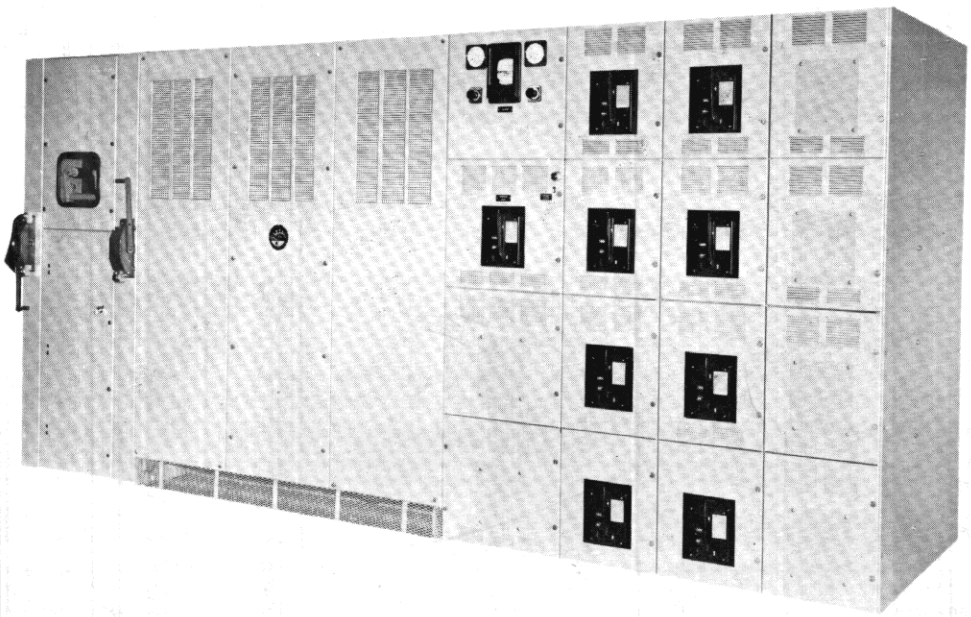
I-T-E Secondary Unit Substations
Low Voltage Metal Enclosed Switchgear
with Drawout Power Circuit Breakers



112½ — 2500 kVA
Primary Voltage: 2.4 kV — 13.8 kV
Secondary Voltage: 208/120 — 600 Volts
Indoor or Outdoor Sheltered-Aisle, Walk-In

GOULD-BROWN BOVERI

I-T-E SECONDARY UNIT SUBSTATIONS

WHAT IS A UNIT SUBSTATION?

A unit substation is a substation consisting primarily of one or more transformers which are mechanically and electrically connected to, and coordinated in design with, one or more switchgear or motor control assemblies, or combinations thereof.

SECONDARY UNIT SUBSTATION

A secondary unit substation is a unit substation in which the outgoing low-voltage section is rated below 1000 volts. Principal areas of application include use in industrial plants, electric power generating stations, and commercial buildings.

An articulated secondary unit substation is a common type of secondary unit substation consisting of:

- An incoming line section which provides for the connection of one or more incoming high-voltage circuits, each of which may or may not be provided with a switching device or a switching and interrupting device.
- A transformer section which includes one or more transformers.
- An outgoing section which provides for the connection of one or more outgoing feeders, each of which is provided with a switching and interrupting device.

These sections are normally subassemblies intended for connection in the field.

PURPOSE OF SECONDARY UNIT SUBSTATIONS

The trend towards location of electrical distribution systems close to the center of loads has become very prevalent in recent years. The secondary unit substation is compatible with this systems design concept because the wide array of components to select from allows tailoring it to your exact application needs. For example, the availability of askarel-filled and dry type transformers permit installation of secondary unit substations in buildings close to the load without the need of costly fire containment equipment. Secondary unit substations provide other benefits and advantages over older distribution methods:

- Reduced power losses.
- Improved continuity of service.
- Increased flexibility.
- Better voltage regulation.
- Less installation expense.
- Efficient space utilization.

FEATURES OF I-T-E SECONDARY UNIT SUBSTATIONS

Gould-Brown Boveri has been designing, engineering and manufacturing secondary unit substations since 1943. Throughout this long history of product manufacture, Gould-Brown Boveri has established itself as a reliable supplier of secondary unit substations. Some salient features of Gould-Brown Boveri secondary substations are:

- Lower transformer and switchgear weight.
- Reduced floor space.
- Increased personnel safety.
- Coordinated engineering.
- Simplified purchasing.
- Prompt delivery.
- Design flexibility.

SEISMIC REQUIREMENTS

The Low-Voltage, Metal-Enclosed Switchgear has successfully passed a seismic test plan which was prepared in accordance with IEEE Std. 344-1971. Extensive testing has been accomplished as recently as 1974, and certified test results are available.

QUALITY ASSURANCE

The Atomic Energy Commission has issued regulations pertaining to Quality Assurance Criteria for Nuclear Power Plants (10 CFR 50 Appendix B).

Further ANSI N 45.2-1971 defines Quality Assurance Program Requirements for Nuclear Power Plants.

