

# **MEDIUM VOLTAGE DRY-TYPE MANUAL**

# INSTRUCTIONS

## SAFETY INFORMATION IMPORTANT - READ CAREFULLY

**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.

**CAUTION** - THE EQUIPMENT COVERED BY THESE INSTRUCTIONS SHOULD BE INSTALLED, OPERATED, AND SERVICED ONLY BY COMPETENT TECHNICIANS FAMILIAR WITH GOOD SAFETY PRACTICES. THESE INSTRUCTIONS ARE WRITTEN FOR SUCH PERSONNEL AND ARE NOT INTENDED AS A SUBSTITUTE FOR ADEQUATE TRAINING AND EXPERIENCE IN SAFE PROCEDURES FOR THIS TYPE OF EQUIPMENT.

THESE INSTRUCTIONS DO NOT PURPORT TO COVER ALL DETAILS OR VARIATIONS IN EQUIPMENT NOR TO PROVIDE FOR EVERY POSSIBLE CONTINGENCY TO BE MET IN CONNECTION WITH INSTALLATION, OPERATION OR MAINTENANCE. SHOULD FURTHER INFORMATION BE DESIRED OR SHOULD PARTICULAR PROBLEMS ARISE WHICH ARE NOT COVERED SUFFICIENTLY FOR THE PURCHASER'S PURPOSES, THE MATTER SHOULD BE REFERRED TO THE NEAREST SALES OFFICE OF MADDOX INDUSTRIAL TRANSFORMER.

ALL APPLICABLE SAFETY PRACTICES INCLUDING, BUT NOT LIMITED TO, OSHA, NFPA, ANSI, REGIONAL AND LOCAL SAFETY CODES, SAFE WORKING PRACTICES AND GOOD JUDGMENT, AS THEY MAY BE APPLIED TO THIS TYPE OF EQUIPMENT, MUST BE USED AND OBSERVED BY ALL PERSONNEL WHEN INSTALLING, OPERATING, AND MAINTAINING THIS EQUIPMENT.

**DANGER - HAZARD OF ELECTRICAL SHOCK OR BURN.** DE-ENERGIZE, LOCKOUT, AND PROPERLY GROUND ALL CIRCUITS SUPPLYING POWER TO THE TRANSFORMER AND ITS ACCESSORIES BEFORE REMOVING ANY CASE PANELS OR COVERS AND WORKING INSIDE. FAILURE TO DE-ENERGIZE THE TRANSFORMER AND ITS ACCESSORIES BEFORE REMOVING THE CASE PANELS OR COVERS COULD RESULT IN SEVERE INJURY, DEATH, OR PROPERTY DAMAGE.

DO NOT MAKE ANY CONNECTIONS THAT ARE NOT AUTHORIZED BY THE NAMEPLATE OR CONNECTION DIAGRAMS.

TRANSFORMER MUST BE PROPERLY GROUNDED BEFORE ENERGIZING.

## INTRODUCTION

This instruction manual details information about installing, operating, and maintaining ventilated dry-type transformers. Each transformer has its own specifications and unique construction features. These features are detailed in the transformer outline and nameplate drawings.

This instruction bulletin is not an application guide for ventilated dry type transformers or a substitute for adequate training in safe working procedures for this and related electrical equipment. Installation of this electrical equipment may require special licenses or training. Consult applicable national, industry, and local codes for specific requirements. The successful operation of any transformer depends on various factors such as installation, loading, service conditions, and maintenance. Electrical systems in which transformers, along with vacuum or SF6 circuit breakers, are used are capable of high frequency over voltages which will not be suppressed by lightning arresters. These medium voltage systems may require a detailed, high frequency over voltage system analysis and/or the addition of high frequency over voltage protection. The transformer should be installed in conditions as specified in ANSI/IEEE Section C57.12.01 Usual Service Conditions, unless the transformer is designed specifically for operation in conditions other than the usual service conditions.

**NOTE:** If additional information is needed that this instruction manual does not cover, visit us on the web at [www.maddoxtransformer.com](http://www.maddoxtransformer.com) or call the Maddox sales team (800) 270-2011.

