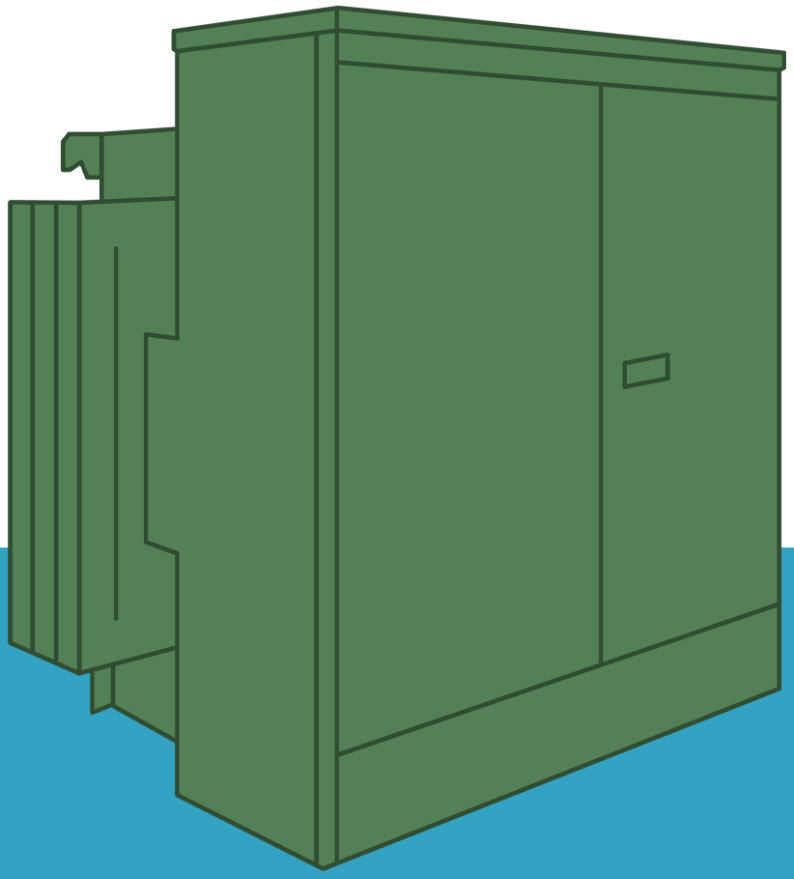
JCL ENERGY

Reception, Installation, Operation and Maintenance Manual

Three-Phase Pad-Mounted Transformers



WARRANTIES

JCL Energy warranties the device herein specified against any bad practice in design, construction, material and workforce.

By this Warranty we promise to repair or replace, as it is necessary, F.O.B. factory, all equipment or part that is defectively in the term of 12 months after commissioning or 18 months after delivery, whichever occurs first and only when it is notified in a written form when the fault is discovered, detailing the fault found and the circumstances in which it happened.

Being this Warranty against design faults or manufacture; our commitment stays without effect in case of inadequate installation, operation or maintenance, or realized by not qualified personnel, as well as for accidental or fortuitous circumstances, such as the lack of suitable protection equipment for overcurrent's, overvoltage's or overcharges, lightning, fires, mistreatment in the transport or maneuver and when there does not exist evidence of satisfactory tests results before the energizing, etc.

To preserve the validity of this Warranty, modifications should not be done to the design or equipment characteristics, without previous factory authorization.

Product spare parts, components, consumable and accessories protected in this warranty, as well as more detailed information to claim the warranty can be obtained in the address showed below.

CONTENTS

Section 1

Introduction

To achieve a safety operation in three-phase pad-mounted transformers and long field life, it is important to respect the nominal design characteristics, like capacity (KVA), oil level, nominal operating voltages and the Instructions found in the Reception, Installation, Operation and Maintenance Manual for Three-phase Pad-Mounted Transformers.

Since the transformer operation can be present dangerous conditions; this manual outlines the CAUTION notes for the activities that need special care, as the following ones.

⚠ CAUTION

Read this manual carefully before you receive, install, operate or give maintenance to the three-phase pad-mounted transformer.

Keep this manual near to the three-phase pad-mounted transformer location.

Any work that involves the use of a three-phase pad-mounted transformer must be carried out by qualified personnel.

Section 2
Shipment

JCL Energy three-phase pad-mounted transformers are shipped hermetically sealed.

Section 3
Receiving Inspection

A meticulous inspection of the three-phase pad-mounted transformers during reception must be done before it is unloaded from transportation (trailer platform or truck). Check that the transformer requested characteristics match those indicated on the nameplate.

Immediately after equipment reception, and before putting it into service, inspect the transformer for any damage that may have occurred during shipment or storage. If rough handling is evident, fill out a damage claim with the transport company immediately and notify JCL Energy representative.

NOTE: A visual inspection will be requested of the interior of the three-phase pad-mounted transformers only when there is evidence of physical damages from the exterior, and in such situation, it will be necessary to communicate the requirement to a JCL Energy representative, and to a transporter representative, before beginning with the inspection works.

In case of having a bolt with spring lock, it is needed a 18mm pentahead socket to open the cabinet. In case of having an opening and closing handle and a lock type “G”, a key will be provided by JCL Energy.

A report of the conditions in which the equipment and its accessories were received must be done for any claim.

Section 4
Handling

A meticulous inspection of the three-phase pad-mounted transformers during reception must be done before it is unloaded from transportation (trailer platform or truck). Check that the transformer requested characteristics match those indicated on the nameplate.

4.1 Transformer.

The transformer always must be lifted or held from the four lifting lugs in vertical position unless it is indicated in any other way. When a derrick cannot lift the transformer, it can be slipped or moved on rollers inside the place, only when the floor allows it. During the maneuvers, special care is needed to avoid any overturning.

When the transformer is in its final place, the external wood protections must be removed.

4.2 Lifting.

The lifting lugs are designed to allow the lifting with a maximum angle of 30° between the sling and the vertical. When lifting with over 30° from the vertical, an extension bar must be used for the vertical lifting, between the slings.

Figure 1.1 Lifting lugs angle.

⚠ CAUTION

The tank cover lifting lugs must be used only to remove the tank cover. The tank cover lifting lugs must never be used to lift the complete transformer.

To avoid transformer damage, lift the transformer from the four lifting lugs.

Do not lift the transformer from the drain valves, pipeline connections nor radiators.

Section 5
Internal Transformer Inspection

To have access to the interior tank, it must be in the presence of a JCL Energy representative or with a written authorization from the company.

Section 6
Storage

If the transformer is not immediately installed, it is suggested to locate it in a safe place, complying with the following recommendations during its storage:

- Look for any damage on the exposed surface. Apply paint if necessary, preparing the surface first with a sandpaper.
- Avoid contact with any corrosive gases and vapors, such as chlorine and sulfur.
- The spare parts provided with the three-phase pad-mounted transformers must be kept in a clean and dry place.

Section 7
Location

The three-phase pad-mounted transformers location should have enough space: a) to allow the installation maneuvers, b) to have access to the HV bushings and accessories cabinets at inspection and maintenance tasks, and c) to have good ventilation.

