Power Partners, Inc.
Distribution Transformer Division
Athens, GA
ISO 9001:2008 Certified

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Instructions for Oil-Immersed Distribution Transformers

Section A: Pole Type, Single Phase and Three Phase

INDEX **Page**

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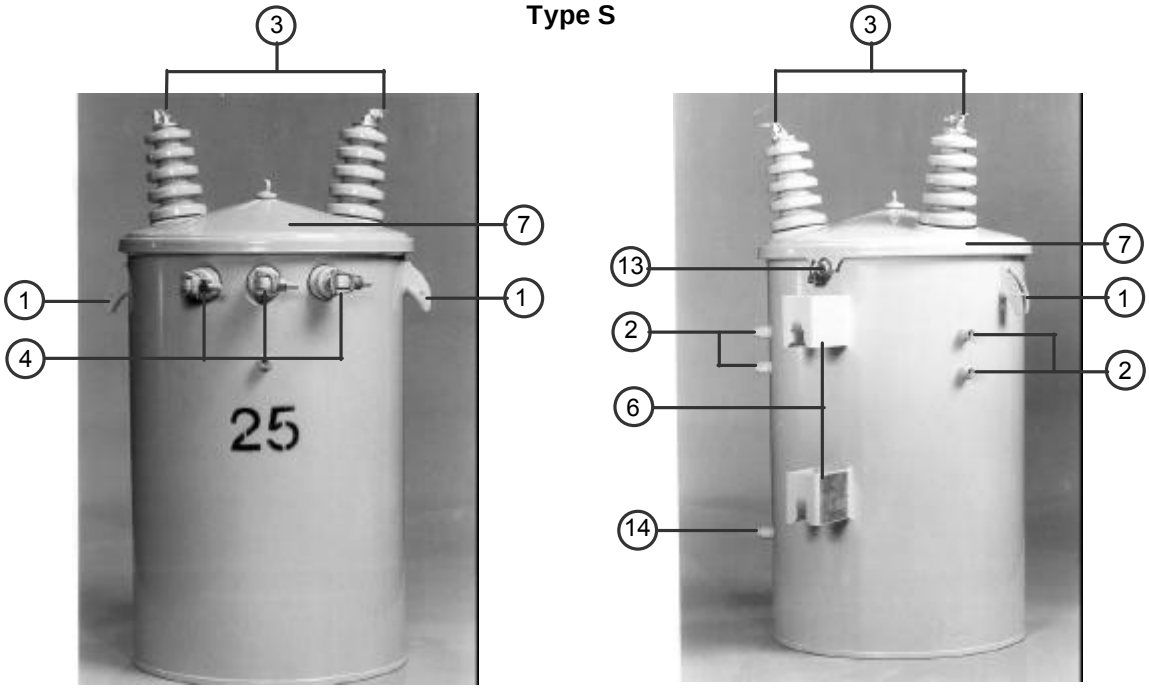
II. SAFETY INSTRUCTIONS

Keep this Instruction Book available to those responsible for the installation, maintenance, and operation of the transformer.

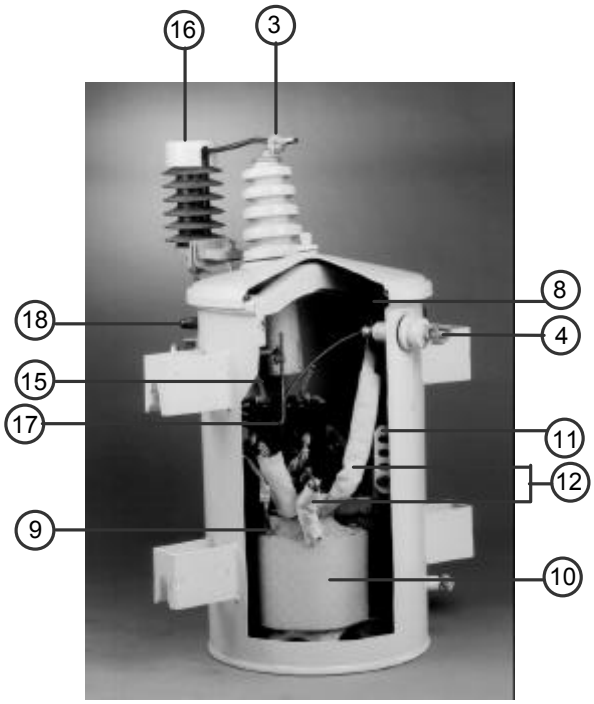
The installation, operation and maintenance of a transformer presents numerous potential unsafe conditions, including, but not limited to the following:

- Improper Tap Changer Operation
- High Pressures
- Lethal Voltages
- Hazardous Chemicals
- Heavy Components
- High Temperatures

Type S



Type CSP®



Standard Features

1. Lifting lugs
2. Arrester mounting pads
3. Cover-mounted high voltage porcelain bushing(s) with eyebolt terminal
4. Low voltage bushings with eyebolt terminals
5. Low voltage neutral grounding strap (Not Shown) (10-50 kVA Class B-2 and B-3 Only)
6. ANSI support lugs (hanger brackets) with laser inscribed nameplate on lower bracket
7. Polyester insulated cover
8. Self-venting and resealing cover assembly
9. Core
10. Coil
11. Centerline core/coil assembly support brackets
12. Low voltage leads
13. Oil fill plug with cover ground strap
14. Tank ground pad

The following additional features are all standard on self-protected Type CSP units only:

15. Primary protective link (mounted in high voltage bushing)
16. Surge arrester
17. Secondary circuit breaker
18. Secondary breaker operating handle with emergency overload reset and overload signal light

Fig. 1 Single Phase Overhead Distribution Transformers

Specialized procedures and instructions are required and must be adhered to when working on such apparatus. Failure to follow instructions could result in severe personal injury, death, and/or product or property damage.

Additionally, all applicable safety procedures such as OSHA requirements, regional and local safety requirements, safe working practices, and good judgment must be used by personnel when installing, operating, and/or maintaining such equipment.

Safety, as defined in this Instruction Book, involves two conditions:

1. Personal injury or death

2. Product and property damage (includes damage to the transformer, other property and reduced transformer life).

Safety notations are intended to alert personnel of possible personal injury, death or property damage. They have been inserted in the instructional text prior to the step in which the condition is cited.

The safety notations are headed by one of three hazard intensity levels which are defined as follows:

1. *DANGER:* Immediate hazard which will result in severe personal injury, death, or property damage.

2. *WARNING:* Hazard or unsafe practice which could result in severe personal injury, death, or property damage.

***3. CAUTION:* Hazard or unsafe practice which could result in minor personal injury, or property damage.**

Some major safety concerns involving the transformer are listed as follows. Refer to appropriate areas of the Instruction Book for further instructions. See Section IX.

1. The tap changer or dual voltage switch must not be operated when the transformer is energized. Operation of the tap changer or the dual voltage switch while the transformer is energized will result in arcing with a possibility of subsequent rupture to the tank. See Section V, E, 6.

2. When the transformer is energized, the bushings and equipment connected to the bushings are at high voltages. Coming too close to such energized parts could result in severe personal injury or death.

3. Using fuses only to protect transformers can permit dangerously high overloads that severely overheat the transformer coil and oil. See Section IX, 18b.

III. SCOPE

***WARNING:* READ THESE INSTRUCTIONS CAREFULLY BEFORE ATTEMPTING TO INSTALL, OPERATE OR MAINTAIN SUCH TRANSFORMERS. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD CAUSE SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

This instruction book has been prepared to assist the purchaser in properly installing, operating and maintaining Oil-Immersed Overhead Distribution Transformers supplied by Power Partners, Inc.

These instructions do not, however, cover all details or variations in the product or provide for every possible contingency met in connection with installation, operation, and maintenance. Should further instructions be desired, or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to Power Partners, Inc.

The transformers covered by this Instruction Book should be operated and serviced only by competent personnel familiar with good safety practices. These instructions are written for such personnel and are not intended as a substitute for proper training and experience in safe procedures for this type of equipment.

Unless specifically ordered otherwise, oil-immersed overhead distribution transformers are constructed in accordance with current IEEE, NEMA, EEI-NEMA and ANSI standards.

IV. SPECIAL INQUIRIES

When communicating with Power Partners regarding the product covered by this Instruction Book, always include the following items of information from the transformer's nameplate: serial number, style number, kVA rating, high voltage and low voltage rating.

NOTE: THIS INSTRUCTION BOOK INCLUDES DESIGN CHANGES NOT COVERED BY INSTRUCTION CARDS 116, 2339, 2447, 2448, 2462, 2652, AND INSTRUCTION BOOKS 5379, 5922, 5922-1, 46-100-1, AND 46-100-1A. IT IS SUGGESTED THAT OPERATORS KEEP THE OLDER INSTRUCTIONS ON FILE FOR OLDER TRANSFORMERS IN SERVICE.

V. DESCRIPTION OF TRANSFORMERS AND ACCESSORIES

A. Application

Oil-filled overhead distribution transformers are normally used for stepping utility distribution voltages (ranging from 2400 to 34500 volts) down to lower utilization voltages. Although some are used for stepping down to commercial and industrial voltages such as 277, 240/480, 2400 and 4800, most are used for stepping down to the single-phase voltage of 120/240. These same transformers are also used for small substations, miscellaneous applications and can serve to step up voltages.

1. WHEN NOT TO USE A DISTRIBUTION TRANSFORMER

For the following a distribution transformer is defined as an oil filled transformer whose primary voltage is 2400 volts or above and secondary voltage is 600 volts or below with kVA ratings of 10 through 500.

a. When the kVA required by the load exceeds 500 kVA per phase on a continuous basis.

b. When fire rules or other rules prohibit the use of oil in the location.

c. When the application requires more than a two winding transformer.

d. When the application calls for the transformer to be externally reconnected to be used as an auto transformer.

e. Distribution transformers are not designed to supply arc furnace or other loads that have a frequent transient voltage imposed on the transformer windings.

f. Distribution transformers are not designed to be used as rectifier transformers without special modifications.

g. Distribution transformers are not designed to be repetitively exposed to short circuits. If the application calls for extensive short circuit duty, a special design may be necessary.

h. Distribution transformers are not designed for marine duty and should not be installed on boats or ships.

i. Distribution transformers cannot be used as a substitute for an electric arc welder.