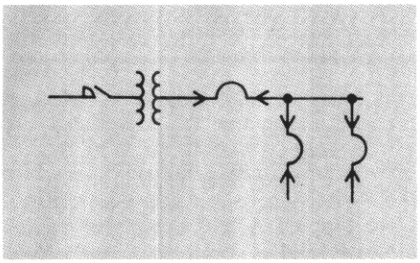
In addition, a working group has issued a draft of ANSI 45.2.14-1974 "Quality Assurance Program Requirements for the Manufacture of Class IE Instrumentation and Electrical Equipment for Nuclear Power Generating Systems." The last documentation has not been approved as yet but is being used as a guide

These documents are used as references in the implementation of the Gould-Brown Boveri Switchgear Division Quality Assurance Program. Our quality assurance organization is aligned with the basic criteria of the documents mentioned above.

NEC & OSHA REQUIREMENTS

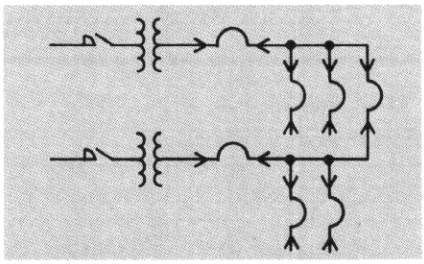
NEC generally describes parameters and techniques for a safe installation, which is also the concern of OSHA. Gould-Brown Boveri equipment is safe and reliable. If there are any questions regarding Gould-Brown Boveri equipment relative to above requirements, contact the Switchgear Division for latest information.

SELECT THE SYSTEM



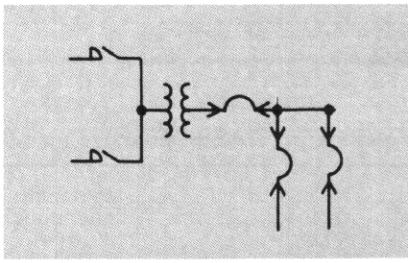
RADIAL

This system generally has a single incoming primary device, single stepdown transformer and an outgoing section for the connection of one or more outgoing power circuit breakers.



SECONDARY-SELECTIVE

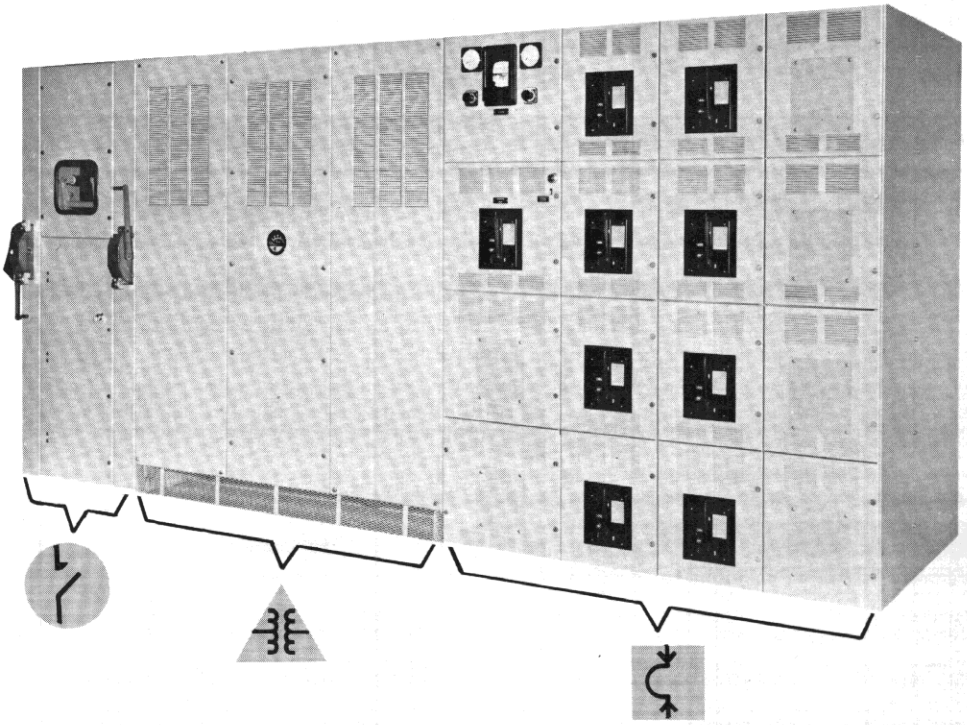
This system generally has two incoming primary devices and two stepdown transformers. The outgoing side of each transformer is connected to a separate bus through a power circuit breaker. The two sections of bus are connected by a normally open power circuit breaker. Each bus has one or more outgoing power circuit breakers.



PRIMARY-SELECTIVE

This system contains two incoming pr mary devices connected to a single ste down transformer and an outgoing sectio for the connection of one or more outg ing power circuit breakers.