The self-cooled three-phase pad-mounted transformers depend entirely on the air that circulates in their surroundings for heat dissipation. As mentioned above and in case of indoor installations, the room where the transformer is located should allow good ventilation, in such a way that the hot air can be replaced by cold air. Therefore, it is recommended that the openings of entrance to the room be near the floor while the exists are in the upper side of the transformers.

The self-cooled transformers will always be separated from one another, from adjacent walls, divisions, etc. so that the free circulation of the air is allowed among the tanks. This separation will be of 0.75 m, minimum.

Section 8
Service Preparation

The three-phase pad-mounted transformers location should have enough space: a) to allow the installation maneuvers, b) to have access to the HV bushings and accessories cabinets at inspection and maintenance tasks, and c) to have good ventilation.

8.1 Oil Level.

The three-phase pad-mounted transformers are filled with oil up to its nominal level from factory, considering the ambient temperature at the moment of filling.

8.2 Audible Sound Emissions.

All the transformers generate audible sounds when energized; this is due to the mechanical vibrations generated by the magnetostriction phenomenon present in the core. However, the noise level should not reach such that cause annoyance to those who remain temporarily near the transformer.

8.3 Low Voltage and High Voltage Electrical Connections.

The cables that are connected to the transformer bushings should be long enough to allow their expansion and contraction due to temperature changes.

It is important to verify that the connections are tight to avoid hot spots generation, and that the transformer terminals are not disconnected due to transformer characteristic vibrations. Besides, it must be assured that the weight and alignment of the cables connected to the bushing do not cause mechanical stress that can generate crack, failures or to provoke leakages through the gaskets.

If the three-phase pad-mounted transformer is going to be connected through a lateral coupling to a solar inverter, the connection must be made with a flexible connector to avoid any stress in the connections due to changes in temperature or possible vibrations.

Figure 1.2 Example flexible connectors.

8.4 Ground Connections.

The transformer must be permanently ground connected to avoid electrical discharge by an induced voltage. The connection must be made through the tank ground pad.

The grounding system must be executed with the regulations of the area where the transformer will be installed.

⚠ CAUTION

Never make connections that are not authorized by the manufacturer or are not indicated in the Nameplate.

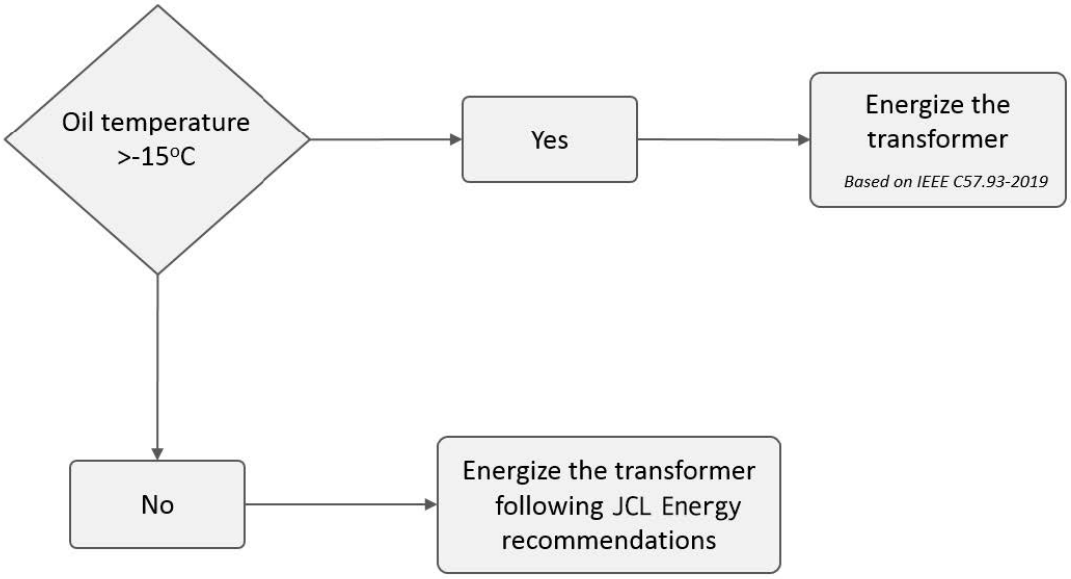
8.5 Operating in Cold Condition.

According IEEE/ANSI standards, it is considered as an unusual operating condition of the transformer when the temperature of the liquid is lower than -20°C [3]. It is important to mention that the liquid temperature inside the transformer (when it is in operation) is higher than the ambient temperature; however, there are some concerns and recommendations for this specific application

JCL Energy Recommendation for energization of Distribution Transformers at ambient temperatures below -15°C

1) Start with No Load Losses and 60% Load losses, keeping this load for minimum period of 4 hours
2) Slowly increase load in 20% increments, allowing minimum of 2 hours between each increment

General energization procedure for JCL Energy distribution transformer.



Since the thermal point of view, it is well known that there is a risk that the heat transfer can be reduced due to the increment of the viscosity of the dielectric fluid at low temperatures, specially in small ducts or pipes. This increment in viscosity that limits the fluidity of the dielectric oil, represents a main concern in components which are mechanically operated, such as load break switches and tap changers, where is crucial that the fluid be in a liquid state. It is important do not operate these devices under these conditions to prevent damage, therefore it is recommended to contact the supplier or manufacturer to validate functionality and operation at cold climates.

Section 9
Installation

Before applying voltage to the transformer, check the following:

The neutral terminals (X0 or H0) are properly ground connected.
Note: Except floated systems as Y-Y.

- The tank is solidly grounded.
- The tap changer has the adequate position to provide the relation of needed voltage.
- All the tools or strange objects have been removed from the transformer.
- All the manhole and hand hole are properly covered.
- Any bolted connection i.e. H.V. bushings flange, etc. are properly tightened.
- No oil leakages or stains are present.
- The oil level is correct.
- All levels, oil and temperature are correct.
- All the electric connections are properly tightened.
- General cleaning is made (see maintenance chapter).
- The bushings are in good condition (without blows or fissures).
- People are not near to the three-phase pad-mounted transformers prior being energized.

If the transformer has been stored for more than six months, it is recommended to run the following field tests:

- Verify the isolation resistance of each winding to ground and between windings.
- Verify power factor of each winding to ground and between windings.
- Turn ratio shall be determined for all taps and for the full windings.
- Verify that the dielectric strength of the insulating liquid remains with values more than 30kV/mm.

9.1 Accessories and Components.

The knowledge of the accessories and the way in which they protect to the three-phase pad-mounted transformers, will give a better security to operatives and a long field life.