## RECEIVING

Upon receipt of the transformer, inspect as follows:

1. Review the shipping papers to ensure the shipment is complete. **If there is a problem with your order, list any noticeable damage on the receiving papers, file a claim with the carrier at once, and notify your Maddox sales representative.**
2. Inspect the transformer for any obvious external damage that may have occurred during shipment, including any evidence that water or other contaminants have entered the transformer during transit. The transformer should arrive from the factory covered by a tarp. An internal inspection of the enclosure is not usually required unless possible external damage has been observed. If an internal inspection is required, carefully inspect the leads, bolted mechanical and electrical

joints, the core and coils, and accessory equipment such as fans, controls, heater strips, control power transformers, or current transformers.

3. Tighten any parts which may have worked loose during shipment.
4. Accumulated dirt or dust should be wiped off inside and outside surfaces and any visible dirt or dust on the windings or in the air ducts should be removed as explained under "Maintenance".
5. Remove shipping braces from the unit. (Shipping braces will be tagged to indicate they are for shipping only.)
6. Do not leave the installation manual or any other foreign objects inside transformer enclosure.

## HANDLING

The transformer case and base are designed to allow the unit to be moved by lifting, skidding, or jacking.

**NOTE:** In the event the transformer is supplied with Super Waffle pads and/or springs and snubber plates please refer to our separate instructions ESP-660 & ESP-661 respectively.

1. Lifting can be accomplished by the following means:

- a) The preferable method for moving the complete transformer assembly is by forklift truck under the base assembly.
- b) To lift the entire transformer using jack pads, add properly-sized eye bolts to the jack pads and lift vertically using four cables. Each cable angle with respect to the vertical must not exceed 30°. If this limit cannot be met or if there is danger of damaging the transformer during lifting, suitable spreader bars should be used. Check to make sure no cables are putting pressure on the transformer panels.

**Note:** If the transformer has an outdoor enclosure, then it is advisable to remove the front and back panels to avoid eye bolts hitting the louvers.

- c) To lift the entire transformer from overhead, remove the top cover and use the lifting eyes or lugs provided on the top of the core and coil structure. Lift vertically using four cables. Each cable angle with respect

to the vertical must not exceed 30°. If this limit cannot be met or if there is danger of damaging the transformer during lifting, suitable spreader bars should be used. Check to make sure no cables are putting pressure on the termination bus.

d) To remove the core and coil assembly from the case, remove the bolts holding the core and coil assembly to the base assembly. Remove any other case panels or parts that will prevent the core and coil assembly from being removed from the case. All high voltage and low voltage line connections must be removed and any accessory wiring disconnected. If a winding temperature indicator or electronic temperature monitor is present, the temperature sensing bulbs must be removed from the tubular wells on the transformer coils. Raise the core and coil assembly about 12 inches from the base. Use a forklift under the core and coil assembly to move it out through the front or rear opening of the case. The unit can be moved in either direction by using rollers under the base.

2. Pulling eyes are incorporated in the bolted-on jacking pads for use when skidding as well as when using rollers on horizontal surfaces.

3. The unit can be jacked under the jacking pads located on the front and back of the unit.

4. The transformer, complete with its enclosure, may be moved without disturbing high voltage and low voltage equipment. To do this, open the high voltage and low voltage bolted line connections, remove all the bolts that attach the high voltage and low voltage equipment enclosures to the transformer enclosure, remove external ground connections to the transformer ground pads, and remove any conduit connections. With all these connections open it will be possible to move the transformer in a direction at 90° with respect to the long axis of the substation.

#### **VIBRATION ISOLATION PADS**

Rubber vibration isolation pads are an integral part of the transformer and are placed between the core and coil assembly and the transformer base to minimize vibration and noise. The bolts used to secure the pads are over tightened at the factory to reduce possibility of damage during shipping. Before operating the transformer, each bolt securing the vibration pads should be loosened one full turn to reduce transformer noise during operation.

**NOTE: IN SEISMIC 4 LOCATIONS IT IS BEST TO KEEP THIS BOLT FULLY TIGHTENED.**

#### **STORING**

If storage becomes necessary, the transformer should be placed in a clean, dry room in which a uniform temperature is maintained. Air circulation through the transformer enclosure should be permitted. The relative humidity to which the insulating materials are exposed should be kept as low as practical. The floor on which the transformer is stored should be impervious to the upward migration of water vapor. Precautions should be taken to guard against entrance of water from any source such as roof leaks, broken water or steam lines, windows, etc.

