DRY-TYPE POWER TRANSFORMERS

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

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1.0 GENERAL & SCOPE

The successful and safe operation of dry type transformers is dependent upon proper handling, installation, and maintenance. Neglecting certain fundamental installation and maintenance requirements may lead to personnel injury, the premature failure of the transformer as well as damage to other property.

This manual covers general recommendations & requirements for the installation, operation and maintenance of single and three phase dry-type power transformers of the following types:

- Ventilated, indoor and outdoor: Self cooled or forced air cooled (ANN/AFN)
- Non-ventilated, indoor and outdoor: Self cooled (ANC)

These recommended practices are for general applications. There may be additional site specific, or transformer specific considerations for your transformer, and any special requirements should be referenced back to Rex Power Magnetics and/ or their representative.

It is further recommended that installation work be governed by ANSI/IEEE C57.94 “IEEE Recommended Practice for Installation, Application, Operation and Maintenance of Dry-type General Purpose Transformers”.

IMPORTANT	
	**All persons working on the equipment should be qualified personnel who have experience and the necessary knowledge in working with high voltage equipment. 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. Certifications are required to transport, operate, store, install or move the product safely. Complying with these instructions will help to reduce hazards and accidents, while preserving the reliability and service life of the transformer.**

For additional instructional videos, visit our YouTube page.

2.0 SAFETY

These instructions do not cover every possible installation, operation, or maintenance scenario, and not all details or variations in equipment may be covered. The safety recommendations and guidelines below 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 Rex Power Magnetics.

DANGER

There is a hazard of electric shock or burn whenever working in or around electrical equipment. Power must be locked off before working inside a transformer enclosure. This equipment is to be installed and maintained by qualified personnel only.

- ☐ Only qualified technicians should attempt to work on electrical equipment.
- ☐ A risk assessment should be conducted to determine what hazards are present that need to be addressed in the project plan.
- ☐ Always wear protective 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 enclosure while it is in operation.
- ☐ The use of electrical safety, arc flash safety grounding, and lockout/tagout procedures should always be followed to ensure personal safety when installing, servicing and uninstalling electrical equipment.
- ☐ Never energize a transformer if it appears to be damaged.
- ☐ When working at heights, fall protection should be worn.
- ☐ 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.
- ☐ Only use the accessories approved by Rex Power Magnetics.
- ☐ In the event of a fire, do not use water to extinguish the flames. Use a suitable quenching agent such as, CO_2.
- ☐ Make sure minimum electrical clearances are maintained (Refer to Table 1, Section 7.4).
- ☐ Terminals are for electrical loading only. Wherever possible, use flexible connectors to avoid mechanical strain on terminal pads.
- ☐ Do not lift or move a transformer without appropriate equipment and precautions.
- ☐ Use the proper “rigging” when handling the units and always connect to the designated lifting points. Refer to section 3.2 for instructions.

- ☐ 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 is more likely to occur if the transformer has been stored 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 supplies are 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.
- ☐ Ensure that all electrical connections are tight. (Refer to Table 1, Section 7.5 for recommended torque values).
- ☐ The proper PPE and insulated tool should always be used when working around potentially energized equipment.
- ☐ Do not attempt to change the primary or secondary tap connections or remove the enclosure panels while the transformer is energized.
- ☐ Do not energize the transformer without properly grounding the unit per the applicable national electrical code.
- ☐ Do not tamper with or attempt to bypass 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 (PEE) while working on top cover of the enclosure (if applicable).
- ☐ After de-energization, the transformer will still 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. Ensure that minimum electrical clearances are maintained. (Refer to Table 1, Section 7.4)

3.0 RECEIVING & HANDLING

The recommendations presented in this section are to assist the operator in the receiving 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. Please contact Rex Power Magnetics if any questions arise in regards to handling the unit.

3.1 Receiving

Dry type transformers are shipped either completely assembled in a metallic enclosure, or as a core & coil assembly, with or without a separate enclosure. Enclosed units are wrapped in a clear plastic sheet and covered with shipping tarps to prevent ingress or moisture and dust (See figure 1). Core & Coil units are wrapped in a more durable shrink wrapping for additional protection (See figure 2).

Figure 1: Typical Enclosed Transformer Shipment Packaging (Shown with Tarp Removed)

Figure 2: Typical Core & Coil Transformer Shipment Packaging with Shrink Wrapping

It is imperative that a thorough inspection of each unit be done immediately upon receipt, prior to its acceptance, and removal from the carrier's vehicle. Confirm that the identifying part number on the transformer nameplate matches the packing list and bill of lading. Since transformers may be shipped in parts or completely assembled, ensure all components have been received.

The units should be visually examined to detect any damage or indication of rough handling which may have been incurred during transit. Covers should be removed to review internal components as well. Inspections should be done to identify missing or damaged parts, loose or broken connections, dirt and standing water. If damage is detected or there are any critical observations from the inspection, write a brief description on the bill of lading, file a claim immediately with the carrier and send notice of the extent of damage to the local sales office.

Note: If the transformer is shipped with an electronic impact recorder, record the time of offloading, and ship the shock monitor back to Rex Power Magnetics.

3.2 Handling & Lifting

CAUTION	
	**Never attempt to lift a transformer from points other than the lifting points provided. No transformer should be laid on its side or end for any reason. The windings, structure and vibration isolators are designed to handle the normal weight and stress from shipment and usage. These parts are not designed to accept stresses from tipping or similar actions. Damage beyond repair may occur if the transformer is tilted/turned on its side or end.**

It is preferable to avoid handling dry type transformers outdoors in inclement weather. If it is unavoidable and necessary to do so, they should be thoroughly protected against the entrance of dust, rain or snow. If the unit is exposed to moisture during handling and storage, it must be carefully inspected and tested as per the instructions in Section 6.0. If necessary, follow the “Drying” instructions in Section 5.0 prior to energization.

All transformers are supplied with lifting provisions. Unless special design considerations have been made, the lifting angles are provided on the top of the core & coil.