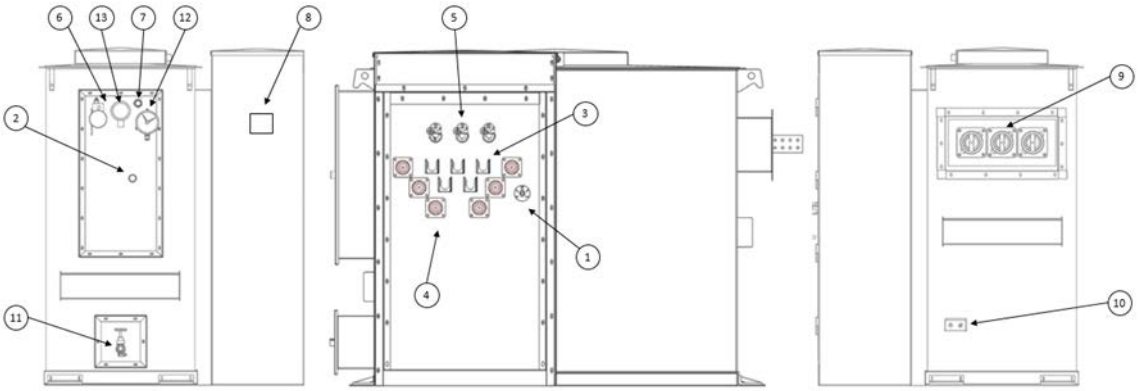


Figure 9.1 Three-Phase pad-mounted transformer with lateral LV connection: a) Gauges and accessories side, b) HV bushings and NLTC side and c) LV bushing side Gauges and accessories side.

ACCESSORIES FOR A THREE-PHASE PAD-MOUNTED TRANSFORMER WITH LATERAL LV	
1. Tap changer	8. Nameplate
2. Feed switch	9. Low voltage terminals
3. Parking stand	10. Ground connectors
4. High voltage terminals	11. Drain and sampling valve
5. Bayonet Fuseholder (optional)	12. Oil temperature gauge
6. Manual and automatic overpressure valve	13. Oil level gauge
7. Nipple with female plug for hermetic test	

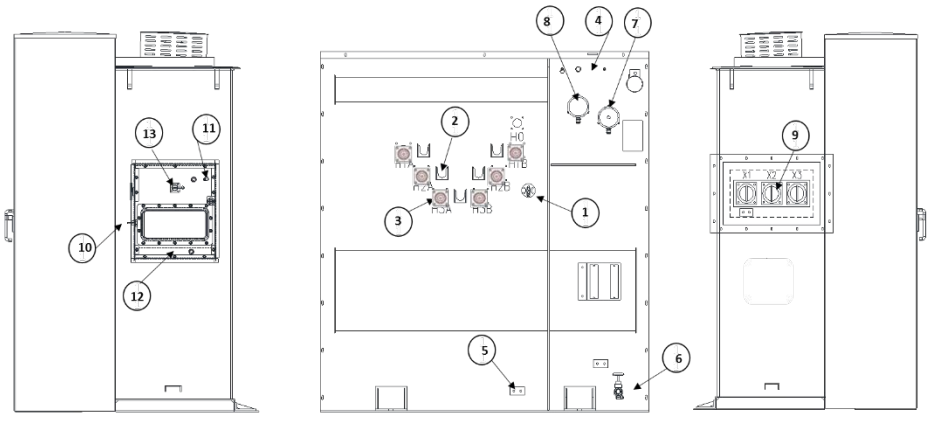


Figure 9.2 Three-Phase pad-mounted transformer with viewing window : a) Loadbreak switch compartment side, b) HV bushings and NLTC side and c) LV bushing sideGauges and accessories side.

ACCESSORIES FOR A THREE-PHASE PAD-MOUNTED TRANSFORMER WITH VIEWING WINDOW	
Main Tank	**Loadbreak Switch Compartment**
1. Tap changer 2. Parking stand 3. High voltage terminals 4. Manual and automatic overpressure valve for main tank 5. Ground connectors 6. Drain and sampling valve 7. Oil temperature gauge 8. Liquid level gage for main tank with alarm contacts 9. Low Voltage terminals	10. Feed Switch 11. Manual and automati overpressure valve for loadbreak switch compartment 12. Drain and sampling valve 13. Liquid level gage for switch compartment

9.1.1 Feed-switch.

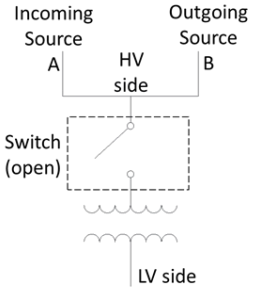
Most of the three-phase pad-mounted transformers have a feed-switch. The feed-switches are on-load operated switches. To operate the feed-switch, the hot-line tool is placed in the feed-switch and turned to the desired position.

9.1.1.1 Radial Feed-switch

The radial feed two position internal oil switch, shown in Figure 3(a), is a gang operated loadbreak switch. It is operated by hot stick and uses a manually charged overtoggle storage spring assembly that is independent of operator speed. The spring loaded operating mechanism ensures quick load breaking and load making operation. It can be used to de-energize the transformer. The operating handle is in the loadbreak switch compartment side. Figure 3(a) is a schematic of this switch.

It is recommended that the loadbreak switch window is covered and locked before load breaking. Viewing the loadbreak switch when operating can harm the human eye

a)



b)

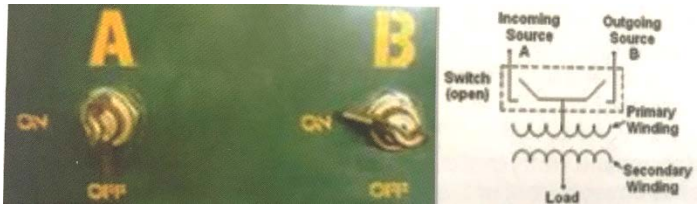
Figure 9.3 a) Switch handle and b) schematic of the Loop Feed Switch.

⚠ DANGER

Loadbreak switch cover must be closed and locked during operation.
The transformer tank must be fully grounded.

9.1.1.2 Loop feed switches

The loop feed switch arrangement, shown in Figure 5(a), consists of two positions, gang operated, internal oil switch. It may be used for sectioned and loop connections such as power source selection in a loop feed primary distribution system, isolated damaged cables or transformers, or isolated transformer during maintenance.

a) 

b)

Figure 9.4 a) Loop Feed Switch b) Schematic of the Loop Feed Switch.

The switch operation is as follows:

a) Both switch handles CLOSED. This position allows loop feed with an adjacent transformer with the transformer energized.

b) Left switch handle CLOSED, right switch handle OPEN. Only one side of the loop (A bushing) is connected to the transformer windings.

c) Left switch handle OPEN, right switch handle CLOSED. Only one side of the loop (B bushing) is connected to the transformer windings.

d) Both switch handles OPEN. Both sides of the loop (A and B bushings) are disconnected, the transformer windings are isolated and deenergized from the loop feed system.

9.1.1.3 Loop-radial switches

Two position loadbreak switches, shown in figure 6, may be used to obtain a combination of the loop and radial switch functions. The combination consists of a transformer switch (line B) and a loop switch (line A).

The switch operation is as follows:

a) Both switch handles CLOSED. The loop is closed by connecting line A to line B, and the transformer is connected to the loop.

b) Left switch handle CLOSED, right switch handle OPEN. The loop is open and the transformer is connected to source A.

c) Left switch handle OPEN, right switch handle CLOSED. The transformer is disconnected from the loop and the loop is closed.

d) Both switch handles OPEN. The transformer is deenergized and the loop is open.