Electric resistance heaters should be used inside the enclosure in cases where the relative humidity during storage is either high or unknown. These heaters should be located under the windings on both sides of the core. If heaters are used, air circulation through the enclosure must be permitted. Generic furnace filters may be mounted temporarily over the inlet and ventilation openings to minimize dust accumulation within the enclosure. These filters must be removed before the transformer is put in service. Before placing the unit in service, check for dryness as outlined under "Operation".

#### **INSTALLATION**

This transformer is to be installed in such a manner and location as to minimize the hazards to all those who have access to it.

#### **SURGE PROTECTION**

The successful operation of any transformer depends on various factors such as installation, loading, service conditions, and maintenance. Electrical systems in which transformers, along with vacuum or SF circuit breakers, are used are capable of high frequency over voltages which will not be suppressed by lightning arresters. These medium voltage systems may require a detailed, high frequency over voltage system analysis and/or the addition of high frequency over voltage protection. The transformer should be installed in conditions as specified in ANSI/IEEE Section C57.12.01 Usual Service Conditions, unless the transformer is designed specifically for operation in conditions other than the usual service conditions.

#### **INDOOR (CATEGORY C)**

Follow all local and national codes when locating the transformer. Make sure the ventilated openings, on the top and bottom of the enclosure, are clear. The transformer must have proper clearances from walls or other obstructions to allow circulation of air through and around each unit (refer to nameplate for specific clearances).

For indoor installations, consult local and national codes to ensure all applicable requirements are satisfied. If the transformer is located near combustible materials, make sure the transformer meets or exceeds the minimum clearances as required by the National Electrical Code® (NEC) or other applicable local codes.

Locate the transformer on a level foundation strong enough to support the weight of the transformer, preferably of reinforced concrete. Maddox recommends that you do not place the transformer directly on an earthen surface. Ensure the foundation has adequate drainage. Seismic regulations may require that the transformer be anchored to the pad or foundation.

#### **RESTRICTING ACCESS**

Ventilated dry type transformers are not designed or constructed to be tamperproof. Install the transformer in an area that is secure and that only allows access to qualified personnel.

#### **OUTDOOR (CATEGORY B)**

For outdoor installations, consult local and national codes to ensure all applicable requirements are satisfied. If the transformer is located near combustible materials, make sure the transformer meets or exceeds the minimum clearances as required by the NEC or other applicable local codes. The transformer must have proper clearances from walls or other obstructions to allow circulation of air through and around each unit (refer to nameplate for specific clearances). Ventilated outdoor substation transformers and pad-mounted unit substations are designed for installation on a well-drained, concrete pad. Unless specified otherwise, the transformer is supplied without a bottom plate in the enclosure. If installing the transformer in a elevated position where the bottom is exposed, add a bottom plate (for rodent resistance) with provisions for drainage to the enclosure. **Proper drainage is mandatory.**

#### **ATMOSPHERIC CONDITIONS**

Atmospheric conditions and accessibility are important considerations when locating the transformer outdoors. Install outdoor ventilated transformers in locations that are free from unusual dust or chemical fumes. The enclosure helps protect the transformer from atmospheric conditions such as dust, rain, or snow. Also, the enclosure is designed to divert water from energized parts, insulation, and wiring. However, it may not protect against internal condensation or ice, or completely stop snow from entering. If possible, locate the transformer in a shielded area such as in the corner of a building or landscaped windbreak to

provide extra protection from driving wind, rain, or snow. When subjected to severe weather, outdoor dry type transformers should be inspected to determine if added protection is necessary.

### VENTILATION

For core and coil transformers, consult with factory for necessary case dimensions to allow proper ventilation.

For adequate cooling the unit should be installed with proper clearances from walls and other obstructions which might prevent free circulation of air through and around the unit (refer to nameplate for specific clearances). Mechanical clearances should be taken into consideration in installing the transformer. Sufficient room should be allowed for removal of panels for cleaning and, with reverse arrangement of units, for changing of taps.

If the transformer is to be installed in a vault, provide ventilation adequate to keep the room temperature from exceeding that of the incoming air by more than 5°C. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. See ANSI Guide C57.94, "Guide for Installation and Maintenance of Dry-Type Transformers".

Arrange air inlets and outlets so that they are permanently open. Do not use windows or doors as ventilators because of the danger of excessive heating if they are inadvertently left closed during periods of heavy load or high temperature. If forced ventilation is used, supply about 5000 cubic feet of air per minute (141 cubic meters per minute) for each 1000 kVA of transformer capacity, and deliver the incoming air uniformly around the transformer at floor level and low velocity.

