Installation and instruction manual
Dry-type transformers

Personnel qualifications

The instructions in this manual should familiarize qualified personnel with the proper procedures to keep all new unit(s) in proper operating condition. Qualified personnel consist of customer service engineers, qualified professionals, and other authorized operating personnel. This document does NOT serve as a replacement for proper training and certifications are required to transport, operate, store, install or move the product safely. Complying with these instructions will help to reduce hazards, accidents and increase the reliability and service life of the transformer.

Note: All persons working with the units must have experience and the necessary knowledge in dealing with high voltage equipement.

Qualified personnel must have knowledge and experience in the following fields, depending on what work will be carried out:

- Disconnection of electrical equipment
- Securing to prevent incidental activation by unauthorized persons
- Verification of disconnection from the power supply
- Grounding and short-circuiting of electrical equipment
- Covering or safeguarding of adjacent live components
- Transportation of transformers
- Safety precautions involving the transportation process
- Storage of transformers
- Installation of transformers
- Connection of transformers
- Operation of transformers
- Cleaning of transformers
- Maintenance of transformers
- Disposal of transformers

World leadership

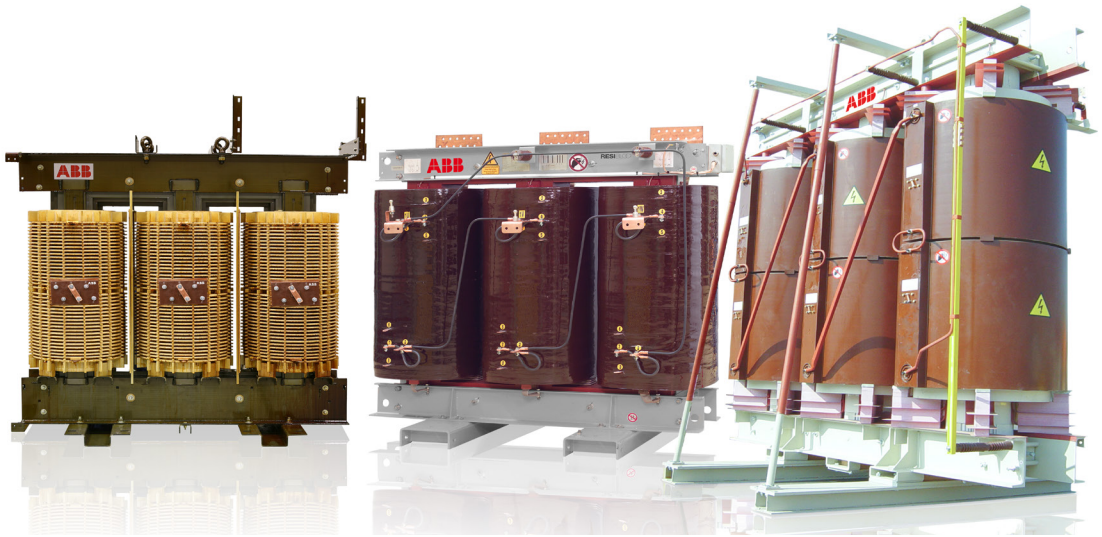

ABB is a world leader in transformer manufacturing, and our transformers can be found in countries all over the world. To minimize environmental contamination and fire hazard, users are specifying dry-type transformers more and more frequently. These transformers supply the electrical needs of millions of homes and businesses - functioning even in areas with extreme climatic conditions.

Why choose ABB?

When working with ABB, customers have access to a worldwide network of factories and facilities, serving customers locally with a full range of products and solutions. Customers are guaranteed “One Simple ABB” quality and service. ABB facilities utilize the most up-to-date technologies, providing the highest quality for standard and custom products and solutions.

Dry-type: transformers: Safe and environmentally friendly

- Reduced environmental contamination
- Zero leakage of flammable or contaminating substances
- Environmentally friendly production
- Well suited for contaminated areas
- Nonflammable and self-extinguishing
- High capacity to support overloads
- High performance in dealing with seismic phenomenon
- Capable of withstanding the most severe rolling and vibrating conditions

Our technology is what makes us different

ABB uses the most advanced production technologies and the most demanding control systems to guarantee the highest product quality and total product reliability.
Quality is designed in from the core - ABB transformers will provide decades of trouble-free service.

Manual intent

The purpose of this manual is to assist the operator in making safe and economical decisions when handling, installing, operating, and servicing the unit. This manual must be kept with the documentation for the transformer and be readily available to the user as it is an integral part of the transformer. If for any reason the ownership of the transformer changes, give this operating manual to the new owner. If any specific requirements or questions should arise, always contact the transformer manufacturer before proceeding. This manual is only intended for those with the required training, certification, and education in the many fields of a transformer.

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Safety

!WARNING:

Read all instructions carefully before attempting to handle, install, use, or service this equipment. Failure to follow instructions could result in severe injury, death, or property damage. A project plan should be developed and communicated to all affected parties. Clear lines of communication should be maintained. If further information is required, or particular problems arise which are not covered, please contact the manufacturer.

Note: These instructions do not cover every possible installation, operation, or maintenance scenario, nor propose to cover all details or variations in equipment. The recommendations and guidelines set forth in the following "Safety" section are to assist the operator in reaching the highest possible level of safety. If further information is required, or particular problems arise which are not covered in this document, please contact the manufacturer.

Safety

- Only qualified technicians should attempt to work on electrical equipment.
- A risk assessment should be conducted to determine what hazards are present that needs to be addressed in the project plan.
- Always wear the appropriate clothing and footwear when working on or around the transformer.
- Any person with a pacemaker, metal implant, or jewelry should not come within 10 feet of the transformer while it is in operation.
- The use of electrical safety, Arc Flash safety grounding, and Lock Out Tag Out. Procedures should always be followed to ensure personal safety when installing, servicing and uninstalling electrical equipment.
- Never place the transformer into operation if it is damaged.
- When working at heights, fall protection should be worn or man lifts should be used.
- Never lift anything over head or over top of other persons.
- When moving material, ensure that there are no other interferences that might come into contact with the unit such as overhead power lines.
- To avoid lacerations, be aware of the possibility of sharp edges on metal objects.
- Never override or bypass any provided protective devices.
- Only use the accessories approved by ABB.
- In the event of a fire, do not use water to extinguish the flames. Use a suitable quenching agent such as, CO2.
- Make sure minimum clearance is sustained.
- Terminals are for electrical loading only; use flexible connectors to avoid mechanical strain.
- Do not lift or move a transformer without adequate equipment and precautions.
- Use the proper "rigging" when handling the units and always connect to the designated lifting points.
- Always inspect the unit to ensure that nothing has entered the enclosure or unit that might create a safety hazard such as debris, rodents, animals, etc. This may occur if sitting for any length of time.
- Ensure the lifting accessories are rated to handle the weight of the product and that the correct lifting calculations are used according to the angles of the cables or chains.
- Do not cut loose any supporting fixtures, cables or remove bolts which support the positioning of the product until it reaches the final installation location.
- Make sure all power is disconnected and properly grounded before attempting to work on the transformer or inside of the control box.
- Only install or operate the transformer in the orientation as shown in outline drawings.
- Use material handling equipment or obtain assistance in assembling or removal of heavy panels. Use proper lifting techniques.
- Do not make any connections that are not authorized by the nameplate or the connection diagram.
- The proper PPE and insulated tool should always be used when working around potentially energized equipment.
- Do not attempt to change the tap connections or remove the enclosure panel while the transformer is energized.
- Do not energize the transformer without proper ground connections.
- Do not tamper with interlocks, alarms, or the control circuit.
- Do not enter the cabinet or stick objects into the unit when energized. This could result in injury or death.
- Use proper personal protective equipment while working on the top cover of the enclosure (if applicable).
- Once energized the transformer will be hot. Allow for the transformer to cool down before starting any work on it.
- No supply cables should come in contact with the core or any live part except the terminal that it is intended for.