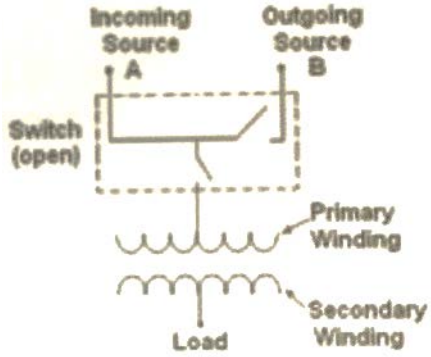
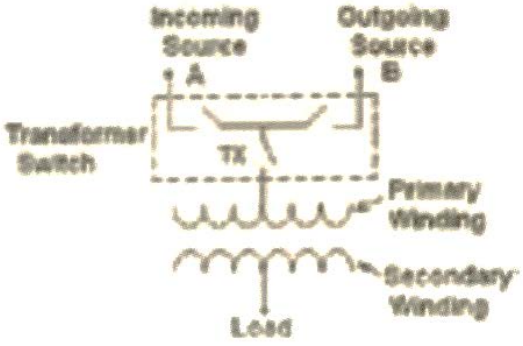


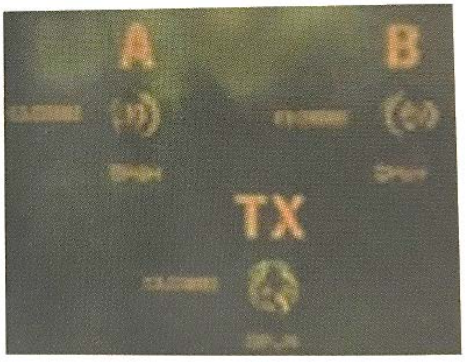
Figure 9.5 Schematic of the Loop-Radial Feed Switch.

9.1.1.4 Loop switch with ON-OFF radial switch

This combination, shown in Figure 7, provides the function of the loop and radial switches, allowing the transformer to be deenergized and any loop to be open.

a)





b)

Figure 9.6 a) Schematic b) Loop Switch with ON-OFF radial switch.

9.1.2 Expulsion Fuse.

Most of the three-phase pad-mounted transformers have a feed-switch. The feed-switches are on-load operated switches. To operate the feed-switch, the hot-line tool is placed in the feed-switch and turned to the desired position.

9.1.2.1 Bayonet type

The device where the expulsion fuse is placed receives the name of bayonet (Fig. 8), and it is accessible from the exterior of the tank. The expulsion fuse acts in fault cases in the LV side of transformer or for overloads higher to the acceptable for the IEEE C-57.91. To replace the fuse (Fig. 9) from the exterior, follow these instructions:

1. De-energize the transformer and verify that there is no voltage in low voltage bushings.
2. Open the doors or access cover in front of the instruments (high voltage side).
3. Activate the pressure-relief valve, pulling the ring to eliminate the internal pressure.
4. Attach hotstick to handle eye.
5. Unlock the handle by turning 90° clockwise in the housing.
6. Draw the bayonet out approximately 10 to 15 cm. Wait a few seconds in this position to drain the oil.
7. Remove the bayonet totally.
8. Unscrew the fuseholder cartridge and extract the fuse element.
9. Remove the fuse and install the new fuse, verifying that it matches with the catalog number that is indicated in the nameplate.
10. Set the bayonet in its place.
11. Fasten the bayonet inverting the process to remove it (points 4 and 5).

Figure 9.7 Bayonet type assembly

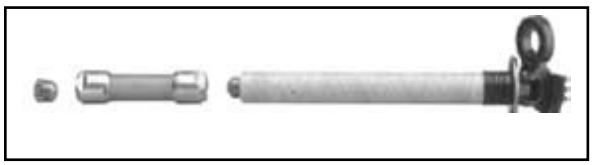


Figure 9.8 Bayonet type fuses

9.1.2.2 Terminal Board Type

This type of expulsion fuse is placed on the rear wall of the tank, on a material called “Glastic” (Fig. 10), and is not accessible from outside of the tank. The expulsion fuse acts in fault cases on the secondary side of transformer or with overloads higher than the accepted by the Norm IEEE C-57.91. To replace the fuse (Fig. 10) from the inside, you should call a technician:

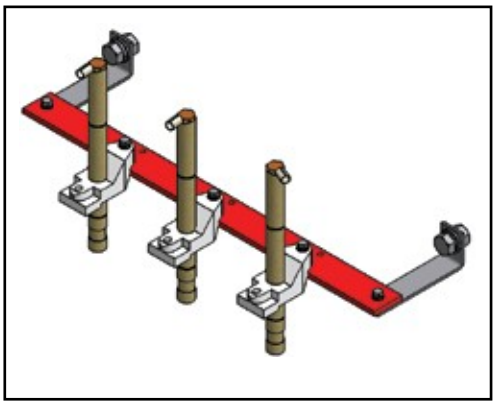


Figure 9.9 Expulsion fuses terminal board type

9.1.3 Current Limiting Fuse.

9.1.3.1 Partial Range Current Limiting Fuse (PRCLF)

These types of fuses operate for transformer internal faults, and are placed inside of the tank.

When these types of fuses operate, the diagnosis, the repair of the unit and the fuses replacement, must be done in a specialized workshop.

9.1.3.2 Partial Range Current Limiting Fuse (PRCLF)

This fuse can be installed inside the transformer when is replaced in the same way as the partial range fuse. A second type of fuse is used in transformers under the K Standard (K0000-07CFE), it has a fuseholder that can be removed from outside of the tank. These fuses have mechanisms that won’t allowed to be removed unless the transformer Radial Feed -Switch is open.

9.1.4 Isolated Links.

Most of the three-phase pad-mounted transformers have a feed-switch. The feed-switches are on-load operated switches. To operate the feed-switch, the hot-line tool is placed in the feed-switch and turned to the desired position.

9.1.5 Thermal or thermomagnetic switch.

The thermal and thermomagnetic switches are optional protection elements in the pad-mounted transformers.
This type of elements is used to protect the transformer from faults in low voltage side against short circuit currents and over elevation temperatures due to an overload.

The switches are operated from the outside with an operation handle (Figure 11) and it is activated using a hotstick.

The operation handle has 3 positions:

RESET
OPEN
CLOSE

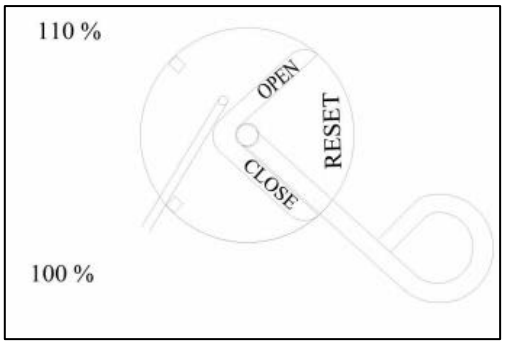


Figure 9.10 Expulsion fuses terminal board type

To open the switch, place the handle on the OPEN position.

