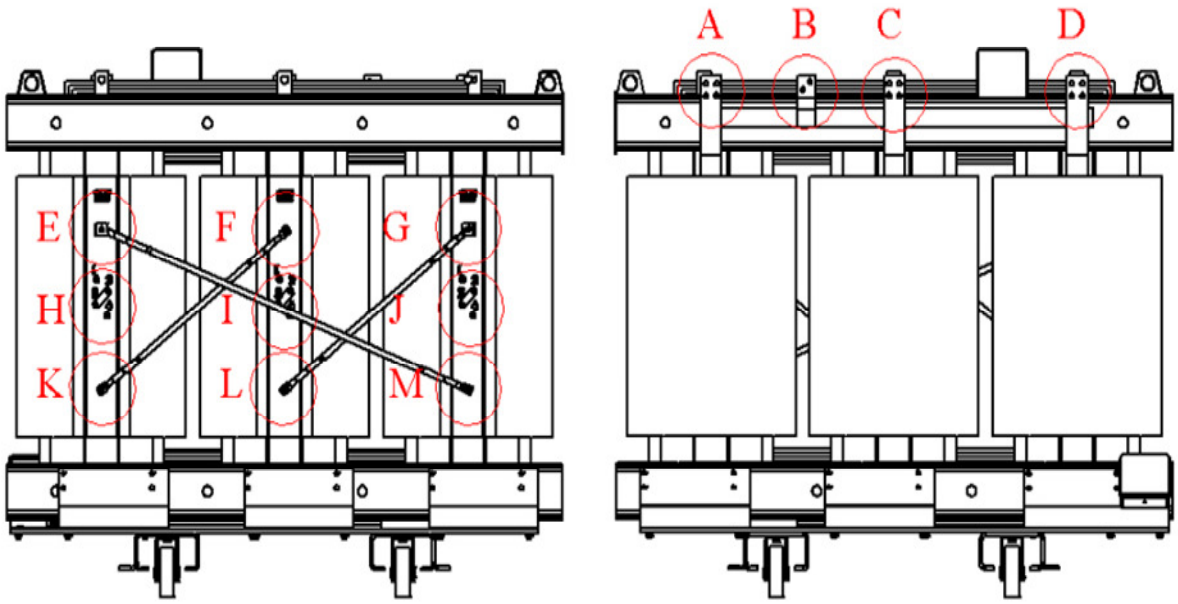
3.4 Torque Values

When one or both of bars are copper or aluminum, the layer of oxide must be removed by brushing or sandpapering.

Aluminum/Copper joints must have a bi-metal plate in between them.

Brass connections on HV bushings must **not** be greased.

MINIMUM TORQUE VALUES



Torques for copper and aluminium bar connections&
Torques for tap links and brass threaded inserts

	Thread Size Torques (Nm)				
Point	M8	M10	M12	M14	M16
A	20	40	70	90	130
B	20	40	70	90	130
C	20	40	70	90	130
D	20	40	70	90	130
E	10	20	35	50	80
F	10	20	35	50	80
G	10	20	35	50	80
H	10	20	35	50	80
I	10	20	35	50	80
J	10	20	35	50	80
K	10	20	35	50	80
L	10	20	35	50	80
M	10	20	35	50	80

4.0 OPERATION

4.1 Placing into Service

Before energizing the transformer, arrange to monitor the voltages on the LV side. Then without connecting the load, energize the transformer, the voltages should be symmetrical. If in doubt, de-energize the transformer and contact factory before proceeding further.

After following the preceding instructions, the transformer may be energized. It is recommended that the unit first be energized at no load followed by a stepped or gradual application of load until full loading is reached. If it is not possible to graduate the load, then full load may be applied.

NOTE: Upon initial energizing and bringing up to full load, some temporary vapour or smoke may be given off from the unit coils/core assembly - this is not an uncommon occurrence, and is due to heating of residual varnish in the coils. This condition will disappear in a few hours after stabilizing at normal operating temperature.

4.2 Parallel Operation

When operating transformers in parallel, their rated voltages, impedances, and turn ratios ideally should be the same. Their phasor relationships must be identical. If these parameters are different, circulation current will exist in the circuit loop between these units. The difference in impedance should in no case exceed 10%. The greater the difference between these parameters the larger the magnitude of the circulating current. When specifying a transformer to be operated in parallel with existing units, all of these parameters should be noted.

4.3 Loading

Before connecting the load, de-energize the transformer and arrange to monitor voltages and currents on LV side. Connect the load and energize the transformer. Then while monitoring the voltages and currents, increase the load. The voltages and currents should change symmetrically. If in doubt, de-energize the transformer and contact factory.

The maximum continuous load a transformer can handle is indicated on the nameplate. However, many specially designed units have specific load capabilities designed into them. If there is any question concerning the load capability of the unit, the factory should be consulted.

Compared to oil-filled distribution transformers, dry type transformers have different thermal capacities, temperature of the insulating system and the thermal time constants, which determine the overload capacity depending on the pre-load, temperatures of the coolants and time. Because of the various constructions and models, general guidelines for loading cannot be applied. They are available upon request. Please contact STS to get this information.

Unless otherwise indicated on datasheet of specific transformers, all transformers are designed according to IEC 60076-5 for short-circuit withstand (2 seconds withstand). Therefore, customer must make sure that protection shall be set accordingly, fuse selection, relay settings, etc.

4.4 Temperature Control

The thermistors (PT100) are connected in series and built into the LV windings. They generally consist of two systems with a difference in nominal set temperature of 20 degrees Celsius, whereby the lower temperature is used as an alarm and the higher temperature to trip the transformer. When the higher temperature for tripping is reached, the temperature limit of the insulation system is usually exceeded and life expectancy of the Transformer is thus reduced.