2. WHEN NOT TO USE AN OIL-FILLED TRANSFORMER

a. Oil-filled transformers should not be used in any application where the National Electrical Code prohibits the use of oil-filled apparatus.

b. When the ambient temperature exceeds 65 degrees C or 149 degree F.

c. When the transformer tank is to be placed in a confined tightly sealed enclosure.

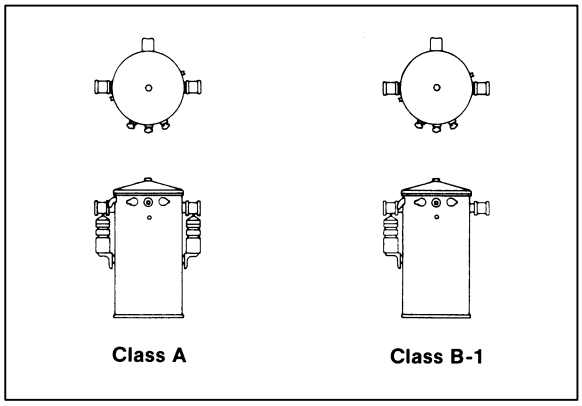
B. Basic Transformer Types by Protective Devices

The transformer type describes the basic protective devices which are included as an integral part of the transformer package. Table I defines each type as a function of the protective device(s) included. These protective devices and their functions are described later in this section.

Table I				
Type	CSP	CP	SP	S
Protective Devices				
High Voltage Surge Arrester	Yes	No	Yes	No
Low Voltage Circuit Breaker	Yes	Yes	No	No
High Voltage Protective Link	Yes	Yes	Yes	No

C. Single-Phase Transformer Designation, Classes A, B1, B2 and B3

1. Type CSP, 5 kV and Below, 10-100 kVA



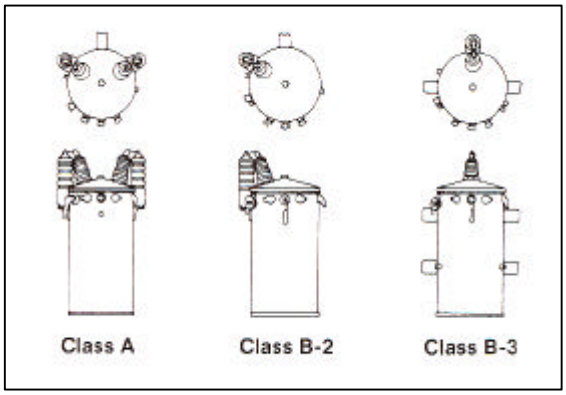
Class A: Two fully insulated high voltage bushings, two arresters, two protective links, and external breaker handle. Suitable for application on either wye or delta distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-1: Two fully insulated high voltage bushings, one arrester, two protective links and external breaker handle. Normally applied on solidly grounded systems.

Class B-2: Not Available.

Class B-3: Not Available.

2. Type CSP, Above 5KV, 10-100 kVA



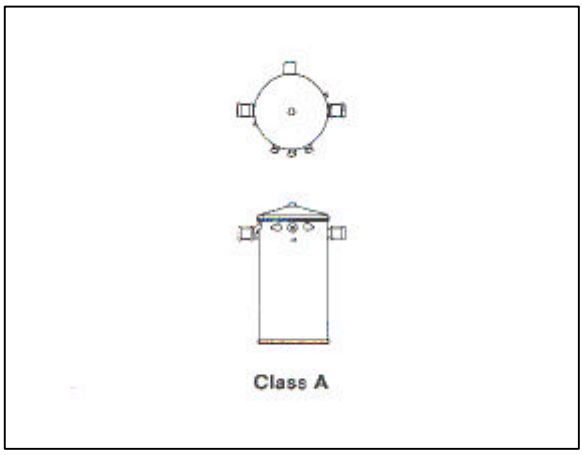
Class A: Two fully insulated high voltage bushings, two arresters, two protective links and external breaker handle suitable for application on either wye or delta distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-1: Two fully insulated high voltage bushings, one arrester, two protective links and external breaker handle. Normally applied on solidly grounded systems.

Class B-2: One fully insulated high voltage bushing, one arrester, one protective link and external breaker handle suitable only for application on solidly grounded distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-3: Same as Class B-2 except with twoposition mounting.

3. Type S. 5kV and Below, 10-500 kVA



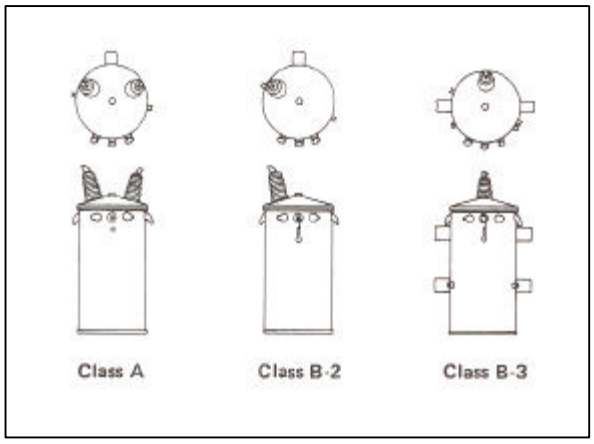
Class A: Two fully insulated high voltage bushings, suitable for application on either wye or delta distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-1: Not Available

Class B-2: Not Available

Class B-3: Not Available

4. Type S. Above 5 kV, 10-500 kVA



Class A: Two fully insulated high voltage bushings, suitable for application on either wye or delta distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-1: Not Available

Class B-2: One fully insulated high voltage bushing, suitable only for application on solidly grounded distribution systems. Single-position pole mounting in accordance with latest ANSI standards.

Class B-3: Same as Class B-2 except with two-position mounting.

D. Construction

Single-phase transformers have one core and coil assembly fastened together in an end frame and housed in a round tank filled with oil. The coil usually has one high voltage coil in between two low voltage coils— the low-high-low design. However, some coils have one high voltage and only one low voltage coil. See Fig. 2.

Shell Form Design Transformer has 1 coil and 2 cores.

Core Form Design Transformer has 2 coils and 1 core.

Three-phase transformers are generally made with 2 single-phase core and coil assemblies, one mounted on top of the other — the T-T design. See Fig. 3. Some three-phase transformers are made with three single-phase core and coil assemblies per Fig. 4 — the triplex design. The main advantages of the T-T designs are lower transformer heights (takes up less pole space) and some savings on materials in comparison to triplex designs.

E. Accessory Devices

The major transformer accessory devices which may be included as an integral part of the transformer package are listed below along with a brief description of the function of each.

1. Surge Arresters (See Fig. 1, also Section I, page 12)

Surge arresters are mounted on the outside of the transformer tank. Their function is to intercept and divert to ground various overvoltage transients (such as lightning surges) which originate on the distribution system.

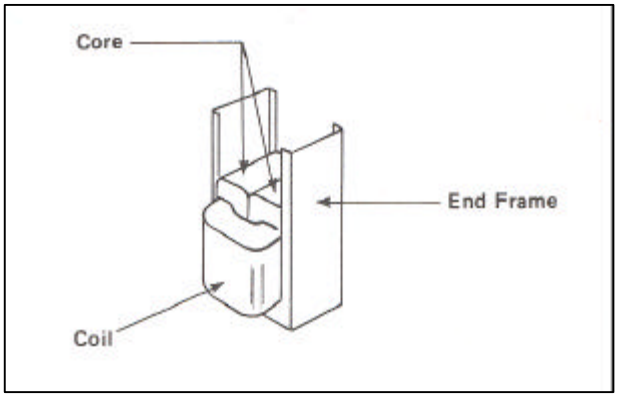


Fig 2 Single-Phase Core and Coil

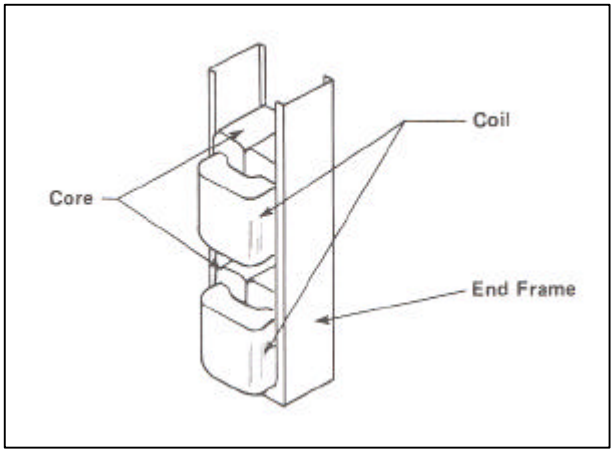


Fig. 3 Three Phase T-T

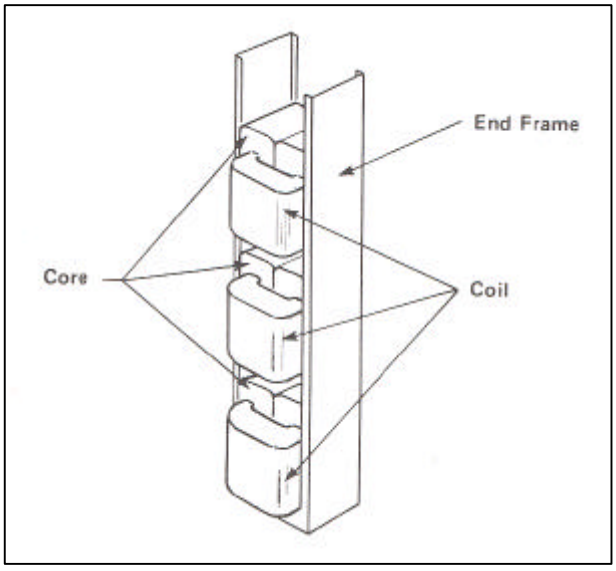


Fig. 4 Three-Phase Triplex

2. Protective Links**

Improper coordination with primary protective devices separate from the transformer could prevent the link from operating properly both for load current characteristics and for fault current characteristics.

Transformer Types SP, CP and CSP have protective links (expulsion type fuses) in them. These are mounted either in the bottom of the high voltage bushing or in a terminal block between the high voltage coil and the high voltage bushing. These protective links must be under oil for proper operation. Upon request Power Partners provides curves giving characteristics of these protective links so their characteristics can be coordinated with protective devices on the primary side of the transformer.