To close the switch when it operates under overload, the handle should be placed to the OPEN position and then to the CLOSE position.

This type of switch has an overload indicator light and a handle for the emergency overloads.

Under an overload condition, the indicator lamp will turn on and it will stay on even if the overload disappears. The indicator light can be turned off if the overload condition disappears and by opening and closing the switch.

The emergency control handle can be used to recalibrate the switch operation temperature. This decreases the transformer's life but provides a system reboot when a less than 10% overload exists.

9.1.6 Tap Changer.

The tap changer is a device that allows windings adjustments to compensate deviations in nominal voltage.

The tap changer operation could be done using a hotstick or with the operation handle (Fig. 12). To operate the tap changer, you must follow these instructions:

1. De-energize the Transformer and prove that there is not voltage in low and high voltage bushings.
2. Remove the screw which is used to lock the operation handle.
3. Attach the hotstick to handle eye tap changer.
4. Place the handle in the desired position. To increase the voltage in the low voltage terminal it is required to rotate it in clockwise.
5. Replace the screw to lock the operation handle
6. Once the instructions above are completed, proceed to energize the transformer.
7. Finally, verify that the voltage value is inside of the design values indicated in the nameplate, typically +/-5% about the nominal value. Higher values can generate transformer over-heating, increment the noise level, or a bad operation of the equipment that the transformer feeds.

Never try to put the tap changer in intermediate positions or any other position that is not clearly indicated in the nameplate.

⚠ DANGER

De-energize the transformer before operating the Tap Changer.

Verify that the tap changer is in a correct and firmly position preventing any unwanted displacement.

Figure 9.11 Tap changer

9.1.7 Dual Voltage Switch.

The dual voltage switch is used to change the connection of deenergized transformer windings between series and parallel to provide different common transformer voltage ratios.

9.1.8 Bushing Insert Threads.

9.1.8.1 Bushing Insert

The Bushing Insert threads into a universal bushing well to provide the same function as an integral loadbreak bushing. Using bushing inserts makes field installation and replacement possible and efficient.

No special tools are necessary. The insert can be installed by hand or with the assistance of a torque tool.

Figure 9.12 Bushing insert

9.1.8.2 Rotatable Feedthrough Insert

The Rotatable Feedthrough Insert is used to provide dual bushings from a single apparatus bushing well. It makes converting radial-feed transformers to feedthrough transformers and adding in-line arrester protection both easy and practical.

Figure 9.13 Rotatable feedthrough insert

9.1.9 Overpressure-relief Valve.

This element is used to relief transformer internal pressure when it exceeds design limits. This valve does not operate under conditions of sudden over-pressure, as those generated in short circuit presence.

9.1.10 Draining and Sampling Accessories.

In the upper side on accessories side, there is a nipple used to connect the filter-press equipment and connect the equipment for hermetic test.

9.1.11 Tank Ground Pad.

Tank ground pads are metallic pieces welded to the tank to make the connection to physical ground. These pieces should be free of painting and grease to avoid false contacts.

9.1.12 Manhole Cover.

These are used to have access to the interior tank, and to be able to make inspection and/or maintenance maneuvers. They are protected of the exterior by the tank cover.

9.1.13 Insulated Liquid Level Gauge.

This device (Fig. 15) has a float that is in direct contact with the insulating liquid, and it allows to know which is the nominal level, minimum level and maximum level allowed in the transformer operation.

The dial is divided in

levels: Under - (MIN)
Nominal - (25°C)
High - (MAX)

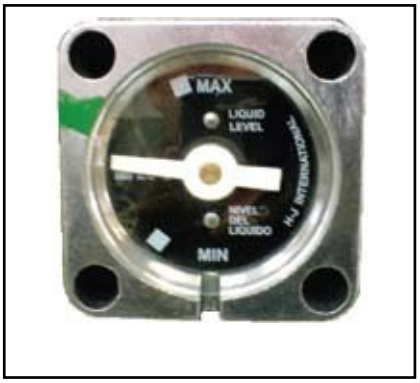


Figure 9.14 Insulating liquid level gauge

9.1.14 Temperature Gauge.

It indicates the oil temperature in the transformer tank upper side. Their graduation is in centigrade degrees (°C), and it has two needles: one indicates the actual temperature in the transformer, the second work as a witness of the maximum temperature reached inside the transformer (Fig. 16).

Temp gauge for 65°C rise design

Temp gauge for 75°C rise designs

Figure 9.15 Insulating liquid temperature gauge

9.1.15 Pressure Relief Device (PRD).

Transformers could have one of these devices located on the main cover. For detail of location, refer to the outline drawing. This device can be installed before oil filling. To assemble the flag, remove one of the cover screws and install the flag so it is centered over the operation indicator pin.

⚠ CAUTION

Never make connections that are not authorized by the manufacturer or are not indicated on the Nameplate.

9.1.16 Rapid/Sudden Pressure Rise Relay.

Install the relay after the vacuum filling process. Once the device is installed, the bleed valve should be opened long enough to allow one half pint of oil to flow out.

9.1.17 Screw Torque.

It should be assured, mainly in the maintenance tasks, that the torque used on the transformer screws comply with Table 1. By following this recommendation, it will contribute to avoid oil leakages or the entrance of humidity into the transformer.

Note: Most of transformers have a plate in which the Table 1 has been recorded.

Table 1. Recommended torque

SCREW	Lb.-in
H. V. Bushings flange	65 – 115
L. V. Bushings flange	190 – 239
46kV H. V. Porcelain Bushings flange	180
Tap changer fastening	69 – 119
Expulsion fuse fastening	110 – 159
Handhole	119 – 170

9.1.18 Jam Nut – Spade Connector Torque on LV Bushings.

After complete cable connections on the spade connector of each of the LV bushings, it is very important for the reliable transformer operation to tight the jam nut to the spade connectors to assure good contact with the LV bushing stud. The cable stress could cause loosening of the joints.

Skipping this step, will cause heating on bushings and potential damage of the transformer. Please follow the instructions indicated below to assure a good tightening of the joint.

Each LV bushing has hanging a “Caution Tag” indicating the importance of this tightening instruction. Please remove this tag before tight the jam nut.

⚠ CAUTION

This brass jam nut was tightened in the factory following these instructions:

Bushing stud diameter	Torque range for “Brass Jam Nut”	Torque applied “In Factory”
1-1/4”	672 – 1008 Lb.-In	700 Lb.-In
1”	672 – 1008 Lb.-In	700 Lb.-In
5/8”	592 – 888 Lb.-In	600 Lb.-In

Brass jam nuts need to be tightened after the cables are connected to the bushing spade connector during installation. This will avoid loose connection of the joints during operation.
“Skipping this step will cause heating on bushings and potential damage on transformer”.
Please follow the instructions indicated on the “LV Bushing tightening jam nut instructive”, #Doc 9.72.11A, Rev1, and Version1, provided.