SELECT THE COMPONENTS



INCOMING LINE SECTION

Air Interrupter Switch
- Fused or Unfused
- Single or Duplex

Air Interrupter Selector Switch
- Fused or Unfused

Air Terminal Chamber
Liquid Interrupter or Disconnect Switch
Oil Cutouts
- Fused or Unfused

Metal-Clad Switchgear

TRANSFORMER SECTION

Ventilated-Dry
Totally Enclosed Non-Ventilated Dry
Sealed-Dry, Gas-Filled
Liquid-Immersed
- Silicone
- Oil

OUTGOING SECTION

Low-Voltage, Metal-Enclosed Switchgear
- Drawout Air-Magnetic Power Circuit Breakers, Fused or Unfused
- Plug-in Molded-Case Circuit Breakers

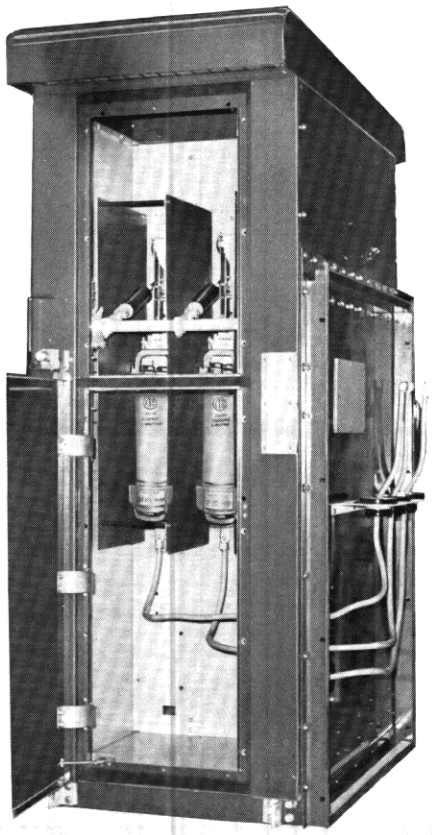
INDEX — SECONDARY UNIT SUBSTATIONS

INCOMING LINE SECTION

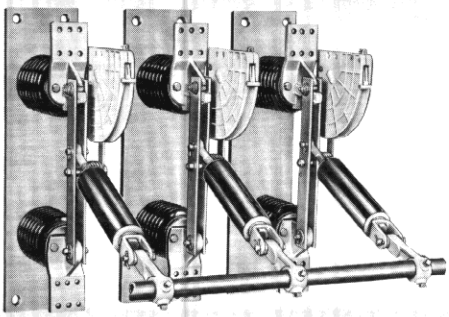
TABLE 1 — AIR INTERRUPTER SWITCH RATINGS

Nominal Voltage Rating, kV	Maximum Continuous Current Rating, A	Fault Closing Rating, kA Asym.	
		Switch* Unfused	Switch Fused
4.8	600	40	Fuse Interrupting Rating (see Table 35, Page 32)
7.2	600	40	
13.8	600	40	

* 61 kA is available.



Outdoor Air Interrupter Switch



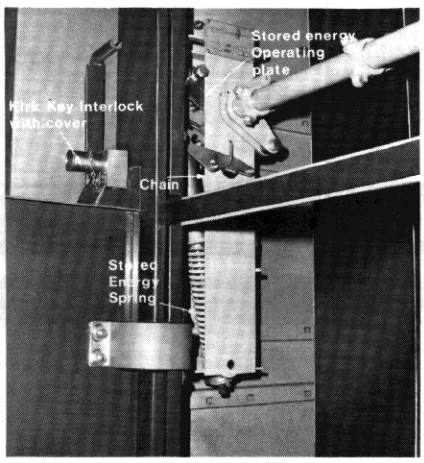
Three-Phase HPL-C Switch Assembly.

AIR INTERRUPTER SWITCH— SINGLE OR DUPLEX

The I-T-E type HPL-C air interrupter switch is a stationary mounted, three-pole, two-position (on-off) device which utilizes a snap-action quick-make, quick-break blade in combination with an arc chute for safe closing and interruption. It is available with or without current-limiting fuses. Visual indication through the safety-glass front window and on the handle mechanism shows the blade position. Fused switches are Kirk™ key interlocked to prevent opening of the fuse door while the switch is in the closed position. I-T-E type CL-14 current-limiting fuses are provided as standard. Fused or unfused switches are available with or without lightning arresters, can be equipped with cable lugs or potheads, and can be arranged for top or bottom entrance. (Lightning arresters are required for use with ventilated-dry type transformers).

Duplex switches are also available, consisting of two Kirk key-interlocked switches located side by side. These various switch assemblies are available in both indoor and outdoor construction, and can be applied to Secondary Selective or Primary Selective Systems.

For complete information on this type equipment refer to Bulletin 8.1-1.

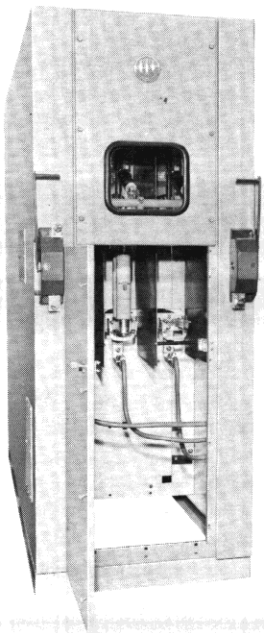


Stored-Energy Operating Mechanism.