Curve 735701— Average Clearing Time, See Fig. 5
Curve 697700— Minimum Melt Curves, See Fig. 6

Protective links are oil-immersed high voltage expulsion fuses designed to isolate the transformer from the primary distribution system in the event of a transformer fault inside the tank on the load side of the link. The purpose of this link is to prevent a line lockout when a transformer fails; not to provide overload or fault current protection for the transformer.

There is an optional HV bushing with protective link available that has higher interrupting capacity than the standard bushings and links. The interrupting ratings of the standard and optional protective links are:

STANDARD BUSHING MOUNTED
(*Mounted in Standard HV Bushing— CSP — 100 kVA and below)

2,400 Volts	.....	5000 Amperes rms
4,800 Volts	.....	4200 Amperes rms
7,200 Volts	.....	3500 Amperes rms
12,000 Volts	.....	3000 Amperes rms
14,400 Volts	.....	2500 Amperes rms
19,900 Volts	.....	1200 Amperes rms
34,500 Volts	.....	1200 Amperes rms

***BLOCK MOUNTED LINK RATINGS—CSP**
2400-14400 Volts, 100 kVA and below…2000 Amperes rms for link sizes #2-#7A
3500 Amperes rms for link sizes #8-#13

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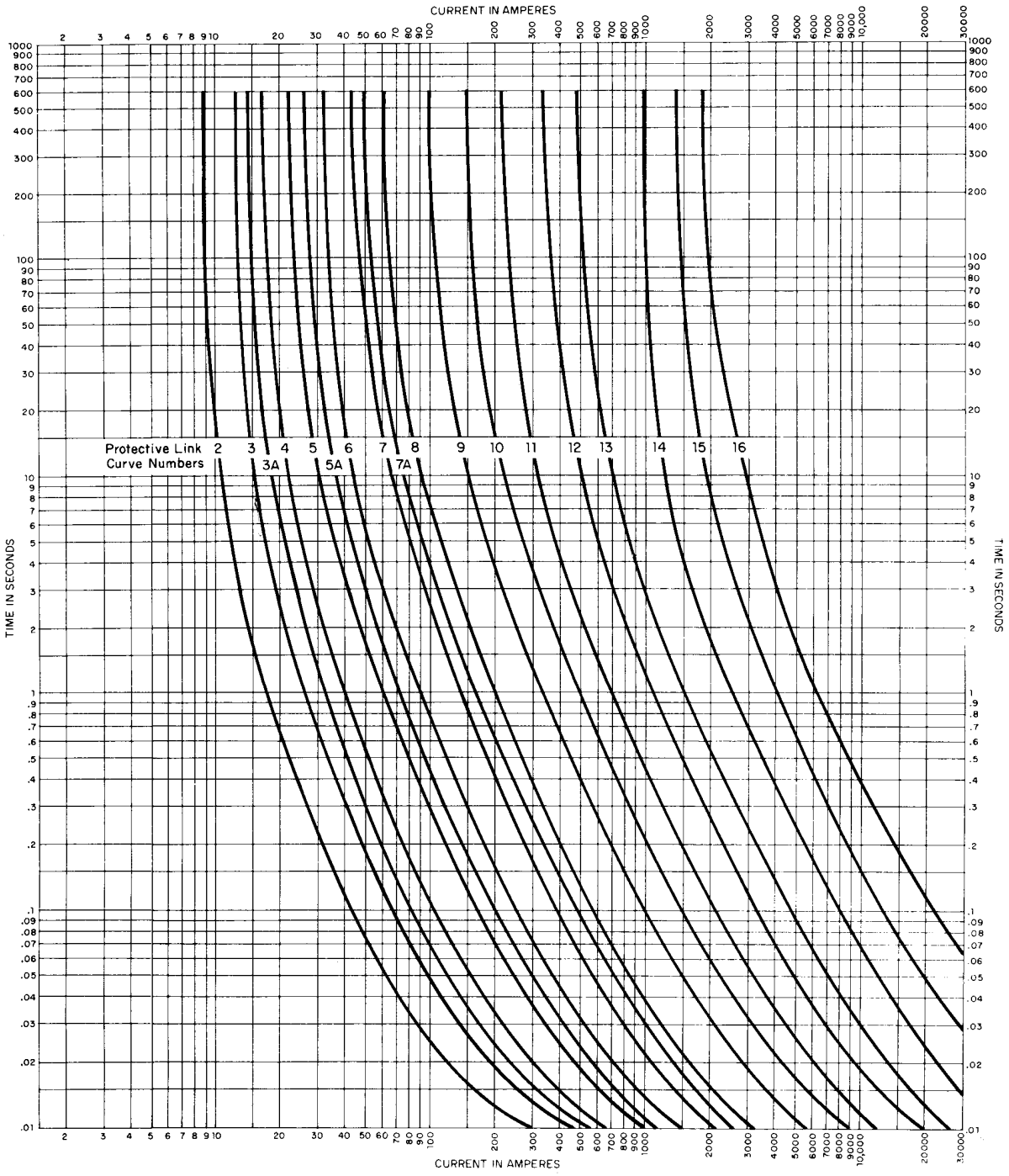
*For non-CSP applications, refer to Power Partners, Inc.

**Contact Power Partners, Inc. representative for additional protective link application information.



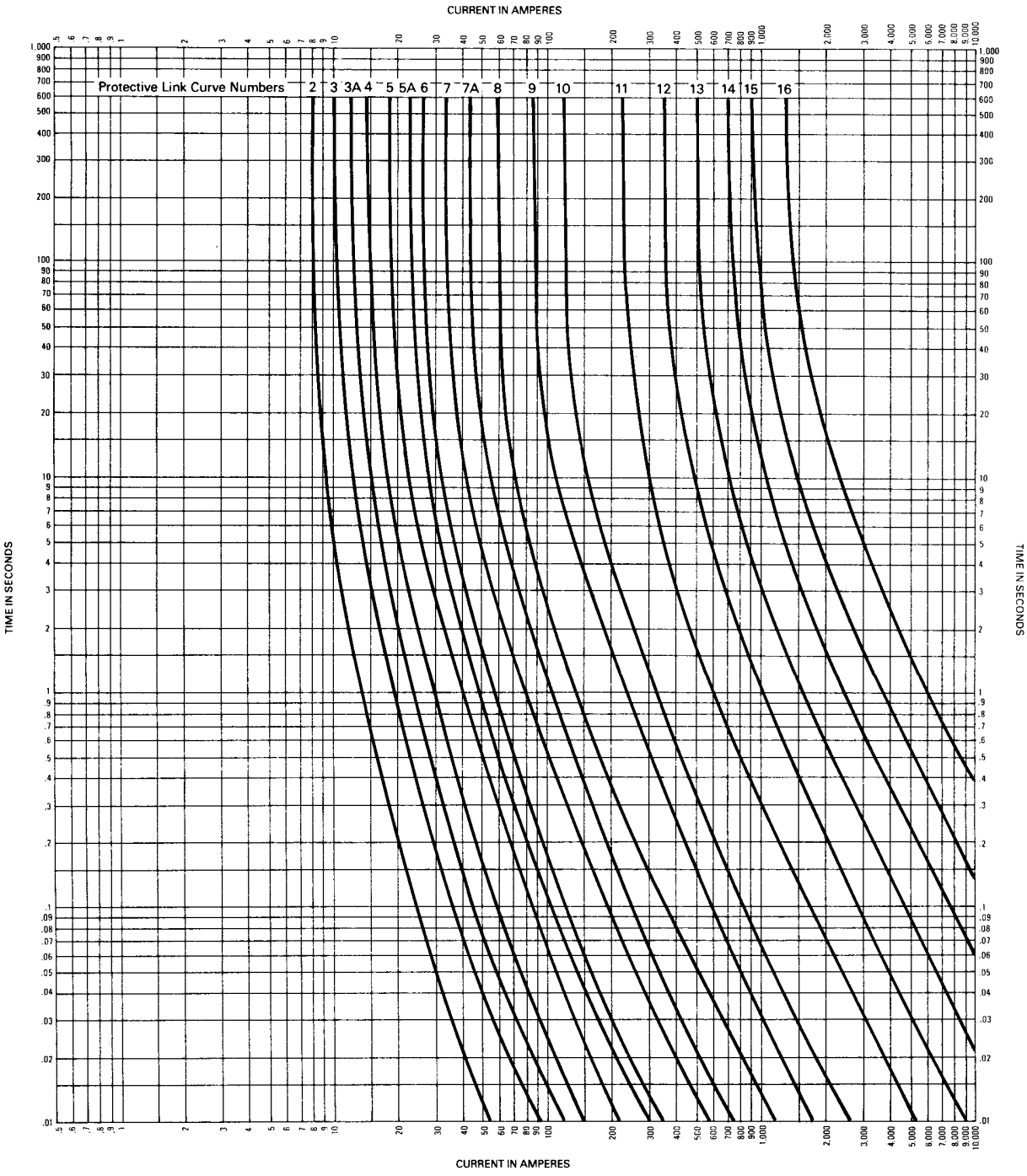
Average Clearing Time-Current Characteristics for Power Partners Protective Links Used in Distribution Transformers

Curve No. 735701

Power Partners, Inc.
Distribution Transformer Division

January, 1990

Fig. 5 Curve 735701



Minimum Melting Time-Current Characteristics
For Protective Links Used in Power Partners Transformers Curve No. 697700

(For Clearing Characteristics See Curve Number 735701)

Power Partners, Inc.
Distribution Transformer Division January, 1990

Fib. 6 Curve 697700

3. Current-Limiting Fuses (See Fig. 7)

High voltage current-limiting fuses are designed to limit the flow of current (and energy) to a low impedance fault. When properly applied, they prevent almost all violent failure of transformers. Like protective links, their purpose is to isolate the transformer from the distribution system in the event of an internal transformer fault. Current-limited fuses usually are applied when the system available fault current exceeds the interrupting capability of the protective link. Because partial range type current-limiting fuses are normally applied on overhead distribution transformers, a series protective link is applied with each current-limiting fuse.