The applied torque value must be in accordance with instructions given on the next table:

Torque value tolerances, based on the bushing stud diameter

Bushing stud diameter	Torque range for "Brass Jam Nut"	Torque applied "In Factory"
1-1/4"	672 – 1008 Lb.-In	700 Lb.-In
1"	672 – 1008 Lb.-In	700 Lb.-In
5/8"	592 – 888 Lb.-In	600 Lb.-In

** Recommended procedure to tight Jam nut to Spade connector.

PROLEC GE internal document: #Doc 9.72.11A, Rev 1, and Version 1

1.- Assure vertical alignment of the LV bushing spade	2.- Locate the jam nut	3. - Set the torque according to the torque value tolerances on the table above.
		
4. - Tighten jam nut counter clockwise against spade. *Repeat these steps on all the LV bushing spades. Note: Maintain vertical LV bushing spade alignment.	5.- JCL Energy recommends paint marking on the area shown after tightened process is completed.	
		

9.2 Altitude.

To have the pad-mounted transformer at the nominal capacity, in kVA, it is very important that at the time of installation, to assure the maximum height over sea level for which it was designed. The reference is shown on the nameplate.

For higher elevation, the air density decreases, reducing the cooling system efficiency as well as the air dielectric strength.

9.3 Ambient Temperature.

The limits specified by the standards by which the transformer was manufactured shall not be exceeded (usually-5°C to 40°C).

When a pad-mounted transformer is operated at an ambient temperature higher than the limit indicated on the nameplate, the nominal transformer capacity will be reduced by each degree Celsius according to the Table 2.

Table 2. Reduction of Transformer capability according to IEEE load guide

TRANSFORMER TYPE	% OF REDUCTION KVA/ DEGREE
Oil immersed self-cooled ONAN	1,5
Oil immersed air forced ONAF	1,0
Oil forced air forced ONAF	1,0

9.4 Voltage Variation.

The transformer can be operated in a continuous way to nominal or a lower capacity if the primary voltage is between 0 and 5% lower than the nominal value.

9.5 Overload.

The transformer can be operated with a higher load than nominal for short periods without suffering damages. It is recommended to refer to the Transformer Loading Guide for mineral oil immersed transformers, Norm ANSI-C57.91.

9.6 Connections.

The connections that are not shown on the nameplate must not be done.

9.7 Fans.

Fans are used on transformers to increase the rate of heat dissipation and thus provide additional transformer load capacity. Fans are to be used only on those transformers designed to operate with a forced-air-cooled rating.

All fans used on any transformer are the same size and their motor ratings are given on the motor nameplate.
Ratings are also shown on the Wiring Diagram.

9.7.1 Installation.

When the cooling's transformer is ONAF-F/KNAF (future), the fans must be properly installed before attempting to operate the transformer at the force-air-cooled rating shown on the nameplate. To obtain this rating, the type, number, and location of the fans must be as indicated on the Outline Drawing and on the Wiring Diagram. The client must install the fans according to the instructions recommended by the supplier of the fans.

Before mounting, inspect for shipping damage and check for proper blade alignment. When installing the fans, make sure they blow air toward the radiators.

After the fans are mounted, the fan wiring must be installed as indicated on the Wiring Diagram.

9.7.2 Maintenance.

A periodic inspection should be made of the forced-air cooling equipment to be sure it is in satisfactory operating conditions. Motor bearings are permanently lubricated and sealed at the factory and require no maintenance.

Do not paint fan blades. Doing so except under controlled conditions will frequently cause the blades to become dynamically unbalanced. When placed in operation, the imbalance will then set up excessive vibration which can eventually lead to destruction of the blade.

Figure 9.16 Transformer Cooling Fan

Section 10
Loading

The transformers can be operated at full load within the temperature elevation nominal range without loss of life, considering the execution of the following conditions:

1. The ambient temperature is not higher than 40°C or the average more than 30°C in a 24-hours period.
2. The transformer altitude above sea level in operation shall not exceed the value indicated on the nameplate. Contact a JCL Energy representative to operate at higher altitudes.

The pad-mounted transformers provided by JCL Energy can be overloaded for short periods without suffering any damage. The allowed overload and the corresponding period must be based according to Table 3, and a reference ambient temperature of 40°C. Table 3 is based on IEEE C57.92

Table 3. Overloads allowed by JCL Energy for pad-mounted transformers

Previous load under stable load conditions expressed in % of the transformer capacity	Allowed overload duration in % of the nominal power				
	10%	20%	30%	40%	50%
50	**3 hr.**	**4.5 hr.**	**1 hr.**	**30 min.**	**15 min.**
75	**2 hr.**	**1 hr.**	**30 min.**	**15 min.**	**8 min.**
90	**1 hr.**	**30 min.**	**15 min.**	**8 min.**	**4 min.**

Section 11
Applicable Standards

The side bushing solar farm transformers have been developed under the following Norms and can be used as Step-up or Step-Down applications:

IEEE C57.12.00	Requirements for Liquid-immersed Distribution, Power and Regulating Transformers.
IEEE C57.12.34	Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformer, 10MVA and lower; High-Voltage, 34.5kV Nominal System Voltage and Below; Low-Voltage, 15kVA Nominal System Voltage and Below.
IEEE C57.91	Loading Mineral-Oil-Immersed Power Transformers Up to Including 100MVA with 55 C or 65 C Average Winding Rise
IEEE C57.104	Guide for Interpretation of Gases Generated in Oil-Immersed Transformers
IEEE C57.106	Guide for Acceptance and Maintenance of Insulating Oil in Equipment
IEEE C57.147	Guide for Acceptance and Maintenance of Natural Ester Insulating Liquid in Transformer

Section 12

Guides for Transformer Maintenance

The transformer disconnection of an electric system causes considerable production losses, as well as other inconveniences. For this reason, it is important to assure a transformer operation free of faults, through a maintenance program that is well structured and that it is correctly performed.

The periodic inspection helps detect abnormal transformer conditions, before the damage is more severe.

12.1 Safety.

The inspection labors and maintenance will be made carefully in such way that their execution is planned in detail considering the safety of the human life and of the equipment, therefore a series of recommendations are included for the performance of inspection labors or maintenance.

The basic rule of safety is to disconnect the transformer from all the electric power sources and to ground the terminals.

To disconnect the transformer, follow these instructions:

a) Disconnect the transformer electric circuit from the primary and secondary terminals.

b) Assure that the disconnection mean is on open position. In case of using fuses, the fuses should be retired and placed in a not easy accessible place, so it cannot be accidentally reinstalled.

c) Ground the primary and secondary windings using the transformer bushings, to discharge any energy stored in the transformer due to the capacitances. These connection cables to ground should be retired until the whole maintenance work concludes.

If it is necessary to work inside the tank, the internal pressure of the tank should be relieved operating the relief valve.

Special care should be taken to not throw or to leave any tool inside the transformer tank. Once the work has been completed, it is necessary to assure that everything is clear before energizing

12.2 Inspection records.

To achieve a good maintenance program, it is necessary to have the transformer’s inspections and repairs registered.

A preventive maintenance system is effective when the following registrations are taken:

An equipment log, which can be a card that contains basic transformer information, such as serial number, location, nameplate, etc.

A repair log. It is a diagnosis register to eliminate future difficulties.