Note: For complete information on HPL-C switches see Bulletin 1630-1; for CL-14 fuses see Bulletin 14.1- 2.

AIR INTERRUPTER SELECTOR SWITCH

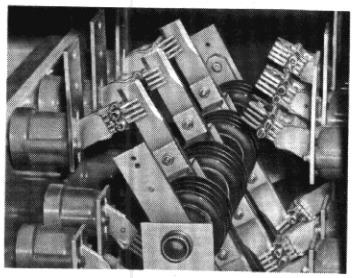
The air interrupter selector switch consists of a stationary rear-mounted, three-pole, two-position (Line 1—Line 2) switch, in series with a three-pole, two position (on-off) I-T-E type HPL-C interrupter switch. Visual indication on the front-mounted handle mechanism indicates Line 1 or Line 2.



The selector switch is Kirk™ key interlocked with the interrupter switch to prevent switching of lines with the load connected.

Fused arrangements are Kirk key interlocked to prevent opening of the fuse door while the interrupter switch is in the closed position. I-T-E type CL-14 current-limiting fuses are provided as standard. Fused or unfused switches are available with or without lightning arresters. Equipment may be supplied with cable lugs or potheads and arranged for top or bottom entrance. (Lightning arresters are required for use with ventilated-dry type transformers.

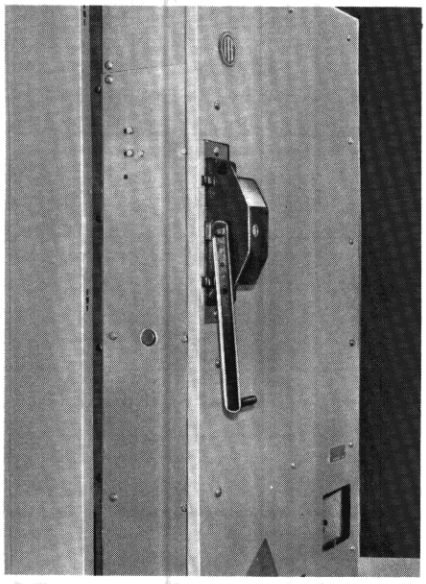
The selector arrangement is available in both indoor and outdoor construction, and is generally installed in Primary Selective systems.



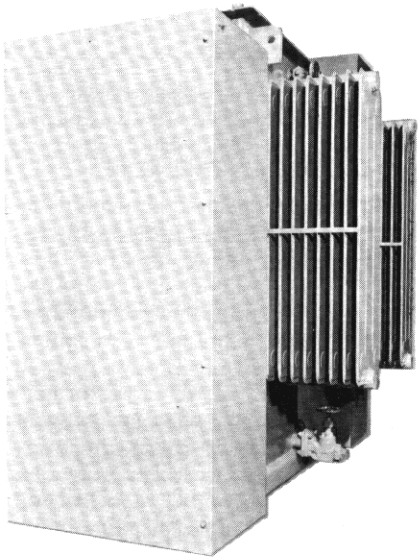
Cutaway of 3-pole selector switch shows blade positioned for connection to one incoming line.

HPL-C DRAWOUT LOAD BREAKER

The load-breaker is a 600A, 15kV maximum, three-pole, two-position (on-off) device which utilizes snap-action, quick-make, quick-break contacts. It is available with or without fuses.

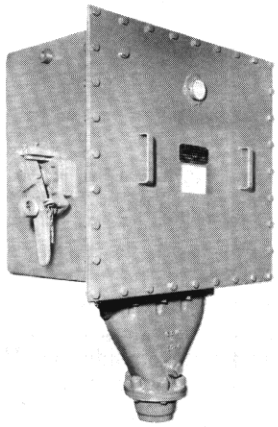


HPL-C Drawout Load Breaker



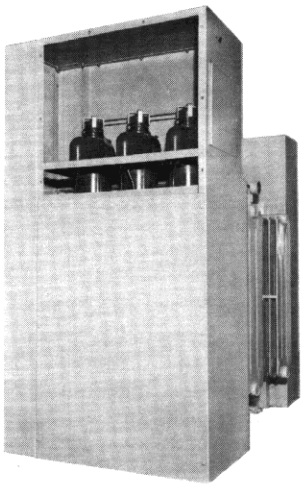
AIR TERMINAL CHAMBERS

Floor-mounted air terminal chambers come equipped with cable lugs or potheads and are directly connected to the high-voltage side of the transformer. They are available in indoor or outdoor construction, and can be arranged for top or bottom entrance.



LIQUID INTERRUPTER OR DISCONNECT SWITCH (OIL)

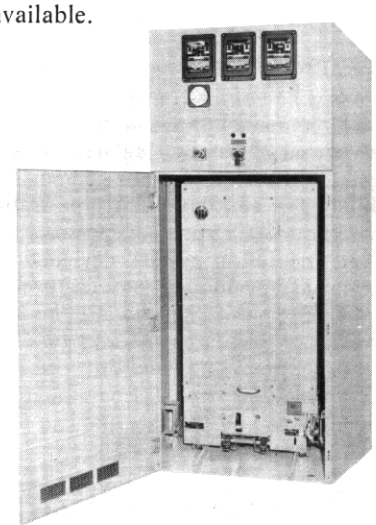
These switches can be provided on liquid-immersed transformers only. They are three-pole, two- or three-position assemblies. The switch enclosure is welded or bolted directly to the transformer tank. The switch can interrupt load currents up to 400 amperes. Potheads are always provided for cable terminations. Oil is shipped in a separate container to eliminate the need of draining the switch to make cable connections.