Intended uses

Adhere to all of the ratings stated on the nameplate and contact the manufacturer for any questions regarding:

– Ambient standards
– Elevation standards
– Short circuiting
– Installation
– Loose connections

The following uses in particular shall be regarded as improper use:
– Overriding and/or manipulation of the settings of monitoring devices
– Alterations to attachment parts, e.g. fans, cooling systems, etc.
– Attachment of adhesive labels to the surface of the coil
– Removal of information and warning signs
– Connections for which no provision is made in the relevant connection diagram
– Application of a higher level of voltage to the respective tapping connection than is shown on the rating plate
– Drawing a higher level of power than is shown on the rating plate
– Use of a different supply voltage frequency than that shown on the rating plate
– Mechanical loads on the user terminals and terminal lugs
– Parallel connection with unsuitable transformers

Any improper use of the transformer (e.g. placing a strictly indoor unit outdoor or installing a unit at an incorrect elevation) may lead to the exclusion of liability for physical defects and may violate any warranty terms agreed to under purchase contract.

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Warning and caution signs

All units are unique, therefore it is important to adhere to all caution/warning signs and stickers on the individual unit. Any questions regarding a meaning of certain caution/warning signs or stickers, please contact the manufacturer.

Emergency and preparedness

No first aid activities are to be started before the working area is safe. Each operator should be well trained in first aid for electrical shocks. To minimize “human factors” in performing work on or near live electricity, working alone is not recommended. It is recommended that a second person observe the work area and assist the operator who is performing the work. If an individual is injured, follow the regular first aid/medical procedures. A procedure should be prepared in advance of how to bring the injured person out to safety in case of a fall from height. Each project should determine a policy for the use of mobile phones or other devices that might distract safe work practices.

Fall risk

Appropriate safety precautions should be taken when working on high equipment to avoid injury from falling. The following equipment is recommended:
– Edge protection
– Fall arrest system
– Ladder / step ladder
– Safety harness with twin legs & lanyards
– Scaffold

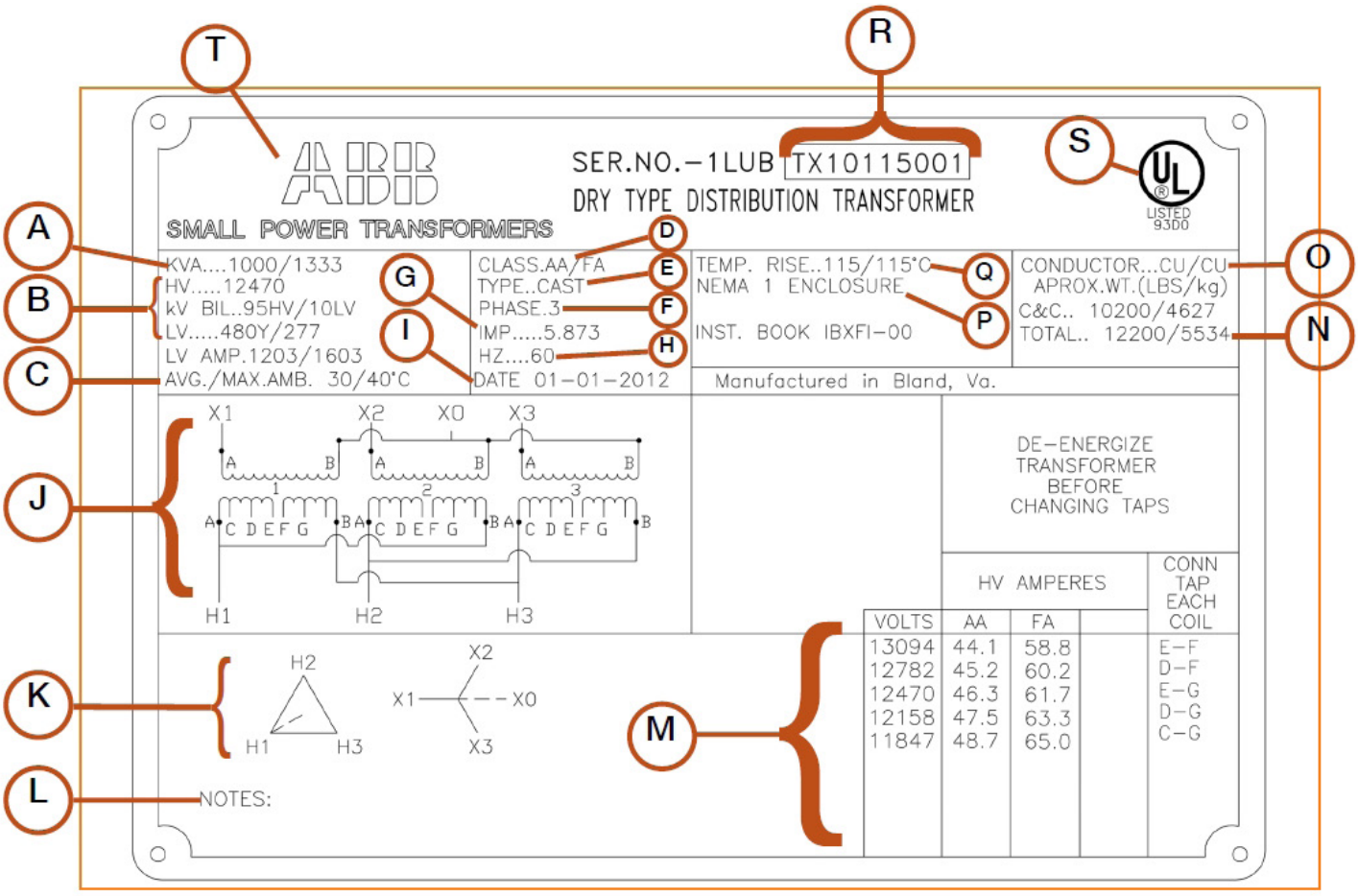
For working safely on the top of a transformers there are different types of harness systems available and local safety personnel should be consulted before use.

Nameplate

Note: Every transformer has a rating plate affixed to it. Adhere to all of the ratings stated on the nameplate and contact the manufacturer for any questions. The nameplate below is a general representation of typical dry-type transformer ratings; specific nameplate ratings and format may differ.

The nameplate contains the following information:

A. Rated power
B. Voltage characteristic and basic insulation level
C. Rated ambient temperature
D. Cooling class
E. Transformer type
F. Number of phases
G. Tested impedance value
H. Rated frequency
I. Tested date
J. Connection diagram
K. Vector diagram
L. Unit specific notes
M. Tapping voltages and tap connections
N. Unit weights
O. Conductor type (HV/ LV)
P. Protection type
Q. Rated temperature rise
R. Serial number (Unit identification number)
S. Third party certification (if applicable)
T. Manufacturer name



Receiving and handling

Note: The recommendations presented in this section are to assist the operator in the reception and handling of the unit. These recommendations do not, however, cover every aspect of handling the unit. It is important to lift the unit with adequate lifting equipment. Any and all questions that arise in regards to handling the unit should be addressed to the manufacturer.