An inspection revision list. It is a list of points that must be reviewed, dates and/or frequencies when those will take effect.

Without these logs it will be difficult for a preventive maintenance program to work, due to the loss of the inspection information.

⚠WARNING

No Individual should attempt to service or perform maintenance activities on the Equipment described here, until such Equipment has been effectively de-energized, and all high-voltage and low-voltage terminals have been adequately made safe.

Only Qualified Personnel should maintain the Equipment described here.

A Qualified Person is an Individual who is well trained in the Isolation and De-energization of Electrical Equipment, in the Installation, Commissioning, Operation and Maintenance of High Voltage Equipment, in the proper use of Personal Protective Equipment, and in First Aid measures.

Be sure to read, understand and follow all Local, State and Federal Regulations as they are applicable to the Work described here.

In case that a protection relay has actioned an alarm, it is important to investigate the cause of the problem. It is essential to detect which relay has operated and in combination with which protection device made it.

Any other abnormal symptom, such as excessive level of audible sound, high or low oil level, etc. must be fully investigated.
The transformer maintenance practices described here, should be performed periodically when the Transformer is operated according to the “Usual Service Conditions” described in IEEE C57.12.00.
Such periodicity should increase when the unit is operated outside those “Usual Service Conditions”.

12.3 Maintenance Procedures.

Being the transformer a static device, it can be put through operation conditions that exceed those specified as normal. Depending on the duration of these conditions, a decrease of its expectation of useful life could be expected. In this section practical procedures are provided to maintain and service the transformer.

What	Frequency	Items to be verified
Visual Inspection	Annual	• Take Digital Photographs of the unit and its surroundings. • Record the values of all Gauges and Indicators • Note the condition of all bolted connections and gaskets, and in general all the items that form part of the Liquid Containment System. • Environmental Conditions (Temperature, Humidity, Abnormal Vibration, Noise, any condition that appears out of the ordinary) • If possibly, obtain Thermographic records of the unit while at load or shortly after disconnection and/or after-reconnection. • If possible, note the Currents and Voltages the unit was operating at, before de-energization.
Oil Sampling and DGA	At commissioning and then Annual	• Take an oil sample and send it to an accredited laboratory to measure and evaluate dissolved gas levels. Use table 4 and 5 as a guideline to define the next steps according to the results.
Testing	At commissioning and then every 3 Years	• Insulation Resistance • Winding Resistance (all taps) • Insulation Power Factor
Maintenance	Annual	• Washing and Cleaning exposed bushings. • Checking and tightening connections. • Verification, and Fill-up of insulating liquid level. • Verification of Alarm/Trip signals. • Verification of Operation/Indication of gages and protective devices. • Verification of Operation of Fans and Pumps • Enclosure integrity. Apply Touch up paint on exposed surfaces. • Recharge gas blanket • Surge Arrester inspection. • Protective Ground inspection.

12.3.1 DGA guidelines for Renewables Transformers.

Diagnosing a transformer can provide information regarding its current state and help detect a mild issue before it reaches a critical level. The following guideline was generated based on the sample monitoring of hundreds of renewable transformers operating in the field. To be able use these guidelines, you need the results of a previous sampling. If this is the first DGA test, it will be considered as the base reference.

To use these tables, first you need to define in which condition the transformer is found depending on the DGA's results according to the values in table 4. After defining the current condition, go to table 5 and see if according to the condition, the transformer should be sampled with a faster frequency, and if any measure needs to be taken in place. This values are applicable for mineral oil.

Table 4. Gas Concentrations for each Condition

	H_2	CH_4	CO	CO_2	C_2H_6	C_2H_4	C_2H_2	TDCG
Condition 1	940	265	710	4400	105	300	5	1499
Condition 2	940-2210	266-1320	711-1050	4401-7650	106-920	301-1900	6-35	1500-4999
Condition 3	>2210	>1320	>1050	>7650	>920	>1900	>35	≥5000

To define the condition, use the TDCG column values. The sum of all the individual gas level in each condition does not correspond to the TDGC because the given levels correspond to the maximum reported within of the studied population. There may be the case where the TDGC is compliant and some individual gas level surpasses the stablished level for that condition. If that is the case, first you need to check if the TDCG, and if there are any abnormalities in the generation rate, an evaluation for each individual gas needs to be made.

Condition 1. In this range of gas generation, it is considered that the equipment is in Satisfactory Condition.

Condition 2. In this range of gas generation, the equipment can continue in service, it is in a safe condition; however, it is necessary to evaluate the gas generation rate to confirm or discard a possible trend that could represent a situation against to equipment operation. The monitoring will be moderate.

Condition 3. In this range of gas generation, the equipment can continue in service, it is still in a safe condition; however, it is necessary to proceed with an intensive monitoring. In this condition, the rates of gas generation will be more critical than in Condition 2, therefore we must not neglect the unit because any time you have to take action to avoid problems and / or possible drive failures.

Table 5. Operating procedures depending on gas generation rates

<table>
<tr><th rowspan="2">Condition</th><th rowspan="2">TDCG (ppm)</th><th rowspan="2">$TDCG_{rate}$ (ppm/day)</th><th colspan="2">Sampling intervals and operating procedures for gas generation rates</th></tr>
<tr><th>Sampling interval</th><th>Operating procedure</th></tr>
<tr><td>1</td><td>< 1500</td><td>NA</td><td>Sampling in 12 months</td><td>Continue normal operation</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">> 1500
< 5000</td><td>< 10</td><td>Sampling in 12 months</td><td>Continue normal operation</td></tr>
<tr><td>≥ 10 & <20</td><td>Sampling in 6 months</td><td>Continue normal operation
Determine load dependence</td></tr>
<tr><td>≥ 20</td><td>Sampling in 3 months</td><td>Exercise extreme caution
Analyze for individual gases</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">≥ 5000</td><td>< 10</td><td>Sampling in 6 months</td><td>Continue normal operation</td></tr>
<tr><td>≥ 10 & < 20</td><td>Sampling in 3 months</td><td>Continue normal operation
Exercise extreme caution</td></tr>
<tr><td>≥ 20</td><td>Sampling in 1 month*</td><td>Analyze for individual gases
Determine load dependence
*Consider removal from service</td></tr>
</table>

Section 13

Fast Reference for Problems Solutions

PROBLEM SHOWN / SUGGESTED ACTION	FUSE AND SWITCHES OPERATION	FUSE OPERATION	DIFFERENT VOLTAGE BETWEEN PHASES	TRANSFORMER TURN RATIO DOES NOT MATCH WITH NAMEPLATE	OIL STAINS ON TANKCOVER OR ACCESSORIES
Verify that the surge arrester is not defective.	X				
Verify that the surge arrester is the correct one.	X				
Verify a correct transformer grounding.			X		
Check that the ground connection systems are the correct ones.			X		
Verify that the tank has a good physical grounding.			X		
Verify that the capacitors bank is disconnected.			X		
Check that all terminals cables are tighten to the bushings.			X		
Verify that there is not voltage drops.			X		
Check that the cables size is correct.	X		X		
Verify that the bushing blade are properly connected.			X		
Verify that the fuses are not operating.				X	
Verify the fuses capacity.	X	X			
Check that there are not faults in the primary or secondary system.	X	X			
Check that the motors or starters are coordinated correctly with the protection system.	X	X	X		
Verify that the transformer is not being used above of its nominal capacity.	X	X	X		
Check that the tap changer is not in different position.				X	
Check that the tap changer is making a correct contact.			X	X	
Verify that the load type is not variable.			X		
Check the primary voltage.			X		
Clean and adjust all the screws according Table 1.					X

ANNEX. A SUPPLEMENTARY INFORMATION FOR ACCIONA UNITS RCI686 AND RCF369 1700 KVA, 34.5D – 12Y/6.92K .