### TORQUE CHART

The table below serves as a guide or suggestions for nominal torque values for bolted electrical connections. Torque values may vary based on individual joints, material and quantity of fasteners, lubricated or not.

BOLT SIZE	TYP TOL +/- NOM	ALUM		SIL BRONZE		STEEL	
		IN	FT	IN	FT	IN	FT
1/4-20	+/- 20%	50	4	60	5	75	6
5/16-18	+/- 20%	85	7	110	9	135	11
3/8-16	+/- 20 %	145	12	195	16	240	20
1/2-13	+/- 15 %	300	25	420	35	540	45
5/8-11	+/- 15 %	480	40	840	70	1080	90
3/4-10	+/- 15 %	720	60	1200	100	1560	130

### NOTES:

1. Always use two wrenches when tightening or loosening bolted connections to prevent damage.
2. Tighten, wait several seconds, then re-tighten all connecting lugs and bolts.
3. Torque values are in pounds.

### CONNECTIONS

The transformer has both high voltage (HV) and low voltage (LV) winding connections. Multiple tap positions are available on the HV winding to allow for adjustments, which may be necessary because of the specific supply voltage or transformer load characteristics. If tap adjustments are necessary, see the "CHANGING TAPS" section below. Connection points are clearly labeled on the transformer. Refer to the nameplate and wiring diagram to make the electrical connections. Never attempt to make any connections that are not indicated on the

nameplate/connection diagram.

When making connections between plated aluminum transformer terminals and copper or aluminum conductors of associated equipment, the following procedure is recommended:

1. Assemble a spring washer and a flat washer under the head of each bolt. Place the spring washer so that the concave surface is away from the bolt head and the periphery is on the flat washer. The flat washer prevents the outer edges of the spring washer from cutting through the plating and distributes the bolting forces.
2. Place a flat washer under the nut on the opposite side of the joint and tighten the nut until the spring washer is just flattened. (Washers are flattened when there is a noticeable increase in bolting torque.)
3. After the nut has been properly tightened it should be locked with a locking nut or such other locking device as may be furnished with the equipment being connected to the transformer.

When clamp-type terminals are assembled on plated aluminum bars, the same basic procedure given above should be followed except that the spring washer and flat washer should be placed on the nut on the eye-bolt and the bar.

When connecting bus bars, be sure the joints are properly aligned prior to bolting to prevent excessive strain on the insulators. In a terminal chamber, long sections of unsupported conductor should be avoided and leads should be flexible enough to allow for expansion and contraction.

For electrical connections, see "SURGE PROTECTION" on page 3.

### GROUNDING

The core and coil structure is connected to the enclosure by means of a flexible connector. This connection must be tight at all times.

Grounding must be in accordance with NEC and all applicable state and local codes. A NEMA Standard stainless steel ground pad with two tapped holes is provided on the base assembly for connecting the transformer enclosure to ground. A substantial and thoroughly reliable connection should be made between the pad and a low resistance ground through a conductor of adequate cross section.

### CHANGING TAPS

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

NOTE: Do not bend tap terminals or position the hardware in a manner that would reduce clearance between or cause damage to tap terminals.

To change the tap position:

1. De-energize and properly ground the transformer following the safety messages above and your company's lock-out/tag-out procedures.
2. Remove the enclosure panel or door to access the transformer high voltage windings.
3. Use an appropriate grounding device to ground the coils and discharge any static charge.
4. Locate the tap jumpers.
5. Change the tap jumpers on each phase to the appropriate tap connection. The tap jumpers must be on the same tap position for three

phase transformers.

6. Torque the tap connections.

NOTE: For multiple voltages or other special arrangements, see the transformer nameplate and/or connection diagram.

7. Inspect the enclosure to ensure all hand tools, equipment, or any other foreign materials are removed from the enclosure.

8. Re-install the door or enclosure panel.

**Make no connections other than those authorized by the nameplate.**

### ALUMINUM TAP TERMINALS

Ventilated dry-type transformers that have aluminum windings are equipped with aluminum tap terminals. Spring washers or spring lock washers are included in the tap terminal hardware. When taps are changed, the nuts should be tightened until these washers are flattened. Washers are flattened when there is a noticeable increase in bolting torque. The terminals as received are free of oxides and taps may be changed at installation without any special precautions. If at some future time taps are changed, the following procedure is recommended.