Receiving

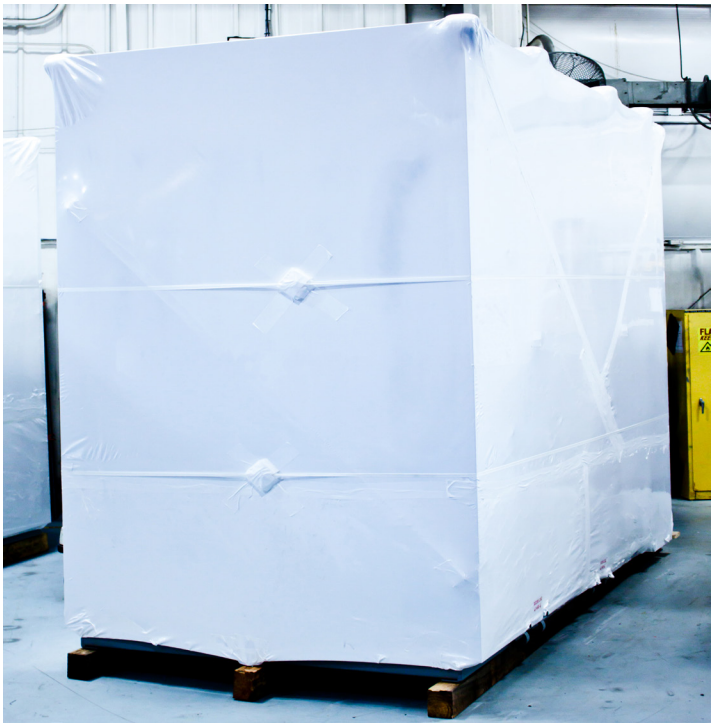
Dry-type transformers are shipped either completely assembled in a sheet metal enclosure or as a core and coil assembly and are covered with a plastic sheet to prevent entrance of moisture and dust. When units are shipped as core and coil assemblies with separate enclosures, a drawing will be included in the document package to assist in assembling the enclosures.

It is very important that a thorough inspection of each unit be made prior to its acceptance and removal from the carrier's vehicle. First, make certain the identifying number matches all paper work and bill of lading. Since transformers can be shipped in parts or entirely assembled, ensure all components have been delivered to the correct destination. Check the bill of lading for the full list of components. If damage is detected or shortages are noticed, write a brief description on the bill of lading. File claims according to terms and conditions of the sale. To complete a thorough inspection, all covers and panels must be removed to review the internal components. Use shipping papers to determine if there are any missing parts, look for water damage, damage to parts, dirt, or standing water. Also, check for loose or broken connections and tighten any loose connections that do exist. Inspect coils, wiring and insulators as any minor damage can cause an open or short circuit. This inspection process should be repeated if the unit is moved or stored before it is installed or put in service.

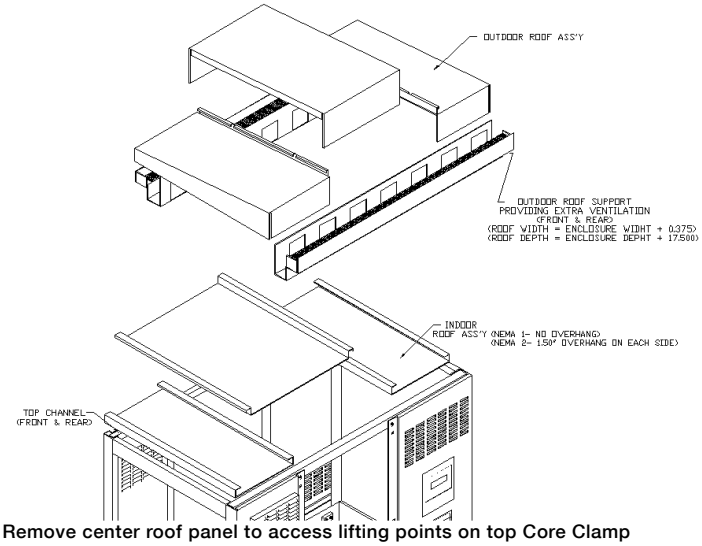
If the unit will go immediately into storage, inspect exterior packaging for possible damage. If damage is not suspected, it is recommended that as much of the original manufacturing packaging is kept in place as possible during storage. If damage is probable, please open the packaging to properly inspect the contents.

For your convenience, below is a representative checklist of areas which should be checked prior to acceptance from the freight carrier:

- ☐ Does the serial number agree with the packing list and bill of lading identification?
- ☐ Does the unit show any damage due to mishandling?
- ☐ Any and all damage must be noted on the bill of lading.
- ☐ Are the accessories damaged in any way?
  - ☐ Winding temperature indicator (if applicable)
  - ☐ Window glass for weatherproof box of the winding temperature indicator (if applicable)
  - ☐ Fan motors and blades (if applicable)
  - ☐ Lightning Arresters (if applicable)
- ☐ Is there any damage to the enclosure parts?
  - ☐ Vents
  - ☐ Front and back panels
  - ☐ Roof structure
  - ☐ Base



Typical Shipment Packaging



Remove center roof panel to access lifting points on top Core Clamp

Unloading / Lifting procedures

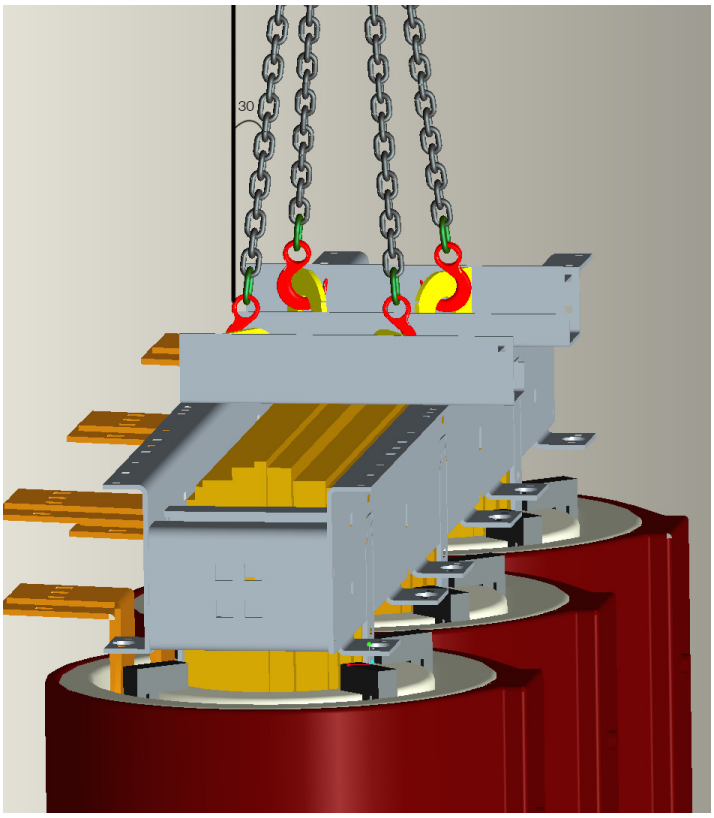
All efforts should be made to avoid handling a dry-type transformer in inclement weather. If it becomes necessary to do so, adequate protection against rain, snow and excessive dust should be provided. If a unit has been exposed to moisture during handling or storage, it must be carefully inspected and tested prior to energization to determine if drying is necessary. See the “Drying process” section under “Maintenance” for appropriate instruction for drying out and testing such a unit.