OIL CUTOUTS— FUSED OR UNFUSED

Oil cutouts are supplied mounted i an air terminal chamber and have pro visions for terminating one three phase incoming cable. When fused application of oil cutouts are limited to 500kVA at 2400 volts and 750kV at 4160 volts and 1000kVA at 13.8kV Unfused application as disconnects ar limited to 750kVA at 2400 volts o 1000kVA at 4160 volts and 2000kV at 13.8kV. Values are based on apply ing fuses at twice the full-load curren rating of the transformer.

Indoor or outdoor construction i available.



METAL-CLAD SWITCHGEAR

For the ultimate in primary protection and personnel safety, specify I-T-E type HK metal-clad switchgear with stored-energy, drawout power circuit breakers.

HK switchgear is available for systems ratings of 4.16, 7.2 and 13.8kV, 75 to 1000MVA. For complete information on this type equipment, refer to Bulletin 8.2-1.

TRANSFORMER SECTION

SELECT FROM FOUR TYPES OF I-T-E TRANSFORMERS.

112½ to 5000kVA
Primary Voltage: 600V to 13.8kV
Secondary Voltage: 208Y/120-600 volt

GENERAL

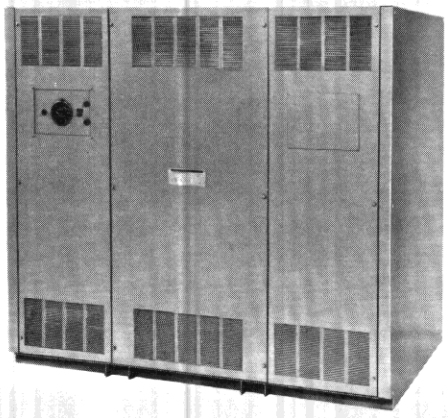
Air as a cooling medium for transformers has a long history. Today, it is coming back into its own as liquid collants prove to be health hazards or coolants prove to be health hazards or fire hazards.

In recent years, air-cooled—or dry type—transformers have been improved to meet the demands placed on them by utilities and industrial users. Dry-type transformer technology has made important advances. New insulating materials have been developed, tested and incorporated into transformers. New gases have been developed for sealed dry transformers—gases which insulate and cool more efficiently than nitrogen. Environmentally approved dry-type transformers have become more compact and more efficient so that they offer all the advantages once thought to belong only to environmentally hazardous liquids.

For more than thirty years, the Switchgear Division of Gould-Brown Boveri has been in the forefront of developments in dry-type transformer technology. Under the respected name of I-T-E, dry-type transformers for secondary unit substations have become a standard for the industry.

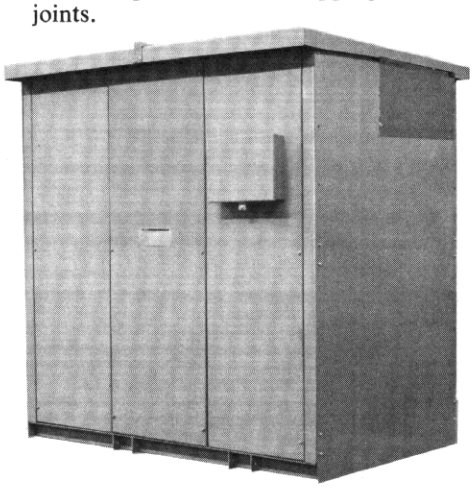
VENTILATED-DRY

A ventilated-dry transformer is one in which the windings are cooled by the natural circulation of ambient air through the transformer enclosure. While I-T-E ventilated-dry type transformers utilize a superior moisture resistant insulation system designed to operate at an average temperature of 150°C such units should not be applied in an area where heavy or conducting contaminates exist in the air. Ventilated type transformers feature reduced size and weight; and are fire, explosion and toxic resistant.



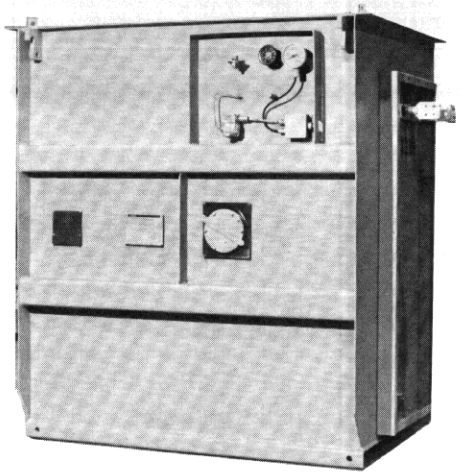
TOTALLY ENCLOSED NON-VENTILATED DRY

I-T-E totally enclosed non-ventilated dry type transformers are constructed without vent openings, making them highly resistant to contaminants in the air and severe atmospheric conditions. Suitable for both outdoor and indoor use, this type of transformers may be installed where askarel transformers had been installed in the past. The enclosures have slanted roofs with overhangs for added weather protection and panels are bolted construction with complete weather-stripping of all joints.