NOTE: Do not bend tap terminals or position the hardware in a manner that would reduce clearance between or cause damage to tap terminals.

1. Apply a light coat of silicone grease (General Electric G623 or equivalent) to contact surfaces on terminals and links.

2. Scrub the contact areas with a wire brush, taking care not to gouge the metal surfaces. This abrading will break up any oxides that may have formed.

3. Wipe clean and reapply a thin film of silicone grease.

4. Bolt connecting link or jumper in the new position and tighten the nut until the washer is flattened.

### ENERGIZATION AND OPERATION

Only qualified personnel should perform the tests before energizing the transformer and placing it in service. Disconnect ALL high voltage, low voltage and neutral connections. Disconnect all auxiliary equipment such as lightning arresters, the fan and temperature control system, meters, or any other low voltage control system that is connected to the windings that are involved in these tests. Please disconnect CPTs and short the secondary of CTs if provided.

Before energizing a dry-type transformer either initially or after any shutdown period in which the unit has cooled to ambient temperature, the transformer should be inspected for evidence of moisture and the insulation resistance should be checked. This should be a one-minute test taken with a 500 volt megohmmeter at approximately 25 degrees C measured from winding to ground with the windings not being tested connected to ground. An insulation resistance in megohms equal to 200 times (rated winding volts/1000) is a satisfactory value of resistance to permit energizing the transformer. (Absorption of moisture can be minimized during shutdown periods by using strip heaters to keep the transformer temperature above ambient.)

If acceptance test is part of customer approval process then Maddox recommends doing applied potential or AC Hi-pot test @ 75 % of the actual ANSI levels.

### DRYING

If moisture is found on the windings, leads, or insulation or if the insulation resistance measurements are unsatisfactory, the transformer should be

dried. To dry, put a short circuit heat run on the unit by short circuiting the low-voltage leads and impressing impedance voltage on the high-voltage terminals. It may be necessary to impress a voltage higher than the impedance voltage in order to heat the windings sufficiently, but the total temperature of the windings as determined by resistance should not exceed 190° C (or 185° C by non-mercury type thermometer placed in the ducts between windings and in contact with them). The heat run should be continued for a minimum of eight hours. Insulation resistance is a function of insulation temperature as well as moisture content. Thus, for comparison, readings must be taken at the same temperature. During the course of a drying heat run, the insulation resistance may initially decline as the insulation heats up. After the insulation temperature stabilizes, the insulation resistance will begin to increase. When the insulation resistance stabilizes, the drying procedure should be terminated. The transformer should then be allowed to cool to ambient temperature after which the insulation resistance should again be measured and compared with minimum requirements. An alternate to the short circuit drying heat run is to use a procedure in which hot air is directed into the bottom of all windings. The temperature of this air should not exceed 150° C but should be as close to this temperature as possible to minimize the drying time. If the transformer is equipped with fans, they should be removed to prevent damage to the fan motors by exposure to this hot air. Oven drying is not recommended because an oven temperature that would be effective in a reasonable length of time could damage the tin plating on the current carrying terminal surfaces. For further information on drying, refer to ANSI Guide C57.94, "Guide for Installation and Maintenance of Dry-Type Transformers".

### FAN COOLING

NOTE: Fans are for temporary overloading only.

When fans are provided they are intended for use only when the transformer is required to carry a load in excess of its self-cooled rating. Fans should not be operated when the transformer is carrying a load significantly less than its self-cooled rating. Such operation may keep some parts of the insulation system at a temperature low enough to permit moisture absorption and may result in serious injury to the insulation system.

### MAINTENANCE

Refer to the "ENERGIZATION AND OPERATION" section.

The transformer should be inspected at periodic intervals and corrective measures taken when necessary. The frequency at which these inspections are made depends on operating conditions and the importance of continuity of service. In clean, dry locations an annual inspection may be adequate. In areas where the air is contaminated with dust or chemical fumes, three-month intervals may be required.