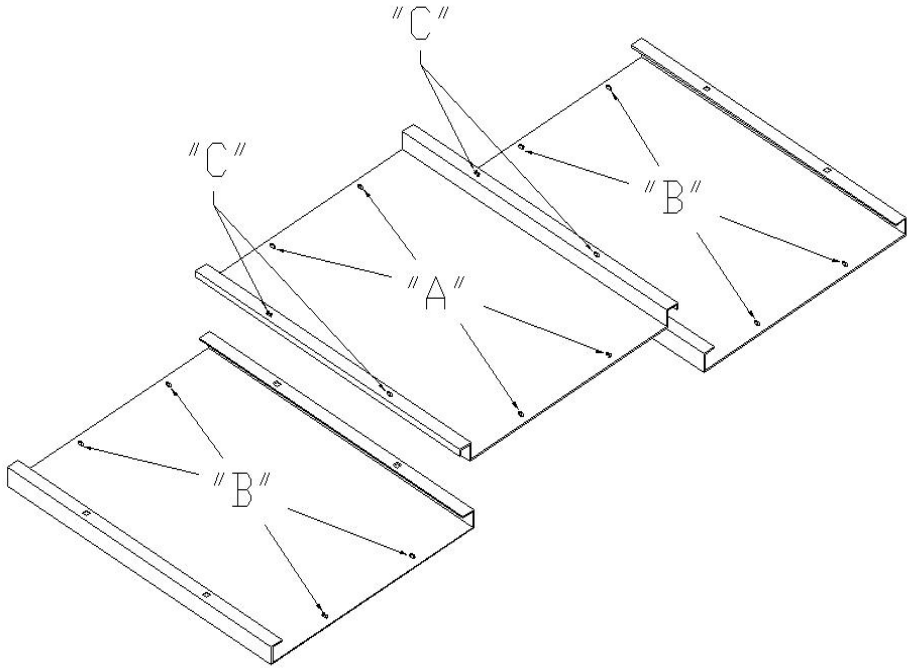
The recommended steps for lifting are as follows:

1) Remove roof from transformer enclosure. Removing the center panel is typically sufficient to access the lifting provisions.
2) Connect to all lifting points on the top core clamps. Most units have four (4) lifting points. Some smaller units only have two (2).
3) Use crane to lift the unit, observing that chains do not exceed 30 degrees.

Alternative methods of lifting are possible but not recommended. Please contact the manufacturer if crane lifting from the Core Clamp is not possible.

All lifting points should be used to lift transformer. Cable pull angles should not exceed 30° from vertical.





To remove center roof panel. of indoor enclosure:

1) Remove (4) four bolts in center of the enclosure labeled "A".

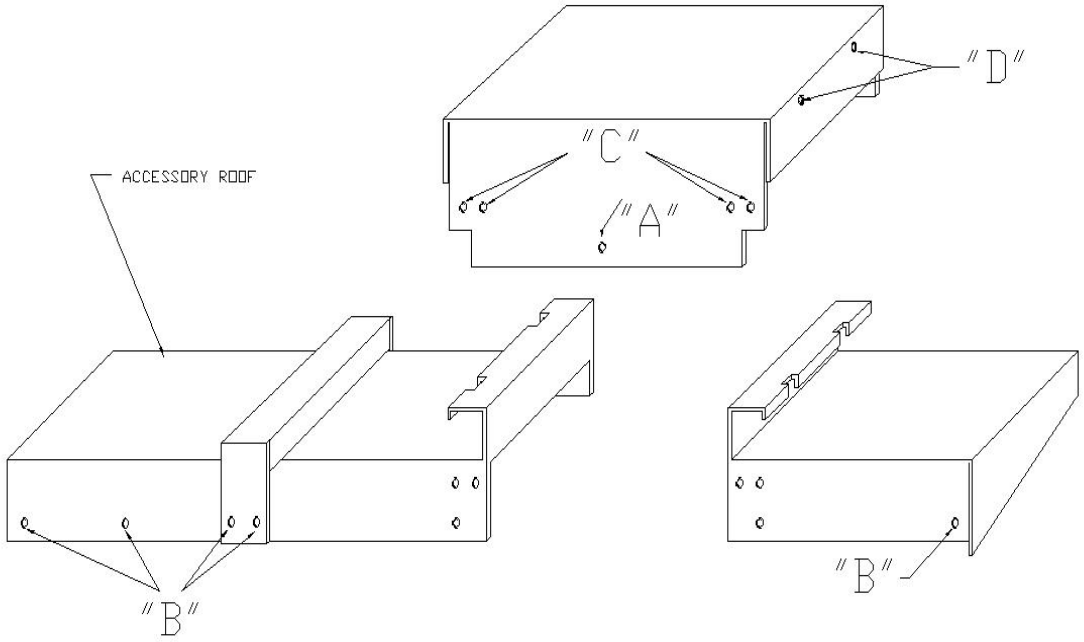
2) Remove (4) four bolts on the lip of the enclosure labeled "C".

3) DO NOT remove bolts in the other 2 roof panels of enclosure labeled "B".

4) Insert (4) four lifting hooks in holes labeled "C" and lift vertically.

To reinstall:

1) Reverse removal procedures, reinstall all bolts and tighten securely.



To remove center roof panel. of outdoor enclosure:

1) Remove (1) one bolt in front and (1) one bolt in rear of encosure labeled "A".

2) Remove (4) four bolts in front and (4) four bolts in rear of enclosure labeled "C".

3) DO NOT remove bolts in front and bolts in rear of enclosure labeled "B".

4) Insert (4) four lifting hooks in holes labeled "D" and lift vertically.

To reinstall:

1) Reverse removal procedures, reinstall all bolts and tighten securely.

Handling

When handling the transformer, DO NOT:

- Lift the transformer by the enclosure, or directly underneath the enclosure
- Lift the transformer from the rigging provisions on the base
- Jolt the transformer to avoid mechanical stresses
- Push, drag or pull the transformer directly on the floor unless it is still on a wooden pallet

Core and coils only

Assemblies with only the core and coils are shipped on pallets and surrounded by crating suitable for moving vwith a forklift truck. Should a forklift truck not be available, all units have lifting eyes provided on the core and coil assembly top core clamp. These lifting eyes should be used when moving the core and coil assembly by an overhead crane.

Transformers with enclosures

Enclosure assemblies are preferably moved by a forklift truck. For crane lifting, removal of the enclosure top allows easy attachment of shackles to the lifting provisions located on the top core clamps.

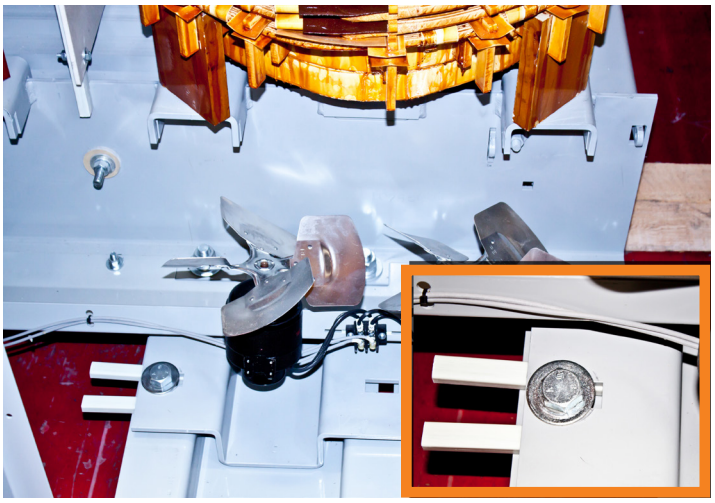
Lifting overhead from the base of the transformer is not recommended. Dry-type transformers have a high center of gravity; therefore, the danger of tipping over is present whenever handling a transformer. Units should remain upright when being moved. Operators should take extra caution to not damage the

unit during this process or allow it to tip over. No foreign material should be around the unit or set on top of the transformer during this process.

Preferred method of handling a unit is from the base of the unit using a forklift.

Possible core and coil shifting may occur while in transit. [The bolted connection between the core and coil assembly and base may shift up to 1"]. The hole provided for this connection is of a rectangular shape to allow for adjustment. A dimensional check of bus locations should be made prior to installation of the unit to its switchgear assembly. [If, due to core and coil shift, proper alignment cannot be achieved, contact the manufacturer for the appropriate method of rectifying the problem.]