In order to lift a transformer safely, follow the instructions below:

1. For enclosed transformers, remove the lifting cover plate on the roof of the enclosure. See Figure 3.
2. Connect lifting chains to all the lifting points on the lifting brackets installed on the top core clamps. Smaller units are supplied with two lifting points, and larger units are supplied with four. See Figure 4.
3. Use an overhead crane to lift the unit, ensuring that the angle between the chains does not exceed 30º. See Figure # 5

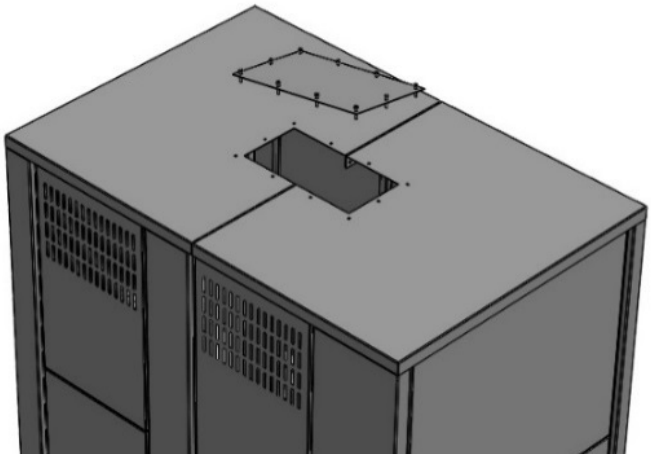


Figure 3: Removable Lifting Cover Plate

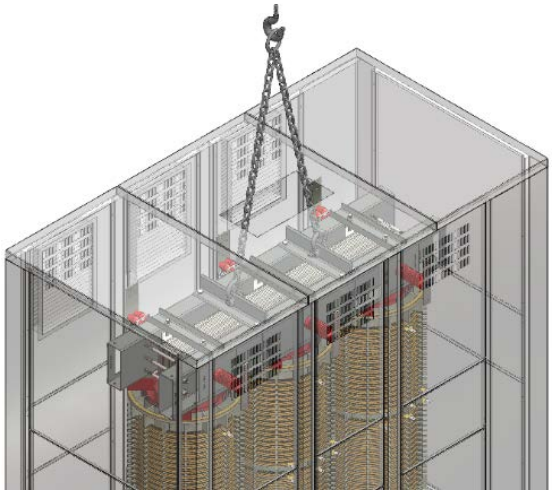


Figure 4: Lifting Chains Connected to Transformer Lifting Bracket.

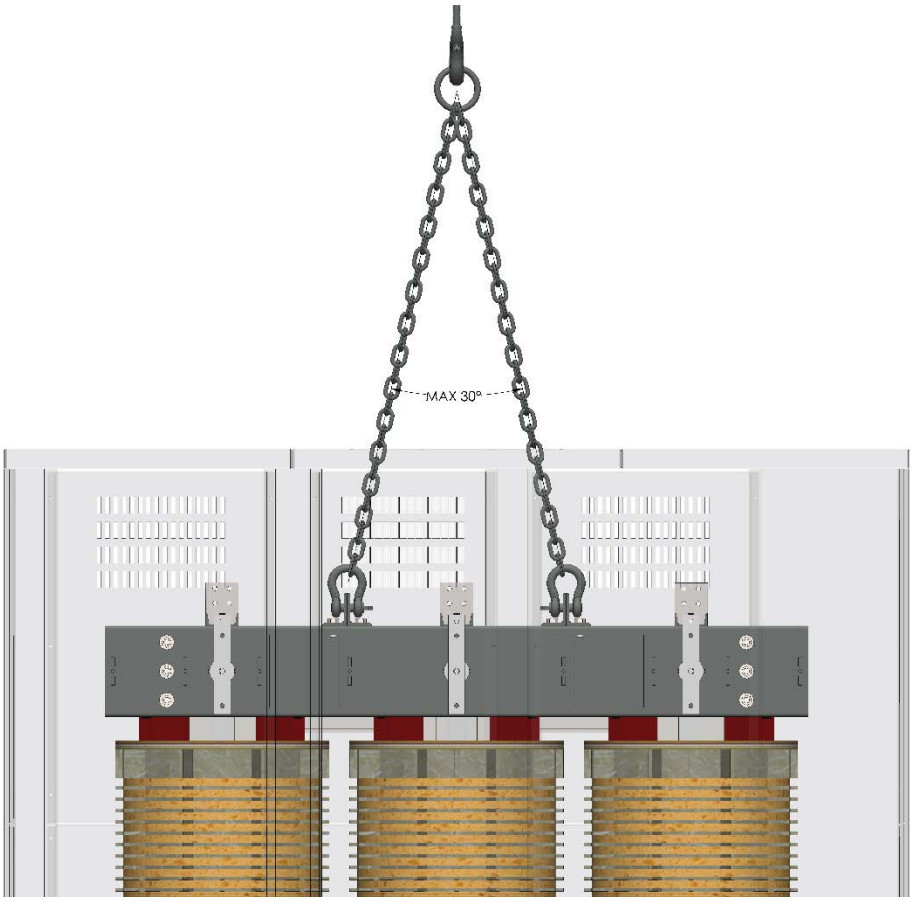


Figure 5: Lifting Chain Angle

When handling the transformer, DO NOT:

- Lift the transformer from the enclosure or from directly underneath the transformer
- Lift the transformer from the rigging provisions on the base.
- Jolt or jerk the transformer, as this can cause damage to internal parts
- Jack, skid or roll the transformer directly on the floor unless it is on a wooden skid or been supplied with provisions to do so.

Once the transformer has been moved into place, ensure that the lifting cover plate is replaced and secured in order to prevent dirt, or other objects from falling into the transformer.

Enclosed Transformers

Unless special arrangements have been made with the customer, all enclosed transformers are shipped with the core and coil assembly attached to the enclosure with shipping bolts at the base, in order to facilitate lifting and handling, and to provide protection during shipment.