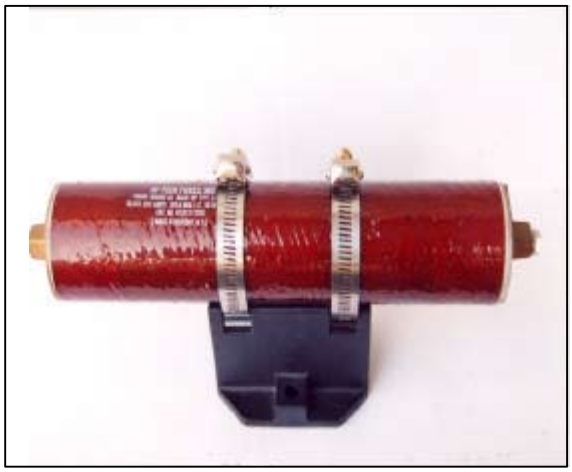


Fig. 7 High Voltage Block Mounted Current Limiting Fuse in Series With Protective Link.

4. Low Voltage Circuit Breaker (See Fig. 1)

Type CSP and CP transformers have circuit breakers mounted under oil and connected between the coils' low voltage winding leads and the low voltage bushings. These are to protect the transformer from severe overloads and short circuits external to the transformers. The low voltage breaker is not intended to protect secondary (low-voltage) circuits and connected apparatus (meters, meter sockets, connectors, service entrance equipment, etc.) from thermal and magnetic effects due to short circuits and overloads. The breaker is calibrated to trip when its bimental reaches a pre-determined temperature. Some breaker sizes have an additional feature that is a magnetic trip element so that breaker can respond quicker to higher fault current.

The breaker is primarily a protective device designed for only occasional switching operations; as such it is not intended for frequent (weekly or daily) switching duty.

The bimetallic element of the breaker is connected in series with the secondary windings of the transformer and responds thermally to the flow of transformer load current through it and to the oil temperature.

The circuit breaker is always used in conjunction with a protective link.

The circuit breaker coordinates with the protective link so it opens first on overloads and faults on the load side of the circuit breaker.

For manual operation of the breaker (see Fig. 8).

To open the breaker, raise the breaker handle to its top position. The top position is to reset the latch mechanism in the breaker.

Transformers are shipped with the circuit breaker closed.

CAUTION: **WHEN THE LOW VOLTAGE CIRCUIT BREAKER IS OPEN, THERE MAY BE ENOUGH CAPACITANCE COUPLING BETWEEN THE HIGH VOLTAGE AND LOW VOLTAGE WINDINGS SO THAT NOTICEABLE SHOCK MAY BE OBTAINED BY TOUCHING THE LOW VOLTAGE TERMINALS**

4a. Circuit Breaker Emergency Control (See Fig. 8)

Should it be necessary for a short time emergency situation, the breaker's calibration can be changed to allow additional overload capacity. The emergency trip setting of the breaker should be used only when absolutely necessary and for as short a duration as possible because extended use of the setting will result in higher winding temperatures before the breaker can trip. These higher winding temperatures cause a reduction in transformer life. When the emergency control setting is made it increases the load at which the signal light will come on and the breaker will trip by about 20%.

The breaker is recalibrated to the emergency position by removing the meter seal and rotating the emergency control handle upward, in a clockwise direction away from the breaker operating handle as shown in Figure 8. After the emergency condition, the emergency control handle should be returned to its normal position. It is recommended that a new seal be applied to the handle when it is returned to the normal position to avoid inadvertent operation of the emergency control.

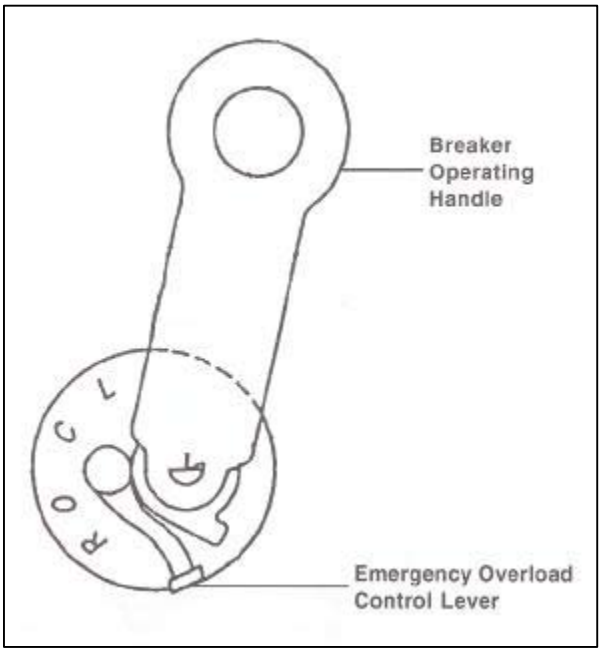


Fig. 8

4b. Signal Lights

Type CSP and CP transformers can be supplied with an overload signal light. When the signal light comes on it gives a warning that the transformer has experienced a heavy overload. The signal light remains lighted until reset by means of the breaker operating handle. It can be reset by operating the breaker handle to the maximum upward position and then back down to the closed position.

If the breaker handle is operated to the reset position and then to the close position and the signal light remains on, the temperature of the transformer oil is still too hot to allow the signal light to turn off.

If the signal light bulb is burned out, it can be replaced with Power Partners, Inc. Bulb No. 12D9161H03 and can be replaced from outside the transformer by unscrewing the signal light lens and then the bulb.

5. Protecto-Combo (See Fig. 9)

The Protecto-Combo device consists of a flip open type of fuse-holder and a surge arrester. The fuse link is normally supplied by the user. The Protecto-Combo device requires field assembly. This protective device is used only on transformers 50 kVA and below, Class B-2 or B-3 type units with one cover mounted high voltage bushing. This optional device is not shown on the nameplate.

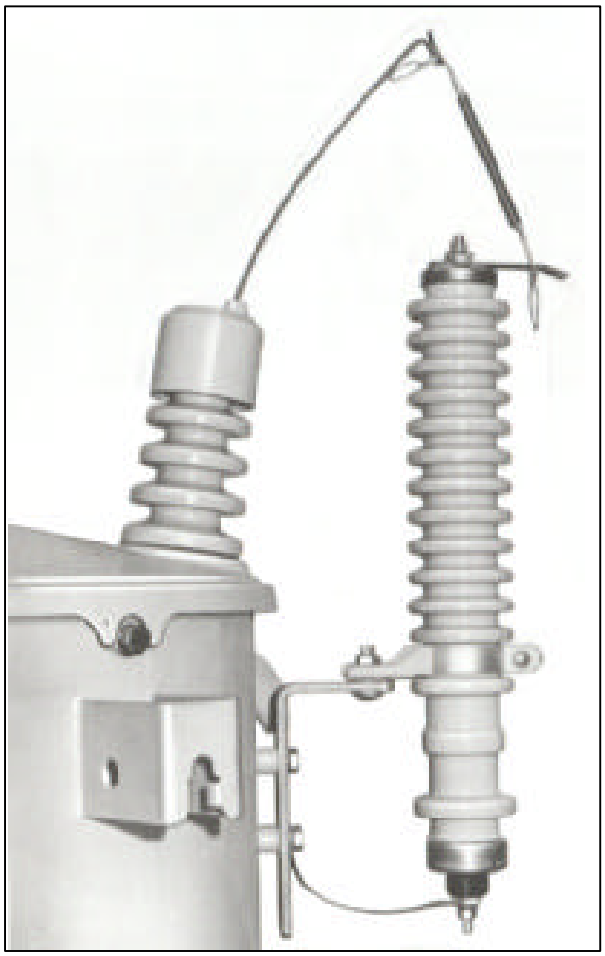


Fig. 9 Protecto-Combo Device

6. Tap Changers (See Fig. 10)

WARNING: **THE TAP CHANGER MUST NOT BE OPERATED WHILE THE TRANSFORMER IS ENERGIZED. TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

Tap changers are connected into the high voltage coil. The transformer output voltage can be increased or decreased by changing the tap changer setting.

The internal tap changer is operated by removing the transformer handhole cover, or transformer cover, and turning the tap changer handle to the position desired on the tap position indicator. The tap changer numbers on the position indicator are the same as ones on the transformer nameplate.

To change taps with the externally operated tap changer, loosen the locking screw in the handle, turn the handle to the tap position needed and tighten the locking screw.

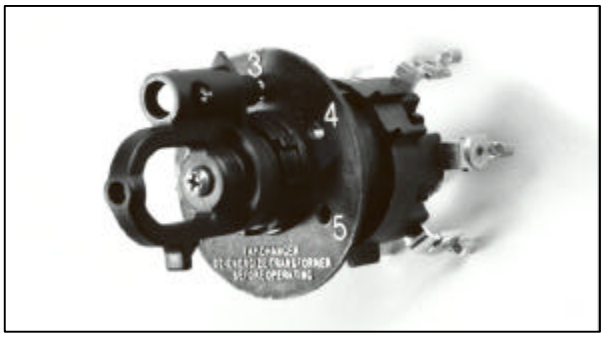


Fig. 10 Tap Changer

7. Dual Voltage Switch (See Fig. 11)

WARNING: THE DUAL VOLTAGE SWITCH MUST NOT BE OPERATED WHILE THE TRANSFORMER IS ENERGIZED. TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.

Dual voltage switches permit the use of transformers on different primary voltage systems. They are externally operated with a handle on the outside of the tank. Voltage ratings are given at the switch handle and on the transformer nameplate.

The switch handle is held in place by a locking screw. Back out the locking screw until it is clear from the locking hole, then rotate the handle. The locking screw should then be put into the locking hole for the new position and tightened.

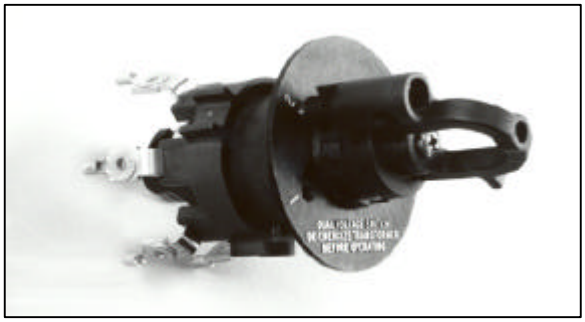


Fig. 11 Externally Operated Dual Voltage Switch

8. Tank Pressure Relief (See Fig. 12)

A unique feature of the transformer cover is its ability to flex and relieve pressure which can build up from some internal faults. Except in cases of extreme dynamic pressure build up, the cover automatically reseals itself. Whenever the cover needs to be removed, any internal static pressure is relieved automatically as the cover bolt is loosened. When the bolt is being loosened, the cover can vent but the bolt is still held by a nut in the cover beam.