Bolted connection between core and coil assembly and base may shift during transit.



Storage

Note: The storage of each individual transformer is unique. Therefore, these guidelines do not cover all possible scenarios and outcomes when storing a transformer. Should any additional information or questions arise, please contact the manufacturer.

If storage becomes necessary, the transformer should be placed in a clean, dry room where a uniform temperature can be maintained as best as possible because fluctuating temperatures can cause condensation issues. The floor on which the transformer is being stored should be resistant to the upward migration of water vapor. Precautions should be taken to prevent storage in an area that water could be present, such as roof leaks, windows, etc. Condensation or absorption of moisture can be greatly reduced by the installation of space heaters (optional). If the transformer is not furnished with internal space heaters, then external, portable heaters can be used. A basic rule to mitigate condensation in the unit is to keep the transformer enclosure 5-10 degrees above ambient temperature. Lamps or heaters should never come in direct contact with the transformer coil insulation. If a transformer has to be left outdoors, protective measures should be taken to prevent moisture and foreign debris from entering the transformer. Also, if the transformer is to be stored for a long period of time, then the transformer should be equipped with a suitable drying agent such as silica gel. The energization of the space heaters (optional) is recommended to prevent moisture collection inside the transformer due to condensation, etc. The unit should be checked periodically for indications of condensation (i.e.,windings, coil support blocks, core, core clamping system, bus/cable, etc.). Before the transformer is placed into operation after being stored, the insulation should be checked for condensation by performing an insulation resistance test (see “Testing”). If condensation is found a drying-out procedure may be necessary (see “Drying process” under “Maintenance”). Space heaters are not adequate for drying.

Installation

Note: Installing a transformer requires taking every possible precaution. The guidelines outline standard instructions when installing a unit, however, they do not cover every possible scenario. Please contact the manufacturer if any questions arise during any process in the installation of the unit.

Location

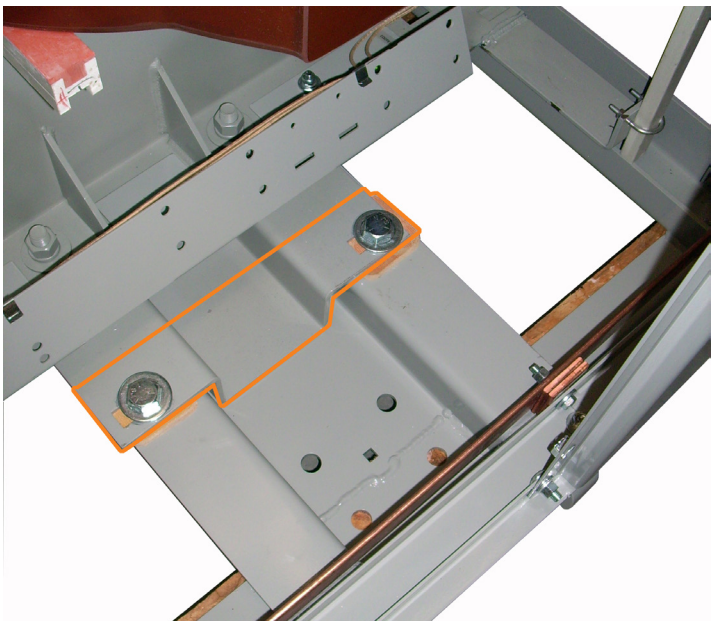
There are many factors to keep in mind when choosing a location for your dry-type transformer. A location should be selected that will comply with all safety codes, and will not interfere with the normal movement of personnel, equipment, and material. The location should not expose the transformer to possible damage from cranes, trucks, or moving equipment. The transformer should be placed on a clean, flat surface with adequate drainage that is capable of supporting the transformer weight. It should always be installed in the upright position with free air circulation. Enclosures are intended for use in secured areas generally inaccessible to unauthorized and untrained persons.

There are also some environmental conditions to consider. Ventilated dry-type transformers should not be located in heavily polluted environments or indoor locations with the possibility of dripping water unless the unit is designed for these areas. If the transformer is located outside, finding a shielded area such as a corner of a building or landscaped windbreak is useful. This feature helps provide extra protection from driving wind, rain, or snow. Dry-type transformers can be located in high humidity areas but special precautions have to be taken if the transformer will be de-energized for any length of time (see “Storage” section). Transformers installed at altitudes over 3300 feet (1000 meters) above sea level must be designed for these areas in order to operate correctly.

Sound level

All transformers have an inherent sound originating from the steel core. The fundamental frequency is twice that of the applied voltage (typically 100 or 120 Hz). Sound waves may be amplified or reflected by means of walls, floors, ceilings, vibrations of air ducts, conduits, and mounting bases. To obtain the average sound levels equivalent to factory test levels, a 10 feet (3 meters) clearance on all sides except floor ground is recommended. Close proximity to hard surfaces may produce higher sound levels. Noise levels can be reduced by using flexible conduit and flexible terminations, installing acoustic absorbing material, and avoiding uneven mounting surfaces. A major noise reduction can come from loosening the anchor bolts* between the core/coil and the enclosure base so that the unit rests on vibration pads only.

*In seismic locations it is required to keep core and coil anchor bolts fully tightened.



Anchor locations highlighted in Orange

Space requirements for installation location

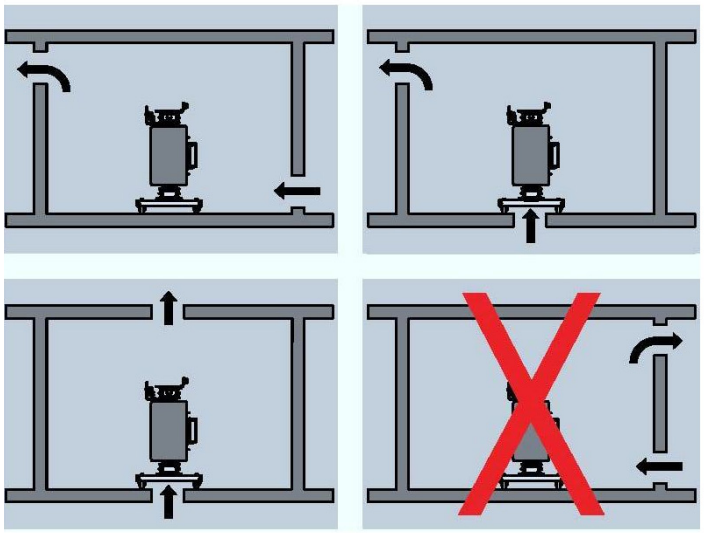
The room in which dry-type transformers are located should be sized to permit positioning the transformers with sufficient spacing between units and sufficient clearances to walls and other obstructions for air circulation. Sufficient space should also be provided to allow for routine inspection and maintenance. Refer to the outline drawing provided during the ordering process for the transformer dimensions. If a transformer must be located near combustible materials, the minimum separations established by the National Electrical Code and local fire marshall should be upheld. The enclosure gives adequate clearance between ventilation openings and the core/coil. Still, you should maintain the appropriate clearance between supply cables and live parts, such as windings, internal cable connections, auxiliary transformer(s), bus bars, and other internal components of the transformer based on system voltages.

Ventilation requirements

Adequate ventilation is essential for proper cooling of a dry-type transformer. All transformer surfaces should maintain proper clearances according to local codes and be located no less than 6 inches (15 centimeters) away from any obstructions unless otherwise marked. Air that is clean and dry is the most desirable. If in an area with a large amount of dust or other contaminant, then filters may be installed to reduce maintenance on the transformer. Proper ventilation should be provided to hold the air temperature near the transformer inlets to within the established environmental limits.