The following components are already included only in our RCI686 AND RCF369 catalog numbers. Our transformers are 100% customized and these accessories could be included per customer's request during order entry stage.

A.1. Switches

The units are provided with two switches as shown with letters "A" and "B" in Fig. A.1. Switch "A" can energize or deenergize the transformer in nominal loading conditions, i.e. NOTICE the switch "A" shall not be operated in short-circuit conditions. Switch "B" is connected on HB terminal side of the transformer. Due to the current carried by switch "B" and nominal operating voltage. NOTICE the switch "B" shall not be operated with load, so before operating it, the electrical loop circuit at which it is connected shall be deenergized.

⚠WARNING

Switch "B" shall not be operated with load. Failure to comply will result in serious personal injury, death, or damage to the equipment.

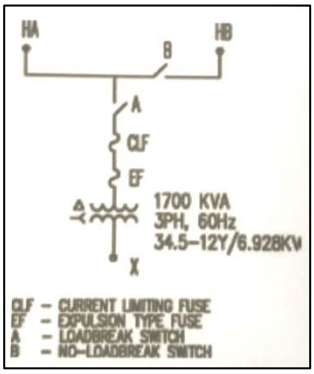


Figure A.1 Schematic of a 1700 KVA transformer

For further information, contact manufacturer's technical datasheets.

A.2. Oil Submersible Protector

The Oil Submersible Protector (OSP) is a partial-range current -limiting fuse that is designed to clear internal failures in the transformer, and its protection is coordinated with expulsion fuses. Current-limiting fuses are located under oil, beneath the transformer handhole (see photo 1 and 2).

⚠ DANGER

Before attempting to remove internal fuses, deenergize the transformer. Qualified personnel must perform installation or replacement of fuses.

⚠ DANGER

Deenergize the transformer before attempting to remove internal fuses. Failure to comply may result in severe personal injury or death.

A.3. Expulsion Fuses

Expulsion fuses protect the transformer against severe overloads and low intensity short circuits. These fuses are located under oil, beneath the transformer handhole (see photos 1 and 2).

⚠ DANGER

Before attempting to remove internal fuses, deenergize the transformer. Failure to comply will result in severe personal injury or death. Qualified personnel must perform installation or replacement of the fuses.

Photo 1. View of handhole installed on transformer tank cover

Photo 1. View of the inside of the tank through the handhole

A.4. Lock

LV compartment door has been set up for installation of a lock, whose function is to prevent from turning the door handle and getting access to the LV compartment.
The following components are required to install the lock. JCL Energy provides one set for each transformer.

a) Kirk Key Type F lock; 1 piece.
b) Mechanical Nylamid base support, 1 piece.
c) Security bolts (truss head) 3/8”-16 x 3”; 2 pieces.
d) Plain washers, 3/8”; 2 pieces.
e) Nuts, 3/8”; 2 pieces.
f) Lock washers, 3/8”, 2 pieces.

Tools required:

a) Truss spanner screwdriver #14 (JCL Energy provides 6 screwdrivers in total).
b) 9/16” socket wrench (JCL Energy does not provide this tool).

A.5. Cushion Clamps Installation

Unistrut channels (1 5/8” X 1 5/8”) have been added to the transformer cabinets, one in HV side and one in LV side, whose function is to support cushion clamps that hold cables connected to HV and LV bushings. See figures A.2. and A.3.

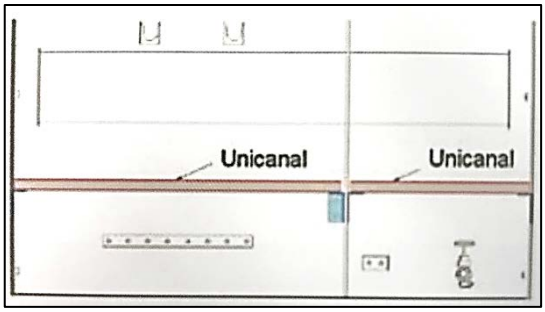


Figure A.2. (Front Tank wall)

Clamps should be installed on-site after cables have been connected to the transformer bushings. According to client’s instructions, JCL Energy provides cushion clamps in four sizes: 1 3/8”, 1 7/8”, 2 1/8”, and 2 3/8”, corresponding to diameters of cable gauges 4/0 for 15 kV class and 250, 500 and 800 for 35 kV class, respectively, every cable with 133% insulation.

First, place cushion around each cable; they can be easily spread out by hand and fit to the shape of the conductor. Next, place the metallic clamps in the Unistrut channel, one at each side of the cushion: slide them along the channel and fit them around the cushion. Finally screw the nut tightly on the bolt so the conductor is firmly held by the clamp. See Fig 3. Repeat this procedure for every cable connected to the transfer (nine in total).

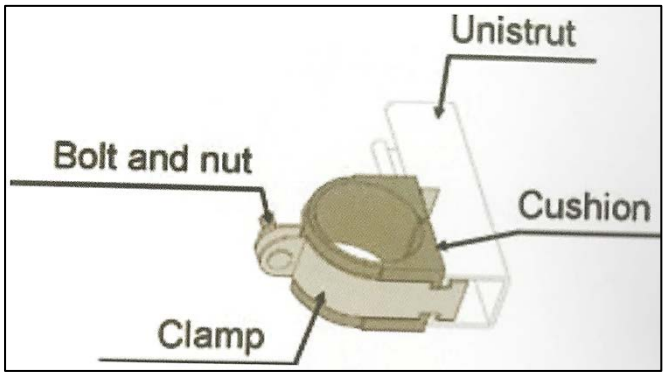


Figure A.3. Assembly of cushion clamp
and Unistrut channel

Three 13/8” cushion clamps shall be installed on LV side Unistrut channel and six clamps of a different size on the HV side Unistrut channel, this size depends on the gauge of the cable used by the client (it will vary from one transformer to other).

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Section 14

Technical Support

If you need assistance, a worldwide service organization is ready to help you. Warranty administration, site testing service, installation, system studies, maintenance, trouble-shooting, site repairs, and training seminars are provided by JCL Energy.

If you need to repair, recondition, or rebuild any electrical apparatus, our Service Team for work in-shop or on your premises. Latest factory methods and genuine parts are used to maintain the original performance of your JCL Energy equipment.

For full information about these services, contact JCL Energy at 724-983-1300 or www.JCL.Energy.

Notes

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