Core & Coil Transformers

Depending on the core & coil weight, transformers without an enclosure may be shipped on a wooden pallet. In that case, it is suitable for moving with a forklift truck. If a forklift truck is not available, the lifting bracket on the top of the core & coil should be used for overhead lifting.

4.0 STORAGE

Any transformer that is not installed and energized immediately shall be stored in a dry, clean space having a uniform temperature to prevent condensation on the transformer windings. Preferably, it shall be stored in a heated building with adequate air circulation and protected from cement, plaster, paint, dirt, water, corrosive gases, powders, and dust. The storage floor shall be resistant to the upward migration of water vapor. Precautions shall be taken to prevent storage in areas where water may be present, such as roof leaks, window infiltration, or similar conditions.

The following minimum storage temperatures apply during shipping, warehousing, and delayed installation, as well as after installation during periods of planed or unplanned power outages:

- **VPI / VPE dry-type transformers**: down to –50 °C, provided the transformer is kept dry and protected from mechanical shock while cold.
- **Cast Coil dry-type transformers**: down to –20 °C. Storage below this temperature is not recommended, as epoxy resin systems may become brittle, increasing the risk of micro-cracking or long-term dielectric degradation, particularly if mechanical shock occurs.

When stored at or near freezing temperatures, precautions shall be taken to prevent condensation caused by temperature cycling. To minimize condensation, the transformer enclosure temperature should be maintained approximately 5 °C to 10 °C above ambient temperature.

4.1 Use of Heaters During Storage

Optional anti-condensation heaters are intended to control moisture and may not be sufficient to maintain the enclosure temperature above the minimum storage temperatures listed above. Additional approved internal or external heaters may be required (refer to Section 5.0).

When heaters are used for storage temperature control, ventilation openings may be temporarily blocked to retain heat; however, sufficient ventilation shall be maintained to allow moisture to escape. All temporary ventilation coverings shall be removed prior to energization. Under no circumstances shall heaters or lamps come into direct contact with transformer windings or insulation systems.

4.2 Outdoor Storage

Outdoor storage of dry-type transformers is strongly discouraged. If outdoor storage is unavoidable, the following protective measures shall be implemented:

- Retain the original factory plastic wrapping.
- Seal all openings to prevent ingress of moisture and foreign debris.
- Install desiccants (e.g., silica gel) within the enclosure and control panels
- Elevate the unit above grade and protect it from standing water. If the original factory plastic wrapping was not retained, care should be taken to seal the bottom of open bottom enclosures to prevent drifting snow from entering the enclosure from underneath.
- Inspect the transformer periodically for signs of condensation or corrosion on windings, core, support blocks, clamping systems, and buswork and replace saturated desiccant bags which can no longer remove moisture from their surroundings

4.3 Pre-Energization Requirements

Prior to placing any transformer that has been in storage into service, an insulation resistance test shall be performed to verify the absence of moisture (refer to Section 6.0 for test procedures). If insulation resistance values are below acceptable limits or visible moisture is detected, a controlled drying procedure shall be completed before energization.

If the transformer has been stored or is to be energized at temperatures below 0 °C, the cold start procedure shall be followed (Refer to Section 9.0)

5.0 DRYING INSTRUCTIONS

If a dry type transformer has been exposed to moisture during handling, stored in a humid environment, or shows any signs of condensation on the internal components, it should be dried out prior to energization. In the case of direct water contact with the internal components due to rain, sprinklers, or flooding, the procedure below may not be sufficient. Contact Rex Power Magnetics with any questions or concerns regarding how to correctly dry a unit.

There are three methods that may be used to dry the core and coil assembly:

1. Internal Heating
2. External Heating
3. External and Internal heating

Before any of the above methods are used, any free moisture should be blown or wiped off the windings in order to reduce drying time. Note: The pressure of compressed air used should not exceed 25 psi and the air must come from a dry source.

5.1 Internal Heat Method

For this method, a variable AC source of impedance voltage is required. The transformer should be located to allow free circulation of air through the windings from the bottom to the top of the enclosure. One of the windings should be short-circuited and sufficient voltage at normal frequency should then be applied to the other winding to circulate 50% – 75% of normal current. It is advised that the loading is increased gradually such that the circulating current begins from 10% of the rated amperage, and increase in 10% -15% increments every 10 minutes until it reaches 50% – 75% of the rated current. Generally, the voltage required will be the rated voltage times the per unit impedance time the percentage of current required. The winding temperature should not be allowed to exceed the average winding temperature rise or 100 ^{0}C, whichever is lower. Refer to ANSI/IEEE C57.94 and/or contact Rex Power Magnetics with any specific questions.

5.2 External Heat Method

External heat may be applied by one of the following methods:

1. By placing the core and coil assembly in a suitably ventilated oven
2. By directing heated air up through the winding ducts.

Since it is extremely rare that a suitable oven would be available and the risk of damage to the transformer if it is overheated, the 2nd option above is preferable. This can be achieved by installing suitably rated strip heaters inside the enclosure under the coils, or by utilizing external heaters with fans blowing hot air into the transformer. Note: To be most effective the air should be directed to flow up into the winding ducts of the core and coil assembly. It is recommended that the air temperature not exceed 110 °C.

5.3 External and Internal Heat Method

This is a combination of the two methods previously described and is the quickest method. External heat should be applied as described in the second method and current circulated through the windings as described in the first method. The current required will be considerably less than when no external heating is used but should be sufficient to produce the desired temperature of the windings.

The time required to adequately dry a transformer depends on several factors. The only way to adequately determine if a transformer is dry is by taking insulation resistance readings at intervals during the drying process. The first reading would be taken before the drying process starts to obtain a base reading, then subsequent readings should be taken at 2-hour intervals until the readings are acceptable and an applied voltage test can be completed (See Section 6.0 for instructions on insulation resistance testing)

Insulation resistance readings can be deemed acceptable if they are comparable to benchmark readings taken previously under similar ambient conditions when the transformer was dry. If benchmark readings are not available, experience to date indicates that 2 MΩ, (one minute reading at approximately 25 °C) per 1000 V of nameplate voltage rating, but in no case less than 2 MΩ total, may be a satisfactory value for insulation resistance.