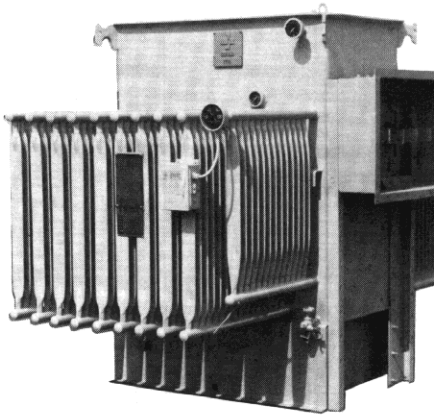
SEALED-DRY

The windings of the standard I-T-E sealed-dry transformers are immersed in a fluorocarbon gas which is contained in a sealed tank to prevent intermingling with outside air. The gas acts as an efficient heat transfer agent and dielectric medium. Sealed-dry transformers are generally applied indoors but can also be utilized outdoors.



LIQUID-IMMERSED

Liquid-immersed transformers have their core and coil immersed in either flammable mineral oil or a high fire point insulating liquid. The oil immersed transformer is generally applied outdoors but may also be used indoors when located in a vault designed to avoid fire hazards. It is operated at 65°C rise and features lightweight and compact size. The high fire point liquid immersed transformer is intended for use outdoors or for indoor application without vaults. Similar to the oil immersed type in construction, the insulating liquid has a fire point above 300°C but if ignited, the flame is non-propogating.



In meeting a variety of requirements, ranging from industrial plants to nuclear generating stations, Gould-Brown Boveri has developed and implemented a highly sophisticated quality assurance program.

I-T-E transformers exceed all of the normal requirements of ANSI, NEMA and IEEE. Designs have been short circuit tested to assure an adequate, reliable service life for any application.

The selection and application of transformers can be a complex, time consuming process. For those not thoroughly familiar with the subject, the Switchgear Division stands ready to help. If you have any problems, or require application engineering assistance, please contact your nearest Gould-Brown Boveri District Sales Office or the Switchgear Division, Transformer Department, Spring House, Pennsylvania.

TABLE 2 — STANDARD TRANSFORMER RATINGS

TYPE	Primary Voltage Delta	kVA 3-Phase Fan-Cooled	kVA 3-Phase Fan-Cooled	SECONDARY VOLTAGE		Standard Impedance* % IZ	NEMA Sound Level, db	
				208Y/120 240 delta	480Y/277 480 delta		Self-Cooled	Forced-Air Cooled
Ventilated-Dry and Totally Enclosed Non-Ventilated	2400	112½	—	x	x	3.0‡	50	—
	4160	150	—	x	x	3.5‡	50	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	667	x	x	5.0	60	67
	12000	750	1000	x	x	5.75	64	67
	12470	1000	1333	x	x	5.75	64	68
	13200	1000	1333	—	x	8.0	64	68
	13800	1500	2000	—	x	5.75	65	69
		2000	2666	—	x	5.75	66	71
		2500	3333	—	x	5.75	68	71
Sealed-Dry Gas-Filled 150°C Rise †	2400	300		x	x	5.0	57	—
	4160	500		x	x	5.0	59	—
	4800	750		x	x	5.75	63	—
	6900	1000		x	x	5.75	63	—
	7200	1000	—	—	x	8.0	63	—
	12000	1500		—	x	5.75	64	—
	12470	2000		—	x	5.75	65	—
	13200	2500		—	x	5.75	66	—
	13800							
Liquid-Immersed Oil or Silicone 65°C Rise †	2400	112½	—	x	x	2.25‡	55	—
	4160	150	—	x	x	3.0‡	55	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	—	x	x	5.0	56	—
	12000	750	862	x	x	5.75	58	67
	12470	1000	1150	x	x	5.75	58	67
	13200	1000	1150	—	x	8.0	58	67
	13800	1500	1725	—	x	5.75	60	67
		2000	2300	—	x	5.75	61	67
		2500	3125	—	x	5.75	62	67

* Standard impedance tolerance is ±7½%. † For application where the average ambient temperature is 30°C.
‡ Transformers with impedances of 4.0% or less are designed to withstand 25 times normal current for two seconds.

CHARACTERISTICS COMPARISON

Table 3 below provides an easily comprehensible framework for comparing pertinent capabilities of liquid-immersed, ventilated-dry, totally enclosed non-ventilated and sealed-dry transformers. A standard oil-immersed transformer rated 1500 kVA, 13.8 kV to 480 volt, was chosen as the base transformer because of its common usage in secondary unit substations. Approximate values of various base transformer characteristics.