To inspect the transformer, **de-energize, lockout and properly ground all circuits supplying power to the transformer and its accessories**, and remove the front and rear panels. **CAUTION: Failure to de-energize the transformer and its accessories before removing the front and rear panels may result in serious personal injury or death.** Inspection should be made for accumulation of dirt on insulating surfaces and in places which would restrict the flow of air, for loose connections, for the condition of terminal boards, and for the general condition of the transformer. The transformer should also be inspected for signs of overheating and of voltage creepage over insulating surfaces as indicated by tracking or carbonizing. Insulation resistance and power factor values may vary considerably with transformer design, size, and voltage. Thus, changes in these values versus time for a given transformer are more significant than a specific value. It is suggested that these measurements be made after cleaning the transformer at each maintenance period. Care must be taken that these measurements are made in the same way and with the transformer at about the same temperature each time. The voltage at which these measurements are made should not exceed the line to ground operating voltage or 500 volts, whichever is greater. The transformer high voltage and low voltage



line connections must be opened for these tests. The trends in these values will permit a more informed judgment as to the condition of the insulation system. Refer to the paragraph under “ENERGIZATION AND OPERATION” for minimum acceptable values. Coil jack bolts, if provided, should be checked and tightened if loose.

### CLEANING

To inspect the transformer, **de-energize, lockout and properly ground all circuits supplying power to the transformer and its accessories**, and remove the front and rear panels. **CAUTION: Failure to de-energize the transformer and its accessories before removing the front and rear panels may result in serious personal injury or death.**

If dirt is found on the windings, insulators, leads, or terminal boards, it should be removed to permit free circulation of air and to guard against the possibility of insulation breakdown. Particular attention should be given to cleaning top and bottom ends of winding assemblies and to ventilating ducts. The use of a vacuum cleaner is recommended as the first step in cleaning followed by the use of compressed air. The compressed air should be clean and dry and should be applied at pressures below 25 PSI (170 kPa). Lead supports, terminal boards, and other major insulating surfaces should be brushed or wiped with a dry cloth. The use of liquid cleaners is not recommended because of the possible deteriorating effects on the insulating materials.

### TERMS AND CONDITIONS

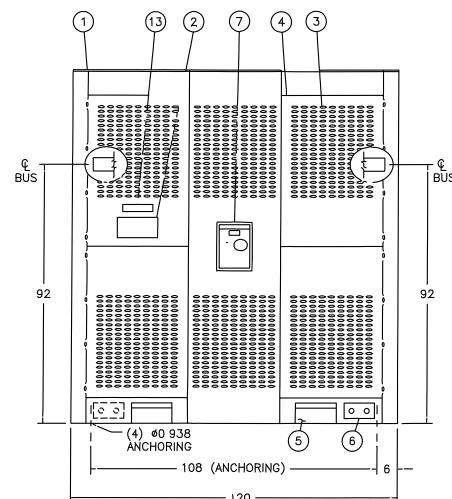
Please refer to your copy of the “Terms and Conditions” for warranty and product liability information. The “Terms and Conditions” are available online at [www.maddoxtransformer.com](http://www.maddoxtransformer.com)

### WHEN YOU NEED SERVICE

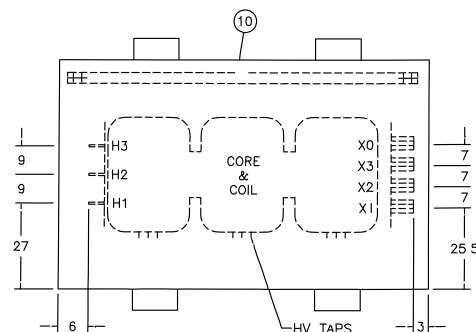
If you need service on products manufactured by Maddox we are ready to serve you. Contact the nearest sales office for more information.

### RENEWAL PARTS

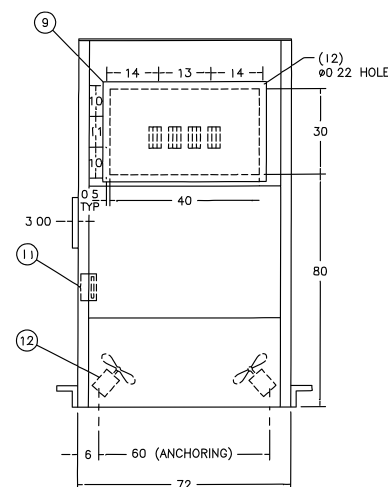
Address orders for renewal parts to the nearest sales office of Maddox. Include a complete description of the part wanted, plus the rating and serial number of the transformer.



(Example Only)



(Example Only)



(Example Only)