Insulation megger test (500 V or 1000 V DC) should be done between LV to HV + Ground and HV to LV + Ground.

6.0 FIELD TESTING

CAUTION

Only qualified personnel should perform any transformer testing. Improper testing by unqualified persons could result in serious injury or death and may damage the transformer.

It is recommended that separate field testing and inspection be done before placing a new or repaired transformer into service (especially if the unit has been placed in prolonged storage). Preservice testing can verify 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.

If a transformer is known to be wet or has been subject to damp conditions, it should be dried out before testing. See section 5.0 for drying procedures.

For additional information about testing procedures, please refer to ANSI/IEEE C57.12.91 "IEEE Standard Test Code for Dry-Type Distribution and Power Transformers" and ANSI/IEEE C57.94 "IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers".

Preservice Tests

It is recommended that the following preservice tests be carried out and the results kept for future comparison:

1. Insulation resistance test
2. Applied-voltage test (Hi-Pot test)
3. Ratio test

Periodic Tests

It is recommended that the following tests be made as preventive maintenance tests before reinstalling a dry-type transformer that has been out of service:

1. Insulation resistance test
2. Applied-voltage test

Test Procedures

Prior to testing, disconnect all high voltage, low voltage, and neutral connections. Disconnect all auxiliary equipment such as lightning arresters, 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 shut down for testing allow it to cool sufficiently before proceeding.

Insulation Resistance (Megger Test)

The insulation resistance test is of value for future comparative purposes and also for determining the suitability of the transformer for the applied-voltage test. Therefore the insulation resistance tests should be made before conducting the applied voltage test.

The insulation resistance is measured in accordance with ANSI/IEEE C57.12.91 and the test data should be recorded with the temperature and humidity at the time of measurement.

Insulation megger test (500 V or 1000 V DC) should be done between LV to HV + Ground and HV to LV + Ground. Variable factors affecting the construction and use of dry-type transformers makes it difficult to set limits for the minimum required insulation resistance. Experience to date indicates that 2 MΩ, (one minute reading at approximately 25°C) per 1000 V of nameplate voltage rating, but in no case less than 2 MΩ total, may be a satisfactory value for insulation resistance.

If a transformer is known to be wet or if it has been subject to unusually damp conditions, it should be dried before application of the applied voltage test or before being placed in service, regardless of insulation resistance test value (Refer to Section 5.0 for drying instructions).

Applied Voltage Test

Applied voltage test method is described in IEEE C57.12.91. Initial installation tests using AC test equipment should be limited to 75% of factory test value and routine ac maintenance tests to 65% of factory test value. If DC test equipment is used, the test voltage should not exceed factory rms test voltage.

7.0 INSTALLATION

Installing a transformer requires taking every possible precaution. The guidelines below are standard instruction when installing a transformer, but they do not cover every possible scenario. Please contact Rex Power Magnetics if any questions arise during the installation of the transformer.

7.1 Location & Environment

Dry type transformers should be located such that they comply with all applicable local safety and electrical codes. It should not interfere with the normal movement of personnel, equipment and material and should not expose the transformer to potential damage from cranes or other moving equipment. Enclosures are intended for use in secured areas, generally not accessible to unauthorized or untrained persons. Transformers with open bottom enclosures, or with bottom ventilation openings should not be installed on or over combustible surfaces.

Dry type transformers are intended for indoor use unless the enclosure is specifically designed for outdoor weather-proof service.

Indoor ventilated units should be installed in a clean room where they will not be exposed to dust or dripping water unless the enclosure has been specifically design for these areas. For rooms with sprinklers, a suitably rated enclosure is required, but additional means could be required at time of installation in accordance with the Canadian Electrical Code, part 1 on sprinklered equipment to direct water spray when sprinkler heads are wall mounted in close proximity to the transformer so that the angle between the sprinkler heads and openings in the enclosure is greater than 45° from the vertical.

Outdoor ventilated units should ideally be located such that nearby buildings or landscape features can help reduce windblown dust, rain or snow from entering the enclosure.

Transformers to be installed at altitudes greater than 1,000 m (3,300 ft.) above sea leave, or in ambient temperatures exceeding a maximum average of 30 ºC and a maximum peak temperature of 40ºC must be specifically designed for these environmental conditions to operate correctly.

7.2 Space & Ventilation Requirement

Transformers should be positioned such that there is sufficient space between adjacent units and sufficient clearance to walls and other obstructions for both adequate air circulation and access for routine inspection and maintenance. The minimum required clearances of a dry type transformer to walls, floors or other equipment must adhere to the Local Electrical Code requirements.

Rex Power Magnetics recommends that dry type power transformers be mounted so that there is an air space of no less than 305 mm (12”) between the enclosure and any adjacent wall unless otherwise marked. Furthermore, it is recommended that a minimum air space of 610 mm (24”) be allowed above the transformer for adequate cooling. A minimum working space of 762 mm (30”) is recommended for all removable access panels that provide access to connections, and any renewable or adjustable parts / accessories. If the transformer must be located near a combustible surface / wall, the minimum clearance established by the Local Electrical Code and Fire Marshal should be maintained.

Note: The spacing guideline above is based on the assumption that the room the transformer is installed in has an adequately sized HVAC system, capable of exhausting the heat generated by the transformer and other equipment installed in the room.