The lower temperature for alarm reacts at an ambient temperature of 30°C if the continuous rated load temperature has been reached. In this case the load must be prevented from increasing. Causes for overheating may be:

- Overload
- Ambient temperature higher than 40°C at rated load
- Insufficient cooling of the transformer (check ventilation)

Maximum Temperature for dry type transformers as following:

- F class transformers: 155 ° C
- H class transformer 180 ° C

Caution: Never set the tripping temperature to higher rated operation temperatures.

4.5 Tap Changing

After installation, the output voltage of the transformer should be checked at some safe access point on the load. Never attempt to check the output voltage at the transformer since dangerous high voltage may be present within the transformer enclosure.

When the output or load side voltage requires adjustment either up or down, the percentage tap jumpers found on the front surface of the coils must be changed in all phases. Consult the Transformer diagrammatic nameplate for information on what tap must be used to correct for high or low incoming line voltage or for voltage drop in the output or load voltage due to long wiring runs. Note that when the load voltage is low, tap connections below 100% of line voltage must be used to raise the load voltage. If the load voltage is high, tap connections above 100% of line voltage must be used to lower the load voltage.

After the correct tap connection has been determined from the nameplate, this procedure must be followed to change taps, unless there is another special procedure or instruction for tap-changing

A. De-energize transformer and properly lock out/ tag out the upstream switch. Make sure there is no back feed from a low voltage tie breaker.

B. Remove front access panels from transformer enclosure, if applicable

C. Change tap jumper on each phase to the correct tap connection. Tap jumper must be on the same tap position on all phases.

D. Check the torque value for tap link connection, refer to section 3.4

E. Tap jumper must be installed on upper side of coil tap with lugs on ends of cable tap jumpers positioned for maximum electrical clearances from ground and other live parts. Be sure bolts are tightened.

F. Replace front access panels, if applicable

G. Replace all panels and energize the transformer and recheck the output voltage.

5.0 MAINTENANCE

DANGER: De-energize transformer and lock out/ Tag out the upstream switch before any inspection or maintenance

Cast resin transformers are largely maintenance free as oppose to fluid filled transformers. However, following checks must be made:

A. Function of fans and fan control must be checked approx. every six months, if applicable

B. Check and tighten screws, nuts for electrical connections. For torque values refer to Section 3.4

B. Check cleanliness of transformer surfaces frequently and clean them if dirty. After installation in a new place with unknown pollution risk we recommend a first check latest six months after. If pollution is unimportant check intervals can be lengthened to 1 year without problems. If transformer surfaces are especially dirty, cleaning should be more frequent according to the extent of the dirt, and preventive measures should be taken to reduce the amount of dirt in the future. When cleaning, special attention must be paid to the cooling ducts and spaces between the windings. Cleaning is done with a vacuum cleaner, dry compressed air and cleaning cloths.

C. The functionality of the temperature control must be checked every 6 months by interrupting the thermistor row on the terminal strip.

6.0 REMOVING FROM SERVICE

If a unit is to be off more than 24 hours, provisions should be made to prevent the core and coils from taking on moisture. Refer to "Storage" Section 2.4.

If the unit is to be moved, it will be necessary to replace the core and coil hold-down bolts and any shipping braces used for first shipment to protect the assembly during movement.

7.0 TROUBLE SHOOTING

Transformer failures may occur in either the electric, magnetic or dielectric circuits.

7.1 Electric Circuit

Symptom	Cause
Overheating	- Continuous overload or harmonics - Wrong External Connections - High Surrounding Air Temperature - Faulty or insufficient Ventilation
Reduced or Zero Voltage	- Shorted Turns - Loose Connections - Faulty Tap Changing
Excess Secondary Voltage	- Input Voltage High - Faulty Tap Changing
Coil Distortion	- Coils short circuited.
Insulation Failure	- Continuous Overloads - Mechanical Damage in handling - Lightning Surge
Breakers or Fuses Opening	- Short Circuit - Overload - Inrush Current
Excessive Bar Heating	- Improper Bolted Connection
High Voltage to Ground	- Usually a static charge condition, using rectifier or VTM meter

7.2 Magnetic Circuit

Symptom	Cause
Vibration and Noise	- Unrated Frequency or Harmonics - High Input Voltage

	- Core Clamps Loosened in shipment or handling
Overheating	- High Input Voltage
High Exciting Current	- High Input Voltage - Shorted Turns
High Core Loss	- High Input Voltage - Damaged Core
Insulation Failure	- Solid Insulation Material Failure

7.3 Dielectric Circuit

Symptom	Cause
Burned Insulation Lightning Surge broken bushings, taps Or arrestors	Switching or Line Disturbance
Breakers or Fuse Open	Insulation Failure

7.4 Solutions

If any of the above symptoms are noticed, the transformer must immediately be removed from service. Immediate attention may save a large repair bill. Many times the trouble can be quickly determined and the transformer returned to service

If the trouble cannot be definitely corrected, the transformer must be taken out of service until the cause has been found.

It may be necessary to make a closer examination. If no apparent fault can be found, the core and coil may have to be removed for a detailed inspection. Removal of the core and coils is usually a factory or service shop operation. As this will mean replacing many parts when reassembling, it is advised that the problem be reported to the factory (STS) before removing the core and coils. Removal of the core and/or coil by anyone other than STS or its authorized agent will void the warranty.

The advice from the factory may again save a large repair expense. When writing, describe the nature of the problem, the extent and characteristic of any damage, and list full nameplate information.