The cover bolt should be tightened to 350 in. lbs. (27 ft. lbs.) ± 10% to insure that the cover vents properly. If there is a handhole cover on the transformer cover, the handhole cover bolt should be tightened to 150 in. lbs. (13 ft. lbs.) ± 10%.

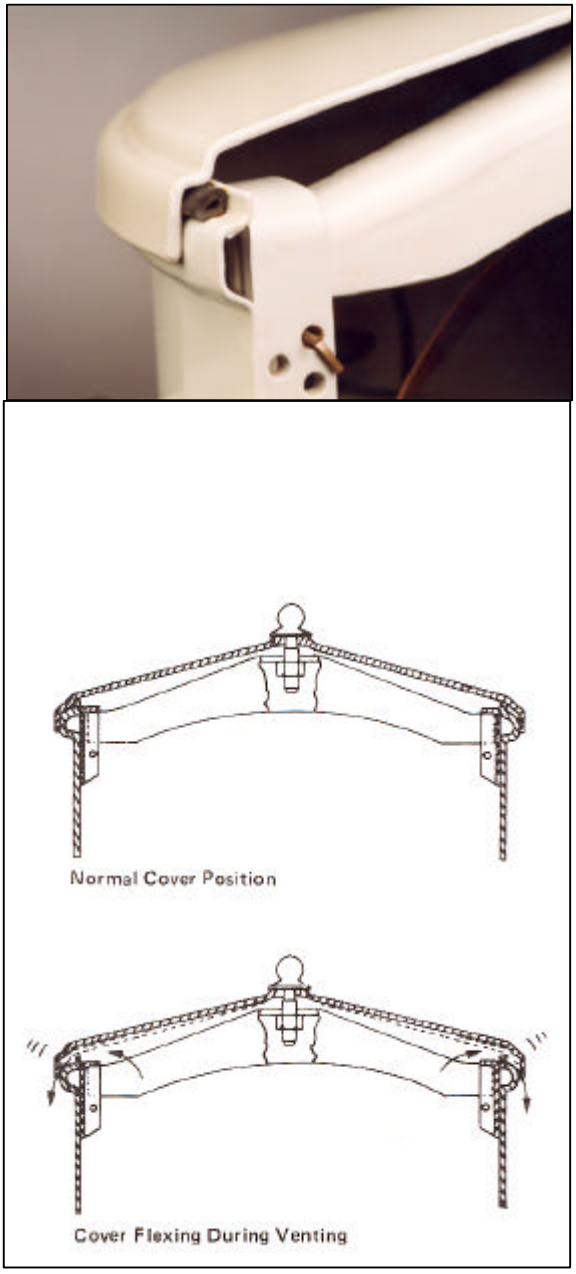


Fig. 12 Self-Venting Cover

VI. RECEIVING, INSPECTION, HANDLING, STORAGE AND INSTALLATION

A. Shipping Damage

All oil-filled overhead distribution transformers should be inspection immediately upon receipt for any external damage. If there is any damage, the transportation company should be notified in writing on the waybill at the time the waybill is signed. This inspection should be for damage to the porcelain bushings or arresters, oil leaks at any place on the transformer, damage to the tank, its cover, switch handles, other accessories or parts.

B. Storing

No unusual precautions for storing are needed because distribution transformers are built for outdoor service. It is recommended that the transformers be stored and transported on their shipping pallets to minimize damage to bushings, arresters, switch handles, etc. resulting from bumping and scraping another transformer during handling. This also minimizes damage to transformer finish and causes of oil leaks.

C. Opening Transformer

Prior to placing in service, it should not be necessary to open up the transformer and inspect its interior. It has been carefully sealed and leak tested at the factory. It therefore should not be opened except for repairing damage, changing taps or changing connections.

CAUTION: **WHEN A TRANSFORMER IS OPENED USE CARE TO PREVENT ENTRANCE OF MOISTURE OR FOREIGN OBJECTS. WHEN THE TRANSFORMER IS CLOSED, IT MUST BE CAREFULLY SEALED TO PREVENT EITHER LEAKING OR BREATHING. MOISTURE, DIRT OR FOREIGN OBJECTS IN A TRANSFORMER CAN WEAKEN THE INSULATION AND GREATLY SHORTEN ITS LIFE.**

D. Lifting

These transformers should never be lifted or moved by the bushings or arresters. This can break the bushings or arresters and it can break the oil tight seals on the bushings or the covers.

These transformers should be lifted by means of a sling with a spreader bar approximately as wide as the transformer. The sling should be put onto the lifting lugs on the transformer tank and not any other part of the transformer. The spreader bar is needed to prevent the sling from scraping the coating off the edge of the cover or damaging the cover, the cover gasket seal or a bushing.

E. Bushing Support Capabilities

The bushings will support a reasonable weight of conductors. Spans of unsupported conductor must be avoided. On low voltage bushings with spade terminals, care must be used not to have the bushings support the weight of the large cable or bus bars connected to them. Cables and bus bars should be properly bent and positioned prior to fastening to the bushings so that the force of the ending or positioning is not applied to the bushing.

F. Tank Grounding

All transformers are provided with a tank grounding pad as shown in Fig. 1. On some ratings a grounding terminal is included. PPI transformers (except those with one high voltage bushing where one high voltage coil lead is solidly connected to the tank) may be operated grounded or ungrounded.

On transformers with surge arresters, the arresters discharge lightning surges to ground through the tank. When tanks are to be operated ungrounded, a tank discharge gap must be used. The gap, normally insulated from ground, sparks over to form a discharge path for dissipating the lightning surge to ground during the time of a lightning strike.

Transformers are **not** normally supplied with a tank discharge gap, but gaps can be ordered as a special item.

The tanks of single-phase transformers with **two** high voltage bushings and all three-phase units, except those with grounded wye ratings, should be permanently and solidly grounded by means of the external grounding provision located on the tank. Some locations may prohibit by local electrical codes this grounding of tanks.

Single phase transformers which have **one** high voltage bushing and three phase units with grounded wye ratings, should have the tank grounded and the low voltage neutral permanently and solidly connected to the common neutral of the system before the transformer is energized. If this is not done, high voltage may be impressed between the tank or low voltage circuit and ground.

Single-phase transformers with one high voltage bushing have one end of the high voltage winding brought through the high voltage bushing. The other end is permanently connected to the transformer tank inside the tank.

When installing a transformer, the safest procedure is to make the ground connection first, the connection to the low voltage lines next and finally the high voltage connections. When a transformer is removed from service, all high voltage connections, including those with protective devices, should be opened before removing the ground connections.

G. Tank Finish

The transformer is supplied with a high quality finish to withstand long outdoor exposure service. However, in transformer shipping and handling the finish may be scratched or abraded. The scratches and abrasions should be touched up with outdoor materials recommended by Power Partners.

H. Insulating Fluid

The type and quantity of insulating fluid is shown on the transformer nameplate.

These transformers are thoroughly dried at the factory by baking and then filled with dry, de-gassed, insulating fluid. The insulating fluid is put into the tank after the transformer has been assembled and while the tank is under vacuum.

Transformers should not be operated with the fluid level more than ½" below the cold oil (77 degrees F., 25 degrees C.) level mark inside the tank. Insulating fluid of normal dryness and cleanliness will test 30 kV or higher in the standard test cup per ASTM Test 877.

Transformers are filled at the factory with less than 1 PPM PCB insulating fluid in accordance with Federal Polychlorinated Biphenyl (PCB) Regulations 40CFR761, dated May 31, 1979. The purchaser should take the necessary precautions so that PCB contamination is not introduced during field filling or maintenance of the transformer.

I. **Surge Arresters**

Some transformers are supplied with arresters mounted on them. Some arresters have their top directly connected to a high voltage bushing terminal and others have a gap between the arrester and bushing terminals. For proper gap spacings see Fig. 13.

All transformers should be protected by surge arresters. Arresters should be as close to the transformer as practical. The sum of the lengths of the line lead to the arrester and the ground lead from the arrester to the transformer ground should be less than 5 feet. The further an arrester is away from the transformer, the less protection it can give.

Transformers with arresters mounted on them have the arresters grounded to the transformer tank. These connections must be tight when the transformer is installed. Ground connections from the tank or from separately mounted arresters should be completed before any connections from the high voltage line to the transformer is made.

Transformers with low voltage ratings above 600 volts should have arresters installed on both the high voltage and low voltage side of the transformer.

Whenever high potential or induced potential tests are made on transformers with arresters, the arrester must be disconnected during the tests. It there is a series gap between the arrester and the bushing, increase the gap setting considerably, remove one electrode of the series gap, or remove the arrester for testing. After the tests, the arresters must be replaced to their proper operating condition with a gap of the correct length.

J. Protective Links

The protective links should be coordinated with the protective devices on the primary side of the transformer. See Section V, E.2. for link identification and warning.

K. Nameplate

Refer to the transformer nameplate for the transformer ratings and for proper connections of the transformer to the system. No internal connections should be made inside the transformer other than those shown on the nameplate.

L. Winding Connections for Transformer with Tap Changers, Dual Voltage Switches or Terminal Blocks.

WARNING: **THE TRANSFORMER MUST BE DE-ENERGIZED WHEN CHANGING CONNECTIONS, OPERATING THE TAP CHANGER OR DUAL VOLTAGE SWITCH. FAILURE TO DO SO COULD RESULT IN SERIOUS PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

Unless otherwise requested by the purchaser:

High voltage windings with taps are connected for the transformer rated voltage when shipped.

Transformers for series-multiple (more than one high voltage rating) operation on the high voltage side are shipped connected for the highest voltage (series connection).

Low voltage windings of single phase transformers designed for both series-multiple and three wire operation, where connections are made inside the tank, are connected for series or three wire operation when shipped.

Three phase transformers with low voltage windings rated 240 x 480 volts are connected for 480 volt operation.

Three phase transformers designed for both delta and wye operation on the high voltage side are shipped connected for the wye voltage (highest voltage).