7.3 Mounting

Unless special provisions have been made on the transformer core & coil base, transformers should be solidly mounted to the floor using the mounting holes provided. The neoprene anti-vibration pads supplied should be positioned underneath the transformer base channels as shown in figure 6. Depending on the weight of the transformers, the unit will be supplied with either 6 or 9 pads. When only 6 pads are supplied, the pads should be located at the mounting holes. The shipping bolts

connecting the core & coil base channels to the enclosure are provided to ensure that the two cannot move relative to each other, and electrical clearances are not compromised while the transformer is being moved into its final location. They should only be removed once the core & coil and the enclosure have been independently secured to the floor, and should be stored for future use. See Figure 6 below for mounting details. For transformers with provisions for lifting, jacking, skidding & rolling, or for mounting on seismic springs and snubbers, an alternative base construction is supplied (See figure 7). Once the transformer has been moved into place, that the lifting cover plate should be replaced and secured in order to prevent dirt, or other objects from falling into the transformer. Refer to the factory approval drawings for details, or contact Rex Power Magnetics for any questions relating to the transformer mounting.

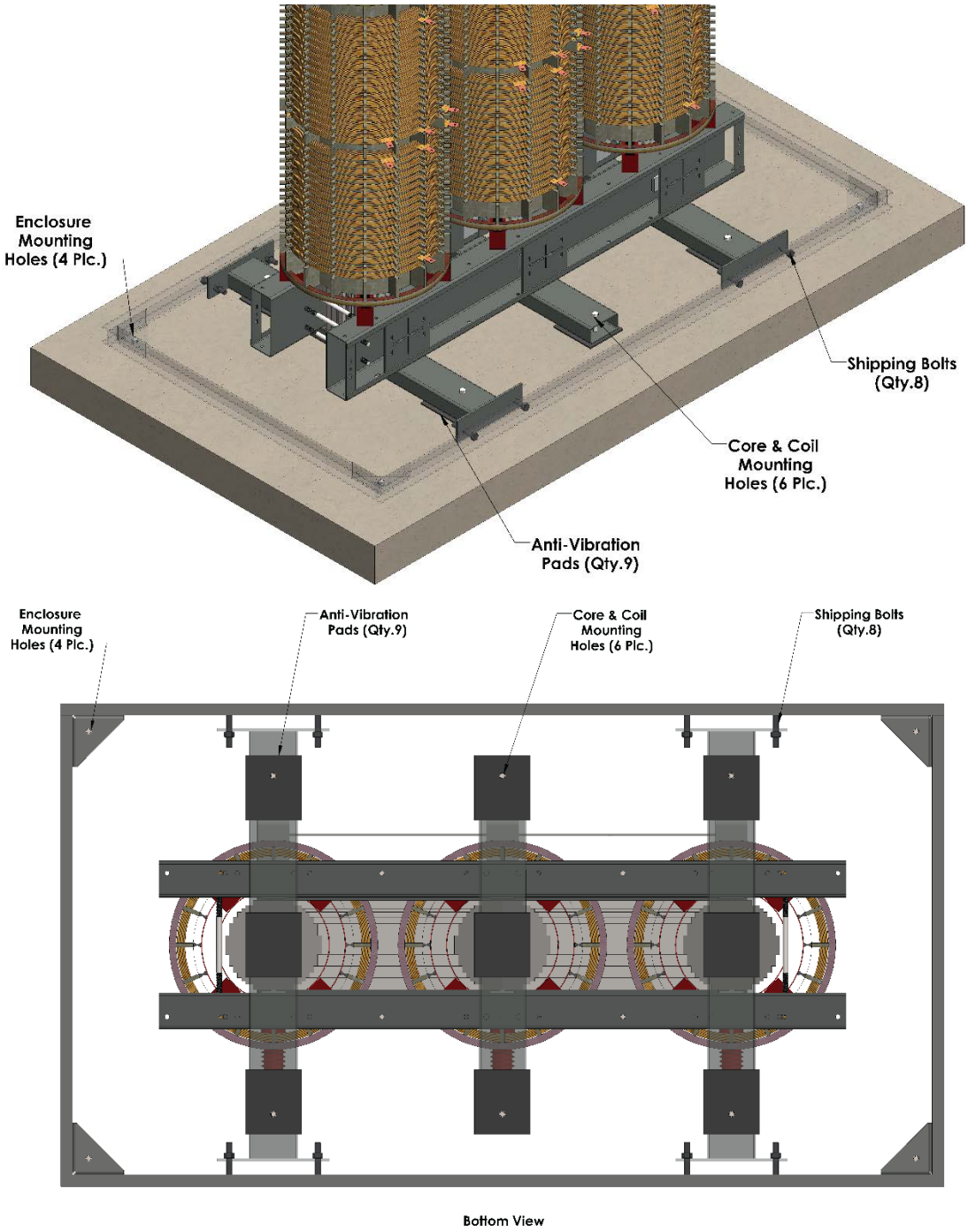


Figure 6: Standard Transformer Base Detail

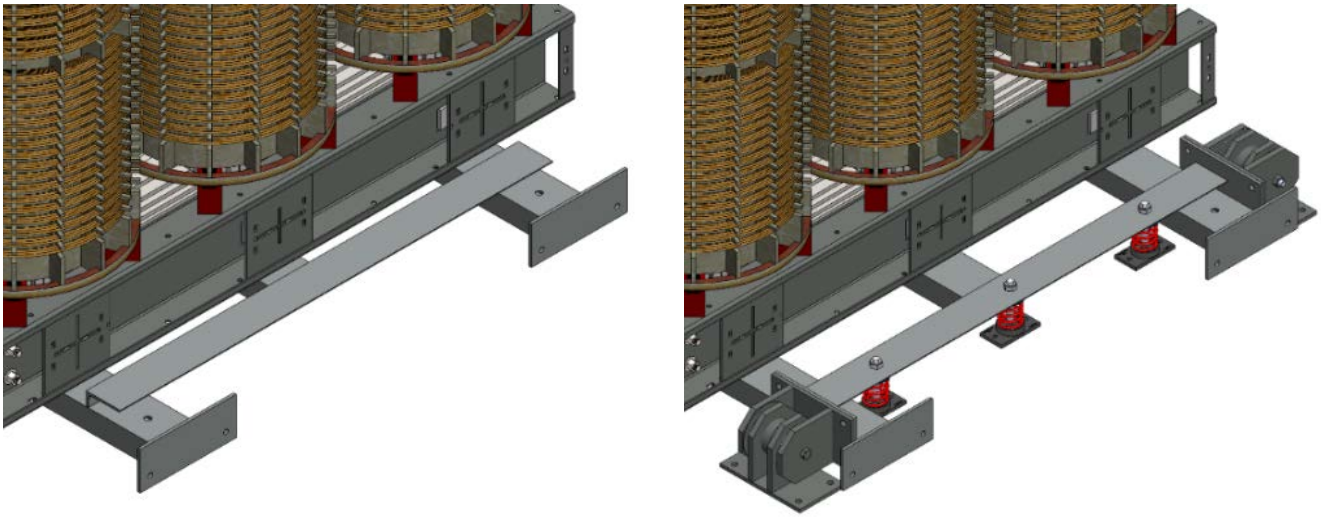


Figure 7: Left – Typical base with Provisions for Lifting, Jacking Skidding and Rolling, Right – Typical Base with Provisions for Seismic Springs & Snubbers (Not Supplied)

7.4 Electrical Connections

CAUTION

Make only those connections shown on the nameplate or connection diagram. Before energizing, check all jumpers for proper locations, and all bolted connections for tightness.

All joints suitable for field connection of cable or bus have tin-plated contact surfaces. The lug or bus used for connection should be tin-plated, or silver-plated. When plated parts are joined, no surface preparation other than ensuring clean surfaces is required. Simply bolt the parts together with the hardware supplied, adhering to the recommended torque values in Table 2, Section 7.5. When connecting bus bars, be sure the joints are properly aligned prior to bolting to prevent excessive strain on the insulators. Flexible bus connections are recommended for such connections to eliminate any excess strain.

Figure 8: Low and High Voltage Terminals with Flexible Connectors, Coordinated to Mate with Adjacent Equipment

User installed cables must be kept as far away from coils and top clamps as possible. Refer to the Table 1 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.

Some tap connections and other joints involve bare aluminum or copper. If it is necessary to change taps or assemble a joint of bare aluminum or copper, lightly clean the contact surfaces. Once the contact areas have been abraded, assemble the parts and tighten securely. Always use two wrenches when breaking or making joints to prevent damage to parts.

Minimum Electrical Clearances	
BIL [kV]	**Minimum Clearance [in (mm)]**
10	1.0 (25)
20	1.5 (38)
30	2.3 (58)
45	3.5 (89)
60	4.5 (114)
95	7.0 (178)
110	8.0 (203)
125	9.5 (241)
150	11.0 (279)
200	16.0 (406)

Table 1: Minimum Electrical Clearances Chart

7.5 Recommended Torque Values