For the best ventilation, the air inlet should be as close to the floor as possible with the outlet being on the opposite end near the ceiling. These inlets and outlets should permanently be open for continuous ventilation. The outlet air should not exceed 15 oC over the inlet air temperature or a forced air exhaust should be installed. In addition room ventilation should not interfere with the normal circulation of air through the transformer. The flow of air should be directed across the unit. It is recommended when installing the transformer that supply cables should come in from the bottom and/or side so as to not block the ventilation openings. Also make sure the ventilated openings on the top and bottom of the enclosure are clear. If there is another heat source present, then the transformer should be located even further away for proper circulation.

Proper room ventilation is essential to transformer cooling



Grounding

All non-current carrying metal parts in a transformer must be properly grounded. Grounding is required to remove static charge that accumulates in the unit by dissipating the charge back into the earth. Be sure to check that the flexible grounding jumper between the core and coil assembly and the enclosure is intact, or that the core and coil assembly is directly grounded from the core clamp through a flexible lead. This connection must be tight at all times. Refer to local codes for proper grounding procedures.

Connections

Connection points are clearly labeled on the transformer. The transformer has both high voltage (HV) and low voltage (LV) winding connections. Solidly connect the terminal lugs and the termination bus bar. Improper connection will cause heating and arcing which may result in connection failure. When connecting bus bars, be sure the joints are properly aligned prior to bolting to prevent excessive strain on the insulators. Flexible bus connections (optional) can be made to eliminate any excess strain at connection points.

User installed cables must be kept as far away from coils and top clamps as possible. Refer to the chart below for recommended minimum electrical clearance when performing final check. You should only make those connections specified by the nameplate or connection diagram. Be sure to check all tap jumpers for correct location and torque. Always use two wrenches when tightening or loosening bolted connections to prevent damage.

Electrical Clearances	
BIL (kV)	**Minimum Clearance in (cm)**
10	1.0 (2.5)
20	1.0 (2.5)
30	1.5 (3.8)
45	2.5 (6.4)
60	3.5 (8.9)
95	4.75 (12.1)
110	7.5 (19)
125	8.75 (22.3)
150	11.25 (29)
200	16.0 (40.6)

If unit(s) are supplied with a lug type connection (either mechanical or crimp type) ensure that properly sized cable and tooling is used to complete the connection. Also, high current bus bar of greater than 4,000 Amps should be cleaned thoroughly prior to making a connection.

Primary voltage & tap connection verification

Test line (supply) voltage before attempting connection of transformer to the power supply lines. The supply lines must be checked using proper precautions and meter(s), probes and accessories rated for at least the full high voltage rating. When line input voltage is higher or lower than nameplate transformer voltage, the high voltage taps must be changed to compensate for the difference between nominal and tested voltage.

Taps

Tap connections may be changed only when the transformer is totally de-energized. Standard units have taps located on the face of each H.V. winding, halfway down the face of all phase coils. These taps are provided to furnish rated output voltage when the input voltage differs from the nominal voltage. The transformer is normally shipped with the tap connections made for the nominal voltage. They are marked with letters. The tap arrangement is shown on the nameplate.

Two tap terminals are connected together electrically by a flexible insulated wire “jumper” or solid copper shunt. Observe the tap letter at the present location of each end terminal of the “jumper.” With a wrench (do not use pliers-type tools), turn the “jumper” attaching nuts counter-clockwise to remove them.

Reconnect the ends of the “jumper” into the new terminal position(s) by turning the attaching nuts clockwise until they are tightened to the recommended torque values as listed on page 16 of this manual.

!WARNING:

Failure to de-energize and ground the transformer properly before removing the panels to change taps could result in serious personal injury and death.

The following is a more comprehensive detail on how to change tap connections:

1) De-energize the transformer, short circuit and ground both the HV and LV terminals.
2) Remove front panel of enclosure to access the taps.
3) Locate the tap jumpers.
4) Next, loosen and remove the hardware on the tap jumpers on the front of the H.V. coil.
5) Remove the tap jumper connection and move the connection to the desired tap on each phase. All coils must have identical tap connections.
6) Make sure that the tap connections are appropriate for the required voltage as listed on the nameplate. NOTE: For multiple voltages or other special arrangements, see the transformer nameplate and/or connection diagram.
7) Verify all coils are connected at identical taps.
8) Torque the tap connections to the recommended values as listed on page 16 of this manual.
9) Remove safety shorts and ground connections from the H.V. and L.V. terminals.
10) Inspect the enclosure to ensure all hand tools, equipment, or any other foreign materials are removed from the enclosure.
11) Replace the front panel of the enclosure and re-energize the transformer.

Open Wound bar taps with jumper connection

Insert tap connection

Some vacuum cast coil units are provided with embedded tap inserts (optional) for bolted solid copper shunt connections. In order to make these connections hardware can be either 3/8 inch or 1/2 inch depending upon mold inserts, with a minimum of 3 threads exposed, and a maximum thread projection of 1/2 inch beyond nut.

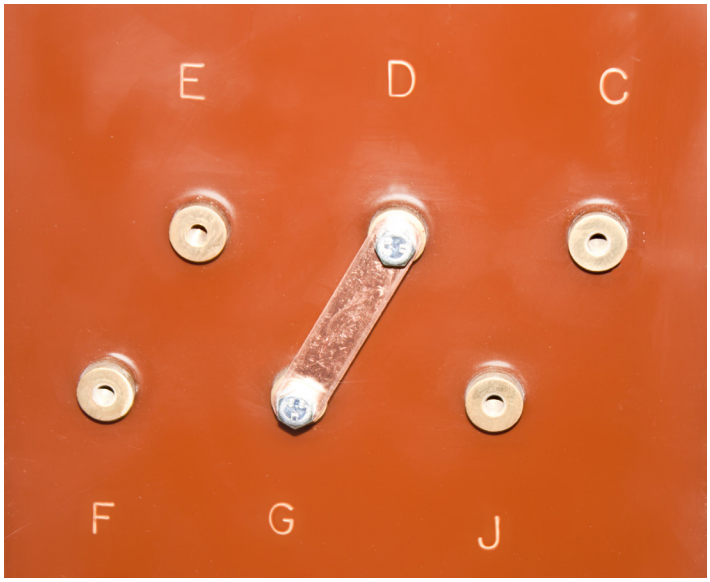
!CAUTION:

In the event that studs or nuts must be replaced on units with the optional insert-tap connection, ensure that fasteners of the original grade and material are installed. Brass provides good conductivity and prevents damage to the threaded brass insert molded in the coil.

Cable

When cable connections are required, conductors suitable for at least 90 deg. C should be used. Minimum clearance at terminals should be maintained. All connections should be made without placing unnecessary stress on the terminals. Connectors should be securely fastened in place and adequately supported with allowances for expansion and contraction.

Insert taps with connecting bar



Cable connection - Delta primary

Recommended torque values

Below are recommended torque values for the different types of bolted connections found on dry-type transformers. All electrical connections should be checked prior to the energization of a unit.