M. Mounting

Single phase and three phase pole type transformers are provided with three different kinds of mounting brackets (hanger lugs) as required by ANSI Standard C57.12.20 for different kVA ratings. (See Fig. 14)

Power Partners recommends against mounting these overhead transformers to the pole while the pole is on the ground and the transformer is in the horizontal position. Also, the transformer should not be stored in the horizontal position. To do so can trap air in the coil and oil and may cause insulation failure when energized.

Transformers in tanks with 24 inches in diameter and larger should not be installed more than 5 degrees from vertical. Those in smaller tanks, not more than 10 degrees from vertical.

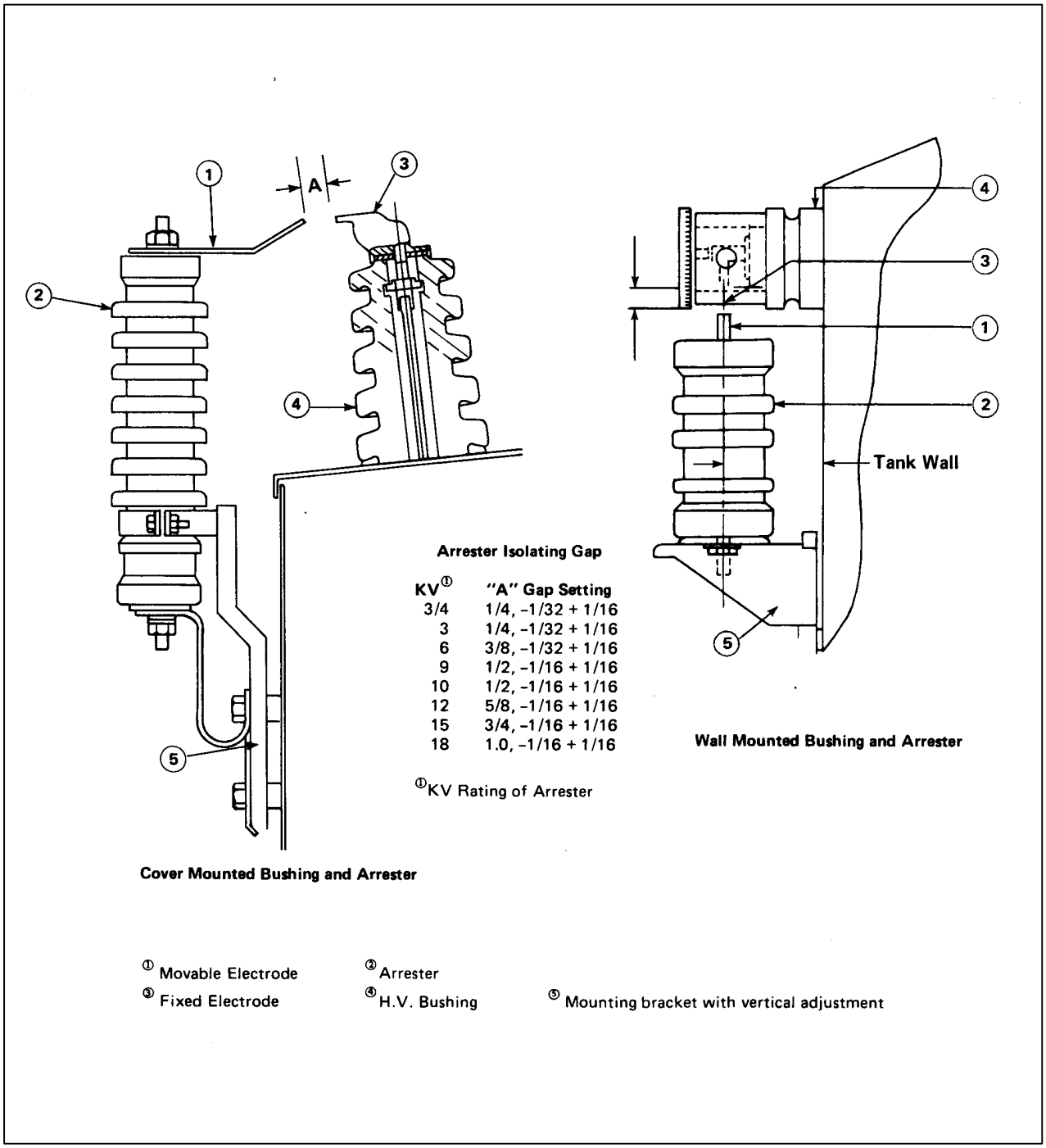


Fig. 13 Lightning Arresters and Gap Adjustments

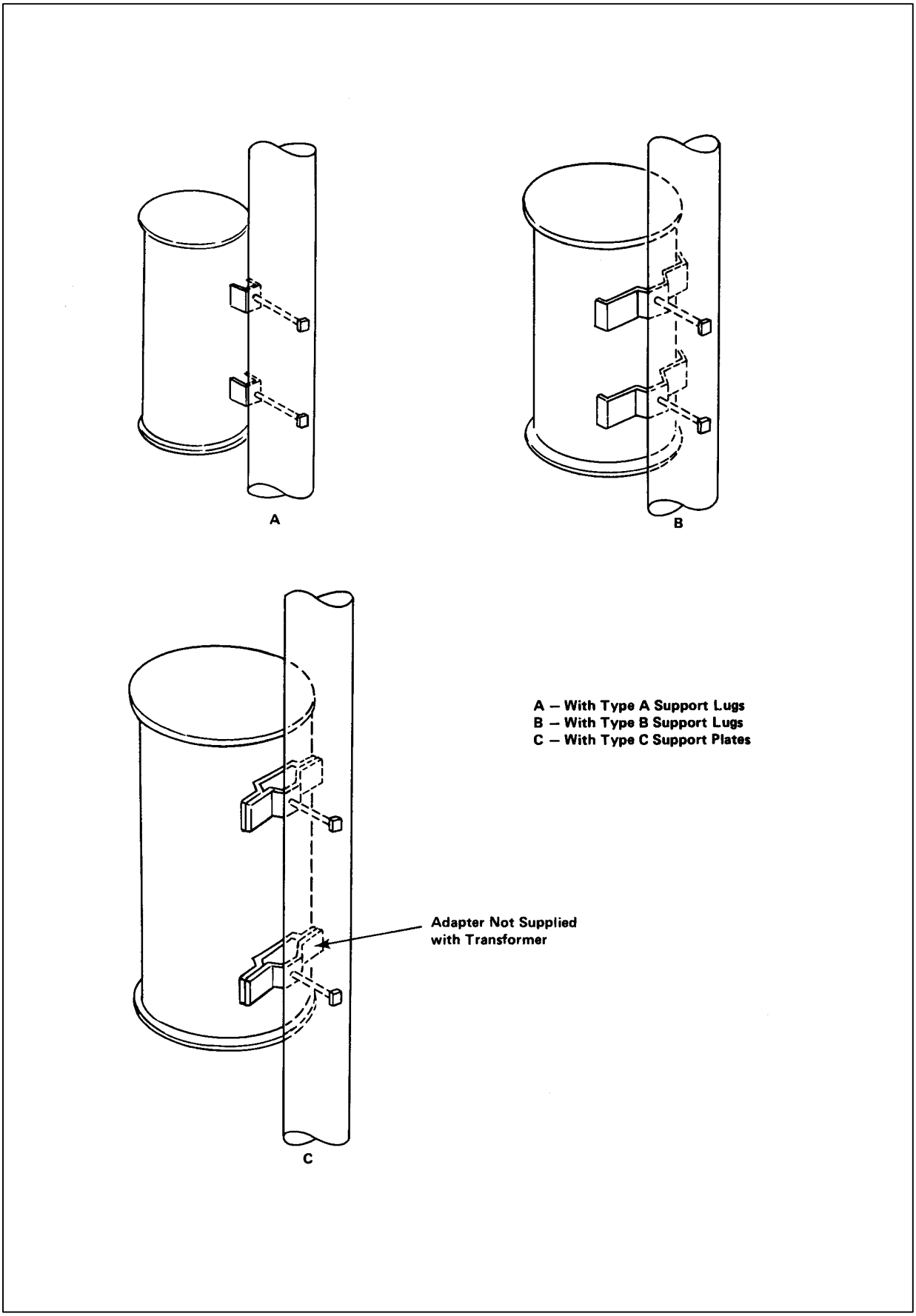


Fig 14 Direct Pole Mounting of Distribution Transformers

VII. ADDITIONAL INFORMATION FOR THREE-PHASE TRANSFORMERS

There are two kinds of three-phase overhead type transformers in general use. One is the triplex design that consists of three separate single-phase core and coil assemblies as shown in Fig. 4. The other is the "T-T", or Scott connected. This kind is constructed with two core and coil assemblies as shown in Fig. 3.

Ratio testing of "T-T" connected transformers with single phase power is different from the usual method of ratio testing single-phase transformers or testing triplex three-phase transformers. Ratio testing three-phase T-T transformers with three-phase power is done in the same manner as ratio testing triplex designs. However, ratio testing of three-phase T-T transformers with single-phase power can be done as follows.

A. Ratio Testing of Three-Phase T-T Connected Transformers

Due to changing conditions (standards, customer requirements, etc.) it is difficult to discuss ratio testing in terms of bushing designation, however, it is possible to discuss this in terms of winding type.

1. WINDING TYPE

a. Main Winding, See Fig. 15

Refers to winding lying wholly between two bushings and with a mid-tap. We will refer to main winding as winding ABC.

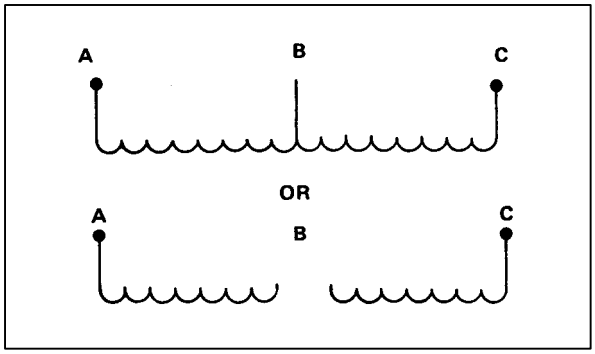


Fig. 15 Main Winding

b. Teaser Winding, See Fig. 16

Refers to winding lying between1-bushing and the mid-point of the main winding. The teaser winding will now be referred to as the DEF winding.