Table 2 below summarizes the recommended torque values for the different types of bolted electrical connections found on dry-type transformers. All electrical connections should be checked prior to the energization of a unit.

Recommended Torque Ranges for Bolted Electrical Connections			
Bolt Size	**Carbon Steel Grade 2 or 5 [ft-lb]**	**Brass Alloy CU270 [ft-lb]**	**Stainless Steel B8 or B8M [ft-lb]**
1/4” – 20	10 – 12	n/a	5 – 10
3/8” – 16	15 – 30	12 – 15	15 – 20
1/2” – 13	40 – 70	20 – 30	30 – 40

Table 2: Recommended Torque Ranges for Bolted Electrical Connections

Note: When a lock washer is used in a connection, it should be tightened until the lock washer is completely compressed, but not distorted.

7.6 Sound Level

Dry type transformers have an inherent sound due to the energization of the core by the alternating voltage applied to the windings. The alternating flux in the core creates vibrations at twice the nominal frequency of the applied voltage. The transmission of sound from the transformer can be by various media such as air, metal, concrete, wood or any combination.

Amplification of audible sound can occur in a given area due to the presence of reflecting surfaces or mounting surfaces.

Sound levels of transformers vary depending on the size, cooling and voltage class of a transformer and can be highly influenced by the geometry of the room they are installed in. Many locations can

result in an amplification of the sound level, especially if there are 2 or more units installed in close proximity to one another. In order to reduce sound levels, the following directions should be followed:

A. Connections to primary and secondary terminals should be made with flexible connectors.
B. Shipping bolts between core & coil base and enclosure should be removed to avoid vibration transferring from the transformer to the enclosure. (See figure 6)
C. Anti-vibration pads should be installed underneath the transformer base channels to reduce vibration transfer to the floor
D. All enclosure hardware tightened so panels do not vibrate.
E. All conduits entering the transformer enclosure should be flexible type.

If noise levels are a factor in the location of a transformer, special consideration should be given to the installation site and attenuation equipment. The Installation of sound absorbing foam or fiberglass material on the ceiling or walls, could be considered.

7.7 Grounding

All non-current carrying metal parts in transformers must be grounded in order to remove static charge that accumulates in the unit. For enclosed units, a flexible grounding jumper from the core clamping structure to the enclosure/ground bus is provided. The transformer enclosure should be solidly grounded so that no danger will exist for operating or maintenance personnel. A transformer ground stud or ground bus is provided for the customer's ground connections. The grounding conductor for the transformer should have a current-carrying capacity in accordance with the National Electrical Code.

7.8 Voltage Taps

CAUTION	
	**Never attempt to change taps or connections unless the transformer is de-energized and all windings are grounded.**

Tap connections are typically provided to adjust for difference between nominal and tested incoming voltage values. Standard units have taps located on the face of each phase coil (See figure 9). Unless specifically instructed otherwise, transformer are shipped with the tap connection made for the nominal voltage. The taps are marked with letters or numbers which correspond to the markings on the nameplate schematic.