!CAUTION:

When lockwashers are used in the connection, it should be tighted until the lockwashers are completely compressed, but not distorted

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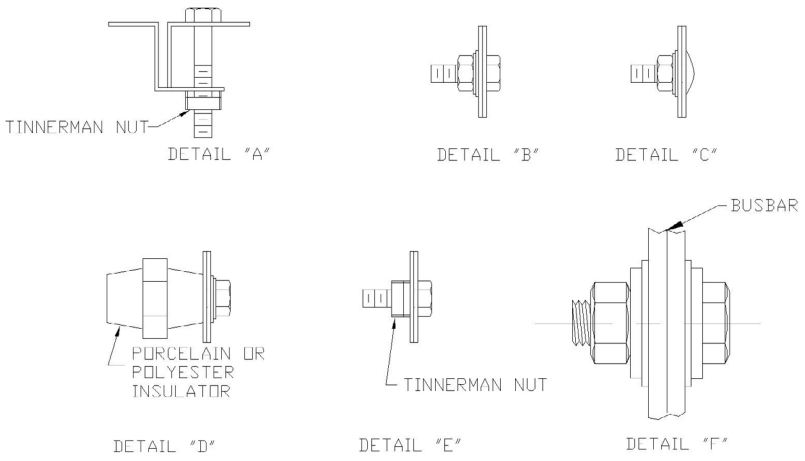
Bolt size	Grade	Detail	Application	Torque range (lb-ft)
3/8” - 16	2 or (Stainless 304, 316)	A	Enclosure Panels (Tinnerman)	3-6
3/8” - 16	2 or (Stainless 304, 316)	B,C,D	Structural Bolting (Brackets, flat contacts, etc.)	15-20
3/4” - 10	5	B,C	Structural Bolting (Brackets, flat contacts, etc.)	100-155
1/4” - 20	2 or (Stainless 304, 316)	E	Flat sheet metal (Tinnerman)	3-6
1/2” -13	2 or (Stainless 304, 316)	B,C,D	Structural Bolting (Brackets, flat contacts, etc.)	40-50
5/8” - 11	2 or (Stainless 304, 316)	B,C	Structural Bolting (Brackets, flat contacts, etc.)	80-90
1” - 14	1018	B,C	Structural Bolting (Brackets, flat contacts, etc.)	110-170
5/8” - 11	5	B,C	Structural Bolting (Brackets, flat contacts, etc.)	110-155
1/4” - 20	Nylon	B	Electrical Insulation assemblies	7-9 lb-in
1/2” - 20	8	B,C	Structural Bolting (Brackets, flat contacts, etc.)	80-100
3/8” - 16	2 or (Stainless 304, 316)	F	Electrical Connection	15-20
3/8” - 16	5	F	Electrical Connection	15-30
1/2” - 13	2 or (Stainless 304, 316)	F	Electrical Connection	40-50
1/2” - 13	5	F	Electrical Connection	40-70
5/8” - 11	2 or (Stainless 304, 316)	F	Electrical Connection	80-90
5/8” - 11	5	F	Electrical Connection	110-130
3/8”	Brass insert	pg. 15	Insert taps on Vacuum Cast Coil	15
1/2”	Brass insert	pg. 15	Insert taps on Vacuum Cast Coil	30



Recommended final checklist

Below is a recommended electrical and mechanical checklist to be used to ensure that the transformer unit(s) are fully prepared for energization and operation. Please follow these checklists for initial startup and also for anytime the unit has been shut down for maintenance or extended periods. These checklists are general startup procedures and are not comprehensive.

Please contact the manufacturer with questions and/or concerns that arise after following the inspection checklist below.

Electrical inspection

- ☐ All external connections have been made properly (Phasing of connections to terminals, etc.)
- ☐ All connections are tight and secure
- ☐ All accessory circuits are operational
- ☐ All tap connections are properly positioned
- ☐ The neutral and ground connections have been properly made
- ☐ Fans (if supplied) are operational
- ☐ Proper clearance is maintained from high voltage and low voltage bus to terminal equipment
- ☐ All windings are free from unintended grounds. A 500V megger test is recommended
- ☐ There is continuity in all windings

Mechanical inspection

- ☐ There is no dust, dirt, or foreign material on the core and coils
- ☐ There is no visible moisture on or inside the core and coils or enclosure
- ☐ There is no visible damage to or shifting of core and coil assembly
- ☐ All plastic wrappings are removed from the core and coils
- ☐ All shipping members have been removed
- ☐ There are no obstructions in or near the openings for ventilation
- ☐ No tools or other articles are left inside of, or on top of, the core and coils or enclosure
- ☐ All protective covers are closed and bolted tight

Notes:

Testing

Note: The recommendations offered in the testing section provide a basis for action while testing your unit; however, this section does not cover every aspect of test procedures. Any additional information can be attained through contacting the manufacturer as well as the answers to any questions that may arise.

Testing

Only qualified personnel should perform these tests. Improper testing by unqualified persons could result in serious injury or death. Prior to energization, it is recommended that separate field testing and inspection be made before placing a transformer in service (especially if the unit has been placed in prolonged storage). This testing determines that the unit is in satisfactory operating condition and benchmarks data for future comparison. Care must be taken that these measurements are made in the same way and at a close temperature range every time for a more accurate trend of the condition of the insulation system over the transformer's lifetime.

Prior to testing, disconnect all high voltage, low voltage, and neutral connections. Disconnect all auxiliary equipment such as lightening arrestors, meters, or any other low voltage control system that is connected to the windings. Make sure not to disconnect the ground connection. If the transformer has to be shutdown for testing allow it to cool sufficiently before proceeding. The following is a list of possible tests to determine the transformers operating condition:

- Insulation Resistance (Megger Test) - This tests should be performed with 500V DC equipment, and should be done before performing an Applied Voltage test. It determines the integrity of the insulation. A general rule is that a minimum of 2 megohms (one minute reading at approximately 25 oC) per 1000 volts of nameplate voltage rating, but in no case less than 2 megohms total, may be satisfactory value. The test should be done between the LV to HV + ground, the HV to LV + ground, and core to ground (if the core is isolated). If the insulation resistance is less than the minimum value, do not energize the transformer (see "Drying process" section under "Maintenance").
- Resistance measurements of windings - This test determines the winding resistance of the assembled transformer for calculation of the I^2R component of conductor losses.
- Ratio test - The purpose of this procedure is to measure the ratio of the primary to secondary turns to check for possible insulation degradation of the windings.

Alternate testing

- Polarity or phase relation - Verifies the polarity of single phase units and the angular displacement (phase relation) between winding of 3-phase units, and also confirms the phasor diagram of the assembled unit which is found on the transformer nameplate.
- Applied Voltage test - Often referred as "Hi-pot" tests. This verifies the integrity of the insulation between the windings and ground as well as the insulation between the different windings (primary and secondary). This test is recommended if the transformer was not already subject to dielectric tests before; and, it should be performed last.

When high potential, induced-voltage, or insulation resistance for acceptance is conducted, the test voltages shall not exceed 75% of factory test values. When field tests are made on a periodic basis, it is recommended that the test voltages be limited to 65% of factory test values.

For more information about testing procedures, please refer to the Standard Test Code for Dry-Type Transformers (IEEE C57.12.91) or the Guideline for Dry-Type transformer Maintenance (IEEE C57.94).

Operation

General operation

Before placing the transformer in operation, be certain that the unit is in its final location, all bolts and parts are secured, and any shipping brackets have been removed.

Never operate a transformer without protective covers or panels. Never probe with any objects through ventilation grills or remove protective panels when the transformer is energized. Injury or death may result, as well as damage to the equipment.

Make periodic temperature checks to assure that the transformer does not operate for any length of time above rated load and temperature.

Normal humidity in the air has little effect on dry-type transformers when they are energized.

Loading

When energizing the transformer, slowly increase the load while monitoring current, voltage, load levels, etc. If it is not possible to begin at no-load, full load may be applied with caution.

It is not recommended to load the unit above the maximum continuous load on the nameplate. If there is any doubt about the load, voltage or current levels, or in any area, contact the manufacturer immediately.

Note: Smoke and vapor may appear during the first few hours of operation. It should dissipate within a few hours.

Over voltages

The insulation values for the transformer are given in the connection diagram and in the test report. You must ensure the high-voltage connections are protected against abrupt increases in voltage.

Forced air cooling

For a higher rated load, the transformer can be fitted with forced air cooling. Optional sensors may be installed for the control of the forced air fans that are installed on the unit. The forced air cooling fans switch on and off depending on the operating temperature.