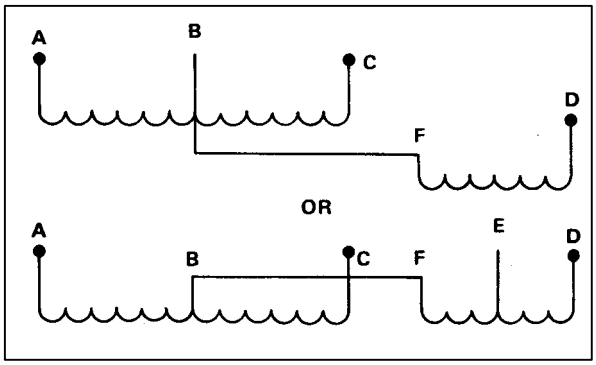


Fig. 16 Teaser Winding

c. Secondary and Primary Designations

The subscript "s" will denote the secondary or low voltage. The subscript "p" will denote the primary or high voltage.

NOTES: THE "E" POINT ON THE LOW VOLTAGE IS COMMONLY BROUGHT OUT AS A NEUTRAL POINT. THE "E" POINT ON THE HIGH VOLTAGE IS GENERALLY NOT AVAILABLE FOR TESTING. THE "B" POINT IS AVAILABLE ON REQUEST AS A LIGHTING TAP ON THE LOW VOLTAGE. TERMINALS A, C AND D ARE ALWAYS AVAILABLE. THESE ARE THE THREE LINE BUSHING TERMINALS FOR A GIVEN WINDING.

2. TEST PROCEDURE

If all of the following ratio tests are made and the unit passes, then the ratio of the unit is correct.

Ratio Connections –- 30° Displacement

Test 1:

Short	Ap to Cp
Input	Dp to Cp
Output	As to Cs
Ratio:	.866 of Rated Primary/Rated Secondary

Test 2:

		IF Bs Available
Short	As to Cs	Not Required
Input	Ap to Cp	Ap to Cp
Output	Ds to Cs	Ds to Bs
Ratio:	Rated Primary/.866 of Rated Secondary	

Test 3:

(When Es is available)

Short	Not required
Input	Ap to Cp
Output	Ds to Es
Ratio:	1.732 x Rated Primary/Neutral Voltage Secondary

Test 4:

(When Bs is available)

Short	Ap to Cp
Input	Dp to Cp
Output	As to Bs or Cs to Bs
Ratio:	.866 of Rated Primary/(Rated Secondary/2.0)*

Ratio Connections –- 0 Degrees Displacement

Test 1:

Input	Ap to Cp
Output	As to Cs
Ratio:	Rated Primary/Rated Secondary

Test 2:

Short	Ap to Cp
Short	As to Cs
Input	Dp to Cp
Output	Ds to Cs
Ratio:	Rated Primary/Rated Secondary

Test 3:

(When ES is available)

Short	Ap to Cp
Input	Dp to Cp
Output	Es to Ds
Ratio:	1.5xRated Primary/Rated Secondary

Test 4:

(When Bs is available)

Input	Ap to Cp
Output	AS to Bs or Bs to Cs
Ratio:	Rated Primary/(Rated Secondary/2.0)

*Rated Secondary/2.0**–-** commonly referred to as lighting tap.

The T-T transformer is system connection independent.

In other words a 30 degree displacement T-T may be used on either a "wye" or a "delta" system and is the preferred connection.

The 0 degree displacement T-T may be used on either a "wye" or a "delta" system, but should be ordered only when you are lying secondaries together from either a delta-delta or wye-wye bank and must maintain identical phase shifts.

The displacement is noted on the nameplate and the name-plate should be checked before connecting the transformer.

B. T-T Phasor Diagrams

Before January 1, 1979, Phasor Diagrams per Fig. 17 were used as (Westinghouse) standard.

After January 1, 1979, Phasor Diagrams per Fig. 18 were used as standard.

C. Terminal Designations for Three-Phase Pole-Mounted Transformers

All three-phase pole-mounted distribution transformers have terminal designations as shown in Fig. 19 regardless of the internal connection.

Neutral terminals (HV and/or LV) will exist as required by the winding connection and will be noted on the transformer nameplate.

D. Type CSP Three-Phase LV Circuit Breakers

These circuit breakers are three-pole gang operated. When a fault occurs on one or more phases, all 3 poles open.

When the full load, low voltage current is 104 amps or less, the Type LR breaker is used. For larger LV current, the Type QR breaker is used that has a magnetic trip device in addition to the thermo-trip feature.

E. Dedicated Motor Loads

Where the motor HP rating is about the same as the transformer kVA rating, magnetic trip type breakers should not be used. Breakers without the magnetic trip device should be used in these cases.

F. Three-Phase Tap Changers

WARNING: **THREE-PHASE TAP CHANGERS SHOULD BE OPERATED ONLY WHEN THE TRANSFORMER IS COMPLETELY DE-ENERGIZED. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

T-T connected transformers have tap changers that are operated by turning only one handle. However, some triplex design transformers have three individual single-phase tap changers.

WARNING: **WHERE THREE INDIVIDUAL SINGLE PHASE TAP CHANGERS ARE UTILIZED IN TRIPLEX DESIGNS, CARE MUST BE USED TO INSURE THAT EACH TAP CHANGER IS ON THE SAME TAP POSITION. FAILURE TO DO SO COULD RESULT IN SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