When changing taps, the following instructions should be followed:

1. De-energize the transformer.
2. Short-circuit and ground the HV and LV terminals.
3. Locate the tap jumpers.
4. Loosen the hardware on the tap jumpers.
5. Remove the tap jumper and move the connection to the desired tap on each phase. (All coils must have identical tap setting).
6. Verify all coils are connected at identical taps.
7. Torque the taps connections to the recommended values per Table 2, Section 7.5.
8. Remove the shorting connection on the HV and LV terminals.
9. Inspect the transformer to ensure that no tools or other objects have been left in the vicinity of the transformer
10. Replace all access panels, and re-energize the transformer

Figure 9: Left: Typical Voltage Taps on Coil Face for VPI Transformer. Right: Typical Voltage Taps on Coil Face for Cast Coil Transformer

7.9 Cable Connections

CAUTION	
	**Installation should be performed only by experienced and qualified personnel. No attempt should ever be made to change the taps, or make cable connections while the transformer is energized. To maintain safe operating conditions, do not remove the panels or cover while the transformer is in operation.**

When cable connections are required, conductors suitable for at least 90ºC should be used. Connections should be made and supported such that they do not stress the terminals with the weight of the cables while still allowing for expansion and contraction. The minimum electrical clearances to the core & coil per Table 1 in Section 7.4 should be maintained and all connections should be torqued to the recommended values per Table 2 in Section 7.5.

Note: Top cable entry is not permitted in the main transformer compartment in accordance with CSA C22.2 No.47. If the enclosure is fitted with air terminal chambers barriered off from the main compartment, then cables may be brought into the top of these terminal chambers. Please contact Rex Power Magnetics or refer to the outline drawings supplied at the order stage for instructions on appropriate cable entry locations.

7.10 Anti-vibration Pads

Dry type power transformers supplied as core & coils, or installed in an open bottom enclosure are supplied with standard neoprene anti-vibration pads to be positioned underneath the core and coil base channel assembly. These anti-vibration pads reduce the transfer or vibration and noise from the transformer core to the mounting surface. Refer to figure 6 for proper location of these pads.

7.11 Accessories

If the transformers is supplied with any additional accessories such as a temperature monitor, neutral grounding resistor, ground fault relay, surge arrester, etc. please refer to the manual for that specific piece of equipment for more information on the application, installation, operation and maintenance of the accessory.

8.0 OPERATION

Before energizing a transformer, ensure that it is in its final location, that the shipping bolts and any other temporary support brackets have been removed and that all bolted connections are tight.

CAUTION

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

8.1 Loading

When energizing a transformer from a cold start, it is preferable to slowly increase the load while monitoring current, voltage and load levels. If this is not possible, full load may be applied with caution.

Note: When energizing a dry type transformer for the first time, some smoke and vapor may appear during the first few hours of operation. This is normal, and should dissipate within a few hours.

8.2 Forced Air Cooling

For handling higher rated temporary loads, dry type transformers may be fitted from the factory with forced air cooling (See figure 10). Forced air cooling fans are controlled by a temperature monitor which activates the fans when winding temperatures reach the set temperature. The circulating air will allow the transformer to handle temporary overloads up to 133% of the ANN rating of the transformer without exceeding the rated temperature rise of the transformer's insulation class.

Forced air cooling may be added to a transformer as a retrofit depending on if the terminals and internal busses/cables are rated to handle the higher current ratings. Please contact Rex Power Magnetics to investigate the option of adding forced are cooling for a specific transformer.

Note: The average service life of a fan motor is far shorter than that of a transformer, and therefore transformers are not designed for continuous overloads with fan cooling.

Figure 10: Typical Installation of Forced Air Cooling Fans

8.3 Parallel Operation

Transformer may be operated in parallel to supply larger load as long as their polarity/phase shift, rated voltage, frequency, impedance and turns ratios are the same. If these parameters differ, circulating currents will flow in the circuit loop between the parallel units. The greater the difference between these parameters, the larger the magnitude of the circulating current.

The difference in impedance should not exceed 10% and the remaining parameters should be identical.

When specifying a transformer to be operated in parallel with an existing unit, the precise parameters of the existing units need to be noted.

9.0 COLD START PROCEEDURE

In order to avoid damaging a transformer which has been stored at freezing temperatures, it is important to ensure that the coils are dry and free from any condensation or moisture. The rate at which the coils are brought up to temperature must be controlled, so that conductors do not expand more quickly than the insulation. The following cold start procedure should be followed when energizing a transformer below 0 °C.

For the purpose of this procedure, coil temperature refers to the temperature of the windings (as measured by installed temperature sensors, or by infrared measurement of the windings where sensors are not available).

1. If the transformer coil temperature is below -20 °C, warm up the transformer coils to -20 °C or warmer using external heaters. The transformer's enclosure ventilation can be blocked in order to speed up the process; however, a minimum of 6" of the top and bottom ventilation openings/louvers should remain clear to allow for moist air to escape. Refer to the drying instructions in the transformer manual.
2. Once the transformer is above -20 °C, perform the recommended pre-service tests as outlined in the transformer manual, including the insulation resistance (megger) test.
3. If the megger readings are below the recommended value specified in the manual, external heat should be applied for an additional 12 hours and the transformer should be re-tested. This process should be repeated until the insulation resistance measurements are acceptable.
4. At this stage, the transformer can be energized with no load and left to warm up for 24 hours, or until the winding temperature reaches at least 0 °C. External heat and partial blocking of ventilation may remain in place to speed up the process.
5. Upon reaching at least 0 °C, the external heat and ventilation blockage may be removed, and the transformer may be loaded fully or as appropriate.