The average service life of the fan motors is 2-3 years. This means they cannot be used for continuous overloads for the total service life of the transformer.

To increase the performance of the transformer retroactively, it may be possible to install forced air cooling fans as retrofits. Please consult the manufacturer to investigate overload ratings for a specific transformer.

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, circulating current will exist in the circuit loop between parallel units. The difference in impedance should in no case exceed 10%.The greater the differences in 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.

Maintenance

!WARNING:

Failure to de-energize and ground the transformer before performing maintenance could result in serious personal injury or death.

Maintenance

Generally, very little maintenance is required for a dry-type transformer. However, periodic inspection and maintenance is recommended to keep the transformer in good running order. A transformer operating in a clean, dry area would require fewer inspections and maintenance than one operating in a more harmful atmosphere. Regular inspections reduce the risk of insulation surfaces becoming extremely dirty and obstructing effective cooling. Dirt buildup on the surface of the active assembly can lead to reduced voltage withstand and danger of flashovers. Within the first few inspections, a routine maintenance schedule should be established.

Before attempting to inspect the unit, first de-energize the transformer. Inspection of the transformer(s) may be performed without de-energization if optional viewing windows are installed. Never open the enclosure while the unit is energized. Next solidly ground the unit for one minute to drain static charge. After grounding, entry to the active assembly can be made. Inspection should be made for dirt, especially accumulations on insulating surfaces or where such accumulations could restrict air flow. Also, inspection should be made for loose connections and the overall condition of the transformer. Signs of overheating and of voltage creepage over insulating surfaces by indication of carbonization should also be checked. Evidence of rusting, corrosion, and deterioration of the paint should be checked and addressed along with the inspection of fans, motors, and other auxiliary devices for service if needed.

If a significant amount of dirt is found on the windings, insulators, leads, or terminal boards then the dirt should be removed to allow for free circulation of air and to help reduce the risk of insulation breakdown. More attention should be given to the top and bottom ends of winding assemblies and ventilating ducts. A vacuum cleaner is the best choice to start cleaning off the dirt, and any smooth surface containing dirt should be wiped down with a dry cloth. For open wound (VPI) transformers liquid cleaners should not be used because of the possible deteriorating effects on the insulating materials. If the unit is outdoors, removal of any accumulation, such as snow, in front of the ventilation openings should be moved to allow free entry of cooling air. Also check for any gasket damage inside the enclosure and replace as necessary.

If conditions of high humidity exist while the unit is de-energized, precautions must be taken to assure that there is no condensation inside the transformer. Space heaters (optional) placed inside housing should be energized to provide protection against this condition. As a simple rule, always keep the transformer a few degrees above ambient temperature.

Prior to re-energizing the unit(s) after performing maintenance, please refer to “Recommended final checklists” to ensure the unit(s) is suitable for startup.

Attached at the end of the document is a Maintenance Log in which the user may record the dates and times of the maintenance and upkeep of the transformer.

Routine maintenance will prolong the functional life of a dry-type transformer.

Drying process

To avoid danger of unwanted moisture, be sure to dry-out the transformer before energization. During the dry-out process, only qualified personnel may undertake the work. Also, if the unit became exposed to more intense moisture, such as direct and heavy rain, floods, or sprinklers, the normal dry-out process may not work. Contact the manufacturer if there are any concerns or questions regarding drying out the unit.

If any moisture is free standing and able to be easily and safely removed, do so in order to quicken the dry-out process.
Methods of Drying a Transformer:

- External Forced Air- Direct the warm-to-hot air through the unit with all the ventilation open and clear. Temperature maximum- 105°C
- Electric Heaters- These may be installed within an enclosure. This method is better suited for outdoor use. Place these heaters under the windings on both sides of the core.
- Internal Heating- This method requires the contacting of the manufacturer so that you can require more instructions. Method Requirements: Short circuit LV/Current to HV of 100% of nameplate rating. Max Winding Temperature: 105°C

Note: Do NOT dry via an oven. This method can damage the unit because of the high temperature required.

Successive Insulation Resistance tests can determine the moisture status during the drying process. An initial measurement and measuring on two hour intervals during the drying is recommended.

If a shutdown occurs during a period of low humidity, no special drying precautions are necessary before re-energizing the transformer.

Replacement parts

Should a transformer be damaged, replacement accessories may be ordered through the manufacturer. Should you require parts or service, give a complete description of the part and serial number as listed on the nameplate of the transformer to the ABB representative. If the proper name of the part is in doubt, a simple sketch or photograph will help with prompt shipment to you.

Decommissioning

The following are recommended steps for decommissioning a unit(s) and taking out of service:

1) Shut down the low-voltage
2) Shut down the high-voltage
3) Secure the transformer to prevent incidental activation by unauthorized persons
4) Allow the transformer to cool down
5) Disconnect the connections on the low-voltage side from the transformer
6) Disconnect the connections on the high-voltage side from the transformer
7) Disconnect the connections on any provided additional components from the transformer
8) Disconnect the ground terminal from the transformer

Disposal

If a transformer needs to be disposed of because it is no longer needed or faulty, please contact the manufacturer. The manufacturer can advise you in separating out the components that have to be disposed of and the ones that can be recycled.

Troubleshooting guide

Note: All persons operating, inspecting or in any way working with the units should be certain that the transformer is de-energized before continuing with any work. Only qualified personnel should operate the equipment.

Symptom	Possible cause	Resolution
Overheating	Continuous Overload Wrong external connections Poor ventilation Ambient temperature exceeds rating Damaged or improperly installed fan blades High harmonic or unbalanced loads High input voltage Dirty Core Blocked ventilation ducts	Evaluate according to final checklist (pg. 17) Check cooling system and ventalation against nameplate environmental specifications Ensure temperature sensor is in the first cooling duct. Check all temperature sensors are operational Ensure temperature monitor is setup correctly Check loading profile Perform preventative maintenance
Smell	Normal operation during commissioning Dirt accumulation on coils	Smell coming from the transformer after just a short time in operation is normal and generally stops after a few hours Inspect coils and perform preventative maintenance
Reduced Voltage	Shorted turns Improper primary tap connections	Ensure tap connections are correct and tight Contact the manufacturer
Excess Secondary Voltage	High input voltage Improper primary tap connections	Verify primary voltage and tap connections (pg. 14) Contact the manufacturer
Unbalanced Secondary Voltage	Overload Mis-matched tap connections Ungrounded neutral	Check load Check tap connections Consult outline drawing to determine whether neutral should be connected
Insulation Failure	Continuous Overload Dirt accumulation on coils Mechanical damage during handling Lightning or switching surges	Inspect coils for damage Check loading profile Contact the manufacturer
Breakers / Fuse Opening	Short circuit Overload	Check load and loading profile
Excessive heating of external termination cables	Improperly bolted connections Incorrect cable size for load Incorrect cable routing	Follow NEC and local codes for cable sizing Evaluate according to final checklist (pg. 17)

Symptom	Possible cause	Resolution
Vibration and Noise	Low frequency High input voltage Core clamps loosened during shipment/ handling Improper tap connection	Increase distance from reflective surfaces Evaluate according to final checklist (pg. 17) Check anti-vibration pads for damage After commissioning, some designs will decrease in noise level. Wait a few hours observing any change. If not, contact the manufacturer.
Smoke	Insulation Failure (see above symptom)	
Burned Insulation	Lightning surge Switching / line disturbance Broken bushings / taps / arresters Dirt accumulation on coils	Contact the manufacturer.

If you are unable to eliminate the problem in spite of the information provided in this listing, please contact the manufacturer with the following information available:

- Serial number (Unit identification number)
- Description of the problem
- Installation location/ambient conditions

Notes:

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