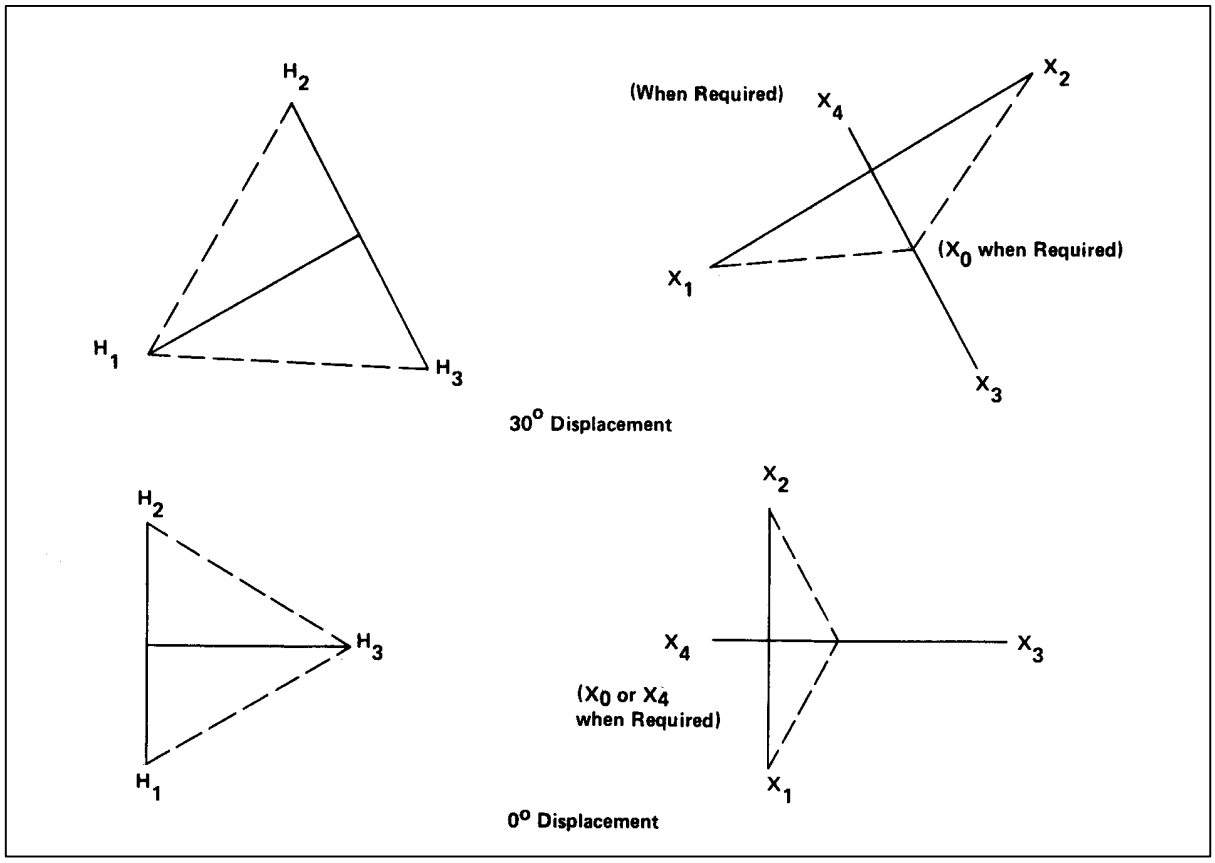


Fig. 17 T-T Phasor Diagrams used before January 1, 1979

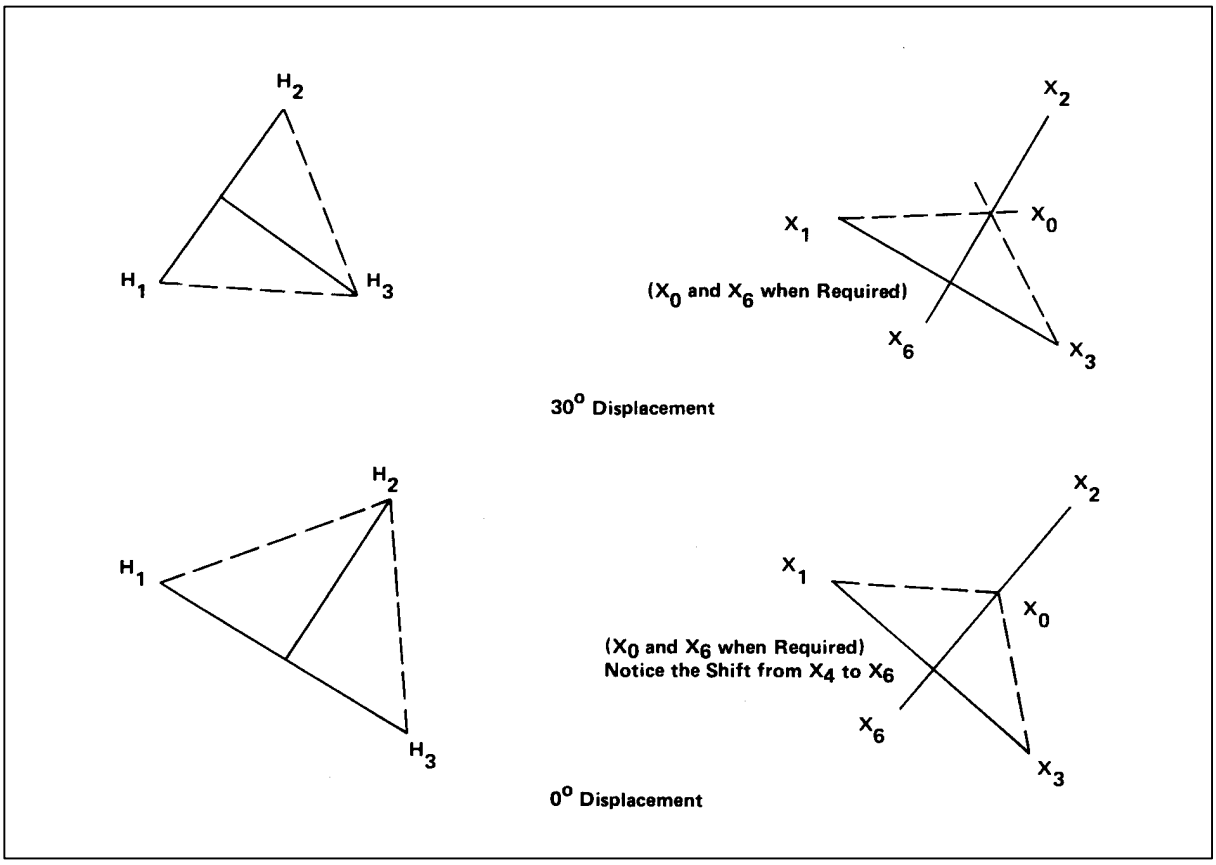


Fig. 18 T-T Phasor Diagrams used after January 1, 1979

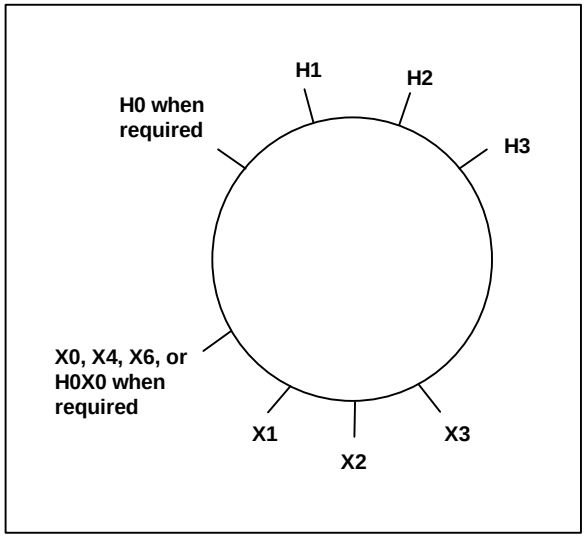


Fig. 19 Terminal Designations for Three-Phase Pole-Mounted Transformers

VIII. OPERATING LIMITS

The transformers described herein are designed for the applications and conditions normally encountered on electric utility power distribution systems. As such they are suitable for use under the "usual service conditions" described in ANSI C57.12.00 (General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers). All other conditions are considered unusual service and should be avoided unless specific factory approval is obtained. Specific considerations include:

1. Frequency should not be appreciably lower than rating.

2. Voltage applied to the transformer should not exceed its rating by more than 5% while under full kVA rating or by more than 10% at no load.

3. Elevation at installation should not exceed 3300 ft. (1000 meters) above seal level unless the transformer was designed for higher elevations.

4. Ambient temperatures should not exceed 40 degrees C (104 degrees F.) and the average temperature for any 24 hour period should not exceed 30 degrees C (86 degrees F.) unless the transformer is specifically designed for higher temperatures.

5. Continuous kVA load should not exceed rating. However, short time overloads do little damage to the transformer when the loadings recommend in ANSI Standards C57.91 are not exceeded.

Type CSP and CP transformers are equipped with an internal circuit breaker that permits loading up to the full thermal capability of the transformer. This is considerably above nameplate rating for short time overloads. The breaker protects the transformer coil from dangerously high short time overloads and fault currents and also from excessive heat caused by long time, heavy overloads.

6. For transformers that are not equipped with surge arresters, circuit breakers or protective links, the owner should insure that there is suitable protection external to the transformer. Contact Power Partners office for recommendations.

IX. SAFETY PRECAUTIONS

WARNING: **THE FOLLOWING PRECAUTIONS SHOULD BE FOLLOWED. FAILURE TO DO SO COULD RESULT IN FIRE, SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

1. When a transformer is to be worked on while installed on a pole or a platform, the primary fuse cutout should be open. Then the HV and LV bushing terminals should be grounded before the leads are disconnected from the high voltage bushings.

2. If a transformer is opened for any reason, care should be taken to prevent loose articles from falling into it. It must be kept free of moisture and resealed carefully to prevent breaking. The life of any transformer depends on the absence of moisture in the insulation.

3. For electrical equipment fires use only approved fire extinguishers such as those using carbon dioxide (CO_2).

4. Never operate tap changers, dual voltage switches or make changes on terminal blocks or arrester gaps when transformers are energized.

5. Never operate or apply voltage to transformers with oil below the proper level. Check the oil level mark inside the transformer tank. For cover mounted high voltage bushings be sure the bottom of the HV bushings are at least 1 inch under oil.

6. Overhead type transformers with tank diameters 24 inches or larger should not be installed more than 15° from the vertical.

7. When transformers are not the CSP type that are protected by surge arresters, circuit breakers and protective links, protection should be provided for excessive overloads, faults, lightning and other voltage surges.

8. Unless surge arresters are direct connected, make sure the external gap settings are correct before the transformer is energized.

9. The sum of the lengths of the line lead to the arrester and the ground lead from the arrester to the transformer should be as short as required too maintain an adequate protective margin. This is usually less than 5 feet.

10. Carefully check the transformer nameplate for its rating and the connections that can be made to it.

11. Never lift or move the transformer by any of the bushings or arresters.

12. Except where prohibited by codes or laws, transformer tanks should be grounded before the transformer is energized.

13. When a transformer is energized, avoid contact with the tank if equipped with a tank discharge gap.

14. Measure the secondary voltage of transformers to be sure the output voltage is correct before connecting a load to the transformer.

15a. When three single-phase transformers are used in a delta-delta bank, make sure the voltage ratios of each transformer are the same.

Before the transformer bank is energized on the primary side, the primary delta should be closed, and the secondary delta should be broken or opened at one corner with a small fuse or voltmeter used to close the secondary delta. If the fuse blows upon energization of the primary windings, or if voltage

appears across the broken delta secondary windings, check for wrong connections, transformer polarity, etc.

15b. Similarly, an impedance difference between transformer in the delta-delta bank can cause a small circulating current which makes it necessary to derate the bank. For units of equal capacity with a transformer with an impedance different from the other two, the bank derating for balanced loading is approximated in the following table:

Ratio of Odd Units Impedance to Impedance of Other 2 Units	Derating Factor
1.6	0.91
1.5	0.93
1.4	0.94
1.3	0.95
1.2	0.97
1.1	0.98
1.0	1.00
.9	.97
.8	.93
.7	.90

16. Pressure inside transformer tanks can sometimes be very high. This is usually caused by an electrical failure inside the tank while the transformer was in service. These transformers are designed with a unique cover assembly that permits venting internal pressure. Loosening the cover bolt permits pressure to be vented before any parts can be blown loose from the transformer. Therefore, whenever opening one of these transformers, loosen the cover bolt first.

17. If a fuse in a cutout on the primary side of a transformer, or the protective link inside a protected transformer, is blown, there is always the possibility that there is an internal fault in the transformer. The cutout should not be refused unless:

a. It is refused from a location remote from the transformer.

b. The transformer is replaced or tested to insure it has not failed.

18a. A periodic check of the transformer load should be made to insure that the transformer is not being unduly overloaded. ANSI Loading Guide C57.91 should not e exceeded.

18b. Permitting high overloads on transformers by protecting them with fuses only and by sizing these fuses so loads of 3 times full load current or more can be on the transformer, can under certain load conditions, cause the transformer to severely overheat.

Under these conditions the oil is at dangerously high temperatures and arcing inside the transformer tank could cause an eventful failure where some part or parts of the transformer could separate from it and cause fire, severe personal injury, death or property damage.

19. These transformers contain a flammable insulating fluid (mineral oil). Transformer failure can result in fire and/or explosion, so all installations of these transformers should be located in accordance with ANSI C2 National Electrical safety Code.

20. Do not lay a transformer on its side. To do so can possibly cause air to be trapped under the bottom of the coil when the transformer is again put in the upright position. This air can get trapped in between the layer insulation and could cause a coil failure.

21. Consult Environmental Protection Agency regulations before removing or disposing of oil or the transformer.

X. MAINTENANCE

WARNING: **IMPROPER OR INADEQUATE MAINTENANCE COULD RESULT IN REDUCED TRANSFORMER LIFE, CAUSE SEVERE PERSONAL INJURY, DEATH OR PROPERTY DAMAGE.**

Distribution transformers can be stored outdoors for two years or less when not in service. However, for longer storage period it is recommended that procedures of ANSI C57.93 be followed:

If a transformer has been removed from service, it is recommended the following inspections be made and repairs made where necessary:

1. Inspect bushings for cracks and leaks.

2. Inspect surge arresters for cracked porcelain and check the gap setting if the arrester has a gap between the arrester top terminal and the HV bushing terminal. If the arrester is connected directly to the HV bushing terminal, make sure the connections are tight.

3. Remove all rust from the tank and cover, prime the bare spots and then repaint them.

4. Inspect all gasket seals for possible leaks.

5. Check oil level. It should be within ½ inch of the oil level line inside the tank.

6. Check for any signs of moisture entering the tank at any of the gasketed joints.

7. If electrical tests are made, the values given in ANSI Standard C57.12.00 should not be exceeded.

XI. REPAIRS OR SERVICE

If any information on how to repair or recondition any of these transformers is needed, please contact the Power Partners office.

Power Partners, Inc.
Distribution Transformer Division
Athens, GA
ISO 9001:2008 Certified

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