10.0 DECOMISSIONING

The following are recommended steps for decommissioning a dry type power transformer:

1. Shut down secondary side load by disconnecting the secondary breaker or fused disconnect.
2. Shut down supply side power by disconnecting the feeder breaker or fused disconnect.
3. Shut down any auxiliary power supplies which may be powering the transformer accessories
4. Lock out power to the transformer to prevent accidental activation by unauthorized persons.
5. If the transformer was energized, allow it time to cool down.
6. Remove access panel.
7. Disconnect the low voltage connection from the transformer terminals.
8. Disconnect the high voltage connection from the transformer terminals.
9. Disconnect the connection on any additional accessories such as temperature monitors.
10. Disconnect the ground connection from the transformer ground bus or lug.
11. Replace the core & coil shipping bolts and any shipping braces that might protect the assembly during movement. (See figure 6, Section 7.3)
12. Remove all mounting hardware securing the transformer core & coil and enclosure to the floor and/or other equipment (See figure 6, Section 7.3)
13. Remove transformer by following the handling instructions in Section 3.0.

For transformers which will be disposed, contact Rex Power Magnetics for instructions on separating out components that have to be disposed of, and the ones that can be recycled.

11.0 MAINTENANCE

CAUTION

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

Like other electrical equipment, dry type transformers require maintenance from time to time to assure successful operation. Inspection should be made at regular intervals and corrective measures taken when necessary to assure the most satisfactory service from this equipment. Evidence of rusting, corrosion, and deterioration of the insulation, varnish or paint should be checked, and corrective measures taken when necessary. Auxiliary devices should be inspected and serviced during these inspection periods.

11.1 Inspection

Inspection should be made at regular intervals and corrective measures taken when necessary to assure the most satisfactory service. The frequency at which the transformer should be inspected depends on operating conditions. For clean, dry locations, an annual inspection may be sufficient, but for other locations, such as those with excessive dust or chemical fumes, monthly inspections may be required. Usually after the first few inspection periods, a definite schedule can be set up based on the existing conditions.

Inspections should look out for the following:

- Dirt or dust accumulation on insulating surfaces or areas which it would restrict air flow.
- Loose or corroded electrical connections.
- Signs of overheating and of voltage creepage over insulating surfaces as evidenced by tracking or carbonisation.
- Evidence of rusting, or corrosion of the paint.
- Dust accumulation on filters (If installed)

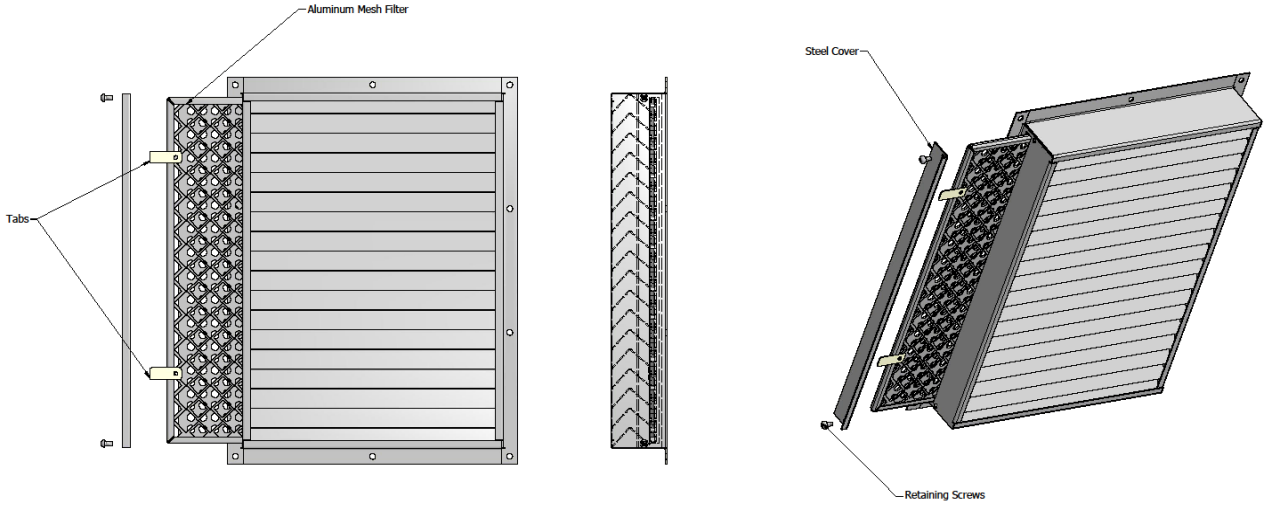
11.2 Cleaning

Accumulations of dirt on the windings or insulators of dry transformers should be removed to permit free circulation of air and to guard against the possibility of insulation breakdowns. Particular attention should be given to cleaning top and bottom ends of winding assemblies, and to cleaning ventilating ducts. Observation should be made for signs of overheating and overvoltage creepage on insulating surfaces as evidenced by tracking or carbonization.

The windings may be cleaned with a vacuum cleaner, a blower, or with compressed air. The use of a vacuum cleaner is preferred as the first step in cleaning followed by the use of compressed air or nitrogen. Care should be taken to maintain adequate ventilation during cleaning. The compressed air or nitrogen should be clean and dry and should be applied at a relatively low pressure (not exceeding 25PSI). Lead supports, tap changers and terminal boards, bushings, and other major insulating surfaces should be brushed or wiped with a dry lint free cloth. The use of liquid cleaners is undesirable because some of them have a solvent or deteriorating effect on most insulating materials

Dust accumulated on filters should be cleaned with soap and water (See Figure 11). For transformers installed in a relatively dust free environment, yearly inspection and cleaning is sufficient. However, if the unit is in an extremely dusty environment, the filters should be inspected and cleaned more frequently to ensure proper air flow. Since the frequency of inspection is dependent on the

environment, it is recommended that the first few inspections be done on a monthly basis until a definite schedule can be set up based on the existing conditions.



Inspecting and Cleaning Filters:

1- Remove Steel cover by unscrewing 2x10-32 Retaining screws.
2- Remove Filter by carefully pulling on the 2 tabs provided.
3- Inspect and/or clean Filter carefully with soap and water.
4- Replace Filter and Steel Cover.

Figure 11: Maintenance of Filtered Louvers for NEMA 3R & NEMA 12 Enclosures.

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