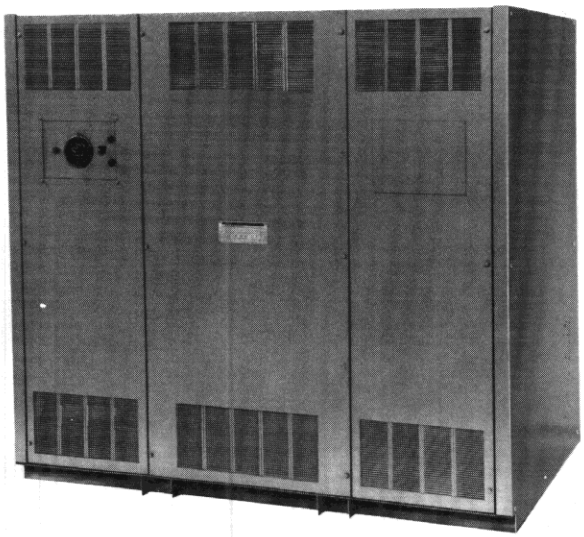
Sound level (self-cooled)—60db
Weight—8,700 lbs.
Floor space—55″ Wide x 87″ Deep
Height—80″

TABLE 3—COMPARISON OF TYPICAL CHARACTERISTICS OF SECONDARY UNIT SUBSTATION TRANSFORMERS

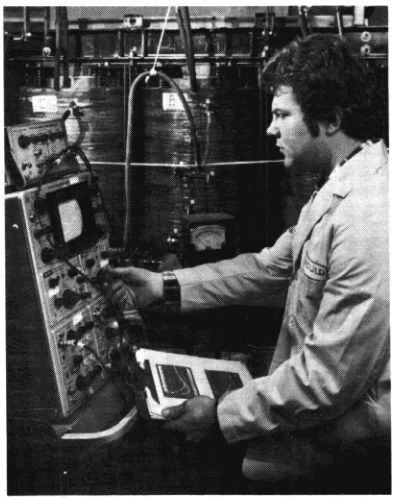
1500 kVA, 13.8 kV to 480 Volts, Oil-Immersed Transformer as Base (See above)

Characteristics	Liquid-Immersed 65°C Rise		Ventilated-Dry 150°C Rise	Totally Enclosed Non-Ventilated	Sealed-Dry 150°C Rise
	Oil	Silicone	Air		Gas
Impulse Strength	95 kV	95 kV	60 kV	60 kV	95 kV
Losses @ operating temp. (20°C Ambient) No Load Full Load	100% 100%	100% 100%	160% 130%	160% 110%	120% 110%
Temperature Ratings: Average Rise°, C Hottest Spot Rise°, C	 65 80	 65 80	 150 180	 150 180	 150 180
Sound Level—Decibels	60	60	65	65	64
Weights	100%	100%	78%	93%	155%
Dimensions: Floor Space Height	100% 100%	100% 100%	110% 112%	106% 100%	123% 130%
Application: Indoor, Outdoor	Indoor (vault only) Outdoor	Indoor Outdoor	Indoor (Limited)	Indoor Outdoor	Indoor Outdoor
Fire, Explosion Resistant	No	Yes	Yes	Yes	Yes
Toxic Resistant	No	Yes	Yes	Yes	Yes
Maintenance: Liquid Cleaning Internal External	Yes No Normal	Yes No Normal	No Yes Occasionally	No Yes Occasionally	No No Normal
Cost	100%	150%	125%	156%	200%

VENTILATED-DRY TYPE TRANSFORMERS



- Moisture-resistant insulating materials
- Reduced size and weight
- Indoor application
- Toxic resistant
- Fire and explosion resistant



Each transformer design has been short circuit tested to assure an adequate, reliable service life for any application.

DETAILS OF CONSTRUCTION

CORE CONSTRUCTION

The core construction of each I-T-E transformer is made of non-aging, high-permeability, grain-oriented, cold-rolled, silicon steel specifically processed for consistently low losses.

The thin-gauge laminations are sheared with special high-quality shear blades in such a manner that the flux path will be aligned with the axis of highest permeability in the steel. Each lamination is flat and free from burrs and is inorganically insulated on both surfaces to minimize eddy-current losses.

Laminations are hand stacked on a specially designed table which ensures flatness and prevents the introduction of bending stresses while the finished core is being set in an upright position. Careful positioning of each lamination produces close fitting joints to fully minimize core loss and noise.

Core legs are assemblies of laminations with cross sections designed to accommodate the coils with the optimum combination of high space factor and air flow.

COIL CONSTRUCTION

The coil may be of rectangular or circle construction depending upon the kVA size. Where possible rectangular construction is used with sheet-wound aluminum secondary windings and insulated, wire-wound primary windings. This construction meets the following requirements:

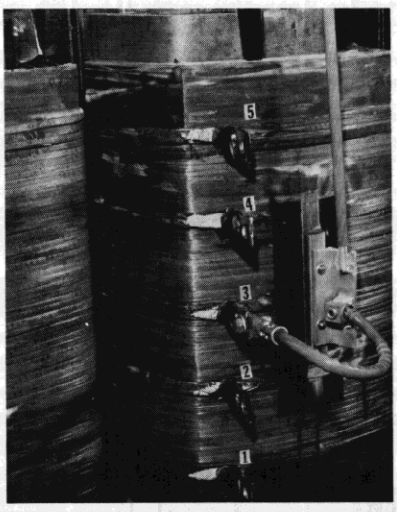
1. Stresses: Where sheet windings are employed axial short-circuit stresses are virtually eliminated. The primary is wound directly on the low-voltage winding with a suitable insulating barrier between the coils consisting of spacers and sheet insulation built up to the proper thickness.
   Where the coils are wire wound adequate bracing is supplied at the end of the coils to assure full short circuit capability. Primary coils may also be of the disk or random type construction with suitable spacers to provide coil to coil cooling and insulation.
   All coils are dried and compressed in preparation for varnish impregnation. A suitable varnish for the temperature rating of the unit is applied by dipping to provide a coil with moisture and dirt resistance. Extreme care is taken to avoid tiny air pockets in the coils where corona might start.
   After dipping the varnish is completely cured in ovens to achieve the highest possible dielectric strength.
2. Cooling: Cooling is achieved by cooling ducts in both the primary and secondary coils. When forced air cooling is required the air is directed through the cooling ducts to achieve the forced air rating.

INSULATING MATERIAL

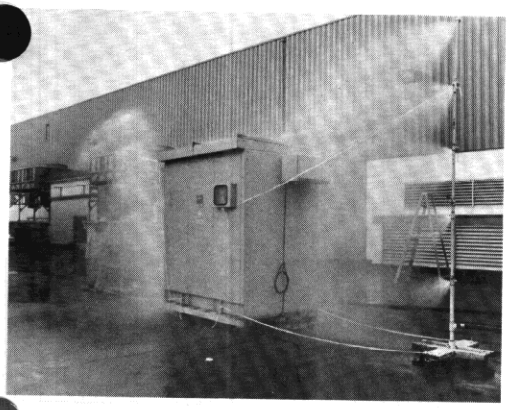
All insulating materials used have been thoroughly tested and proven with respect to their electrical or mechanical characteristics and are stable at operating temperatures and compatible with the cooling medium. All wire is Nomex paper-wrapped. All other insulating material in the core and coil is chosen for the temperature system of the transformer and capability for that point of application.

TAPS

Taps are applied on the face of the coil for link or cable connection to provide for adjustment in the primary winding to accommodate system voltage.

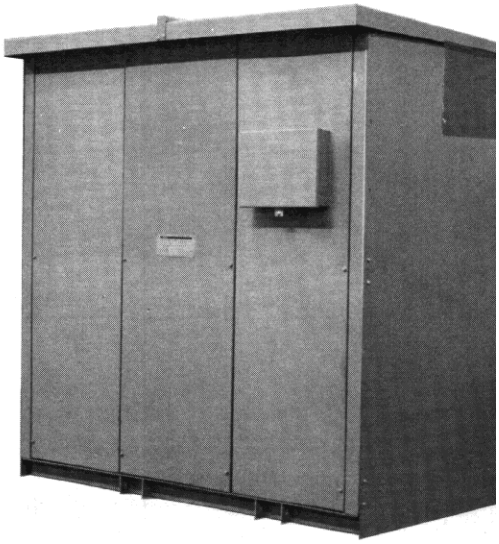


TOTALLY ENCLOSED NON-VENTILATED DRY TRANSFORME



Totally enclosed outdoor transformer being tested to meet the requirements of ANSI C37.20 and UL 891.

- Resistant to severe atmospheric conditions
- Fire and Explosion resistant
- Toxic resistant
- Minimum maintenance
- Indoor and Outdoor application



DETAILS OF CONSTRUCTION

CORE CONSTRUCTION

Each I-T-E transformer core is designed and built for optimum performance and long reliable life. To achieve these objectives, the core is made of non-aging, high-permeability, cold-rolled steel specifically processed for consistently low losses.

Thin-gauge laminations are sheared with special shear blades to assure that the flux path will be aligned with the axis of highest permeability in the steel. Each lamination is flat and free from burrs and is inorganically insulated on both surfaces to minimize eddy-current losses.

Laminations are hand stacked on special fixtures which insure flatness and prevent the introduction of bending stresses when they are set upright. Careful positioning of each lamination produces close fitting joints to minimize core loss and noise.

Core legs are assemblies of laminations with cross sections designed to accommodate the coils with the optimum combinations of high space factor and air flow.

COIL CONSTRUCTION

The coil may be either rectangular or circular construction depending on the KVA size. Wherever possible, rectangular construction is used with sheet wound aluminum secondary windings and with insulating wire wound primary windings. This construction virtually eliminates axial short circuit stresses. The primary winding is wound vertically on the low voltage winding with an insulation barrier between the coils consisting of spacers and sheet insulation built up to the proper thickness.

On wire wound coils, adequate bracing is supplied at the end of the coils to assure short circuit capability. Primary coils may be disk or random type construction with suitable spacers to provide coil-to-coil cooling and insulation.

In preparation for varnishing and vacuum impregnation, all coils are dried and compressed. A suitable varnish for the temperature rating of the unit is applied by dipping to provide a coil with moisture and dirt resistance. Extreme care is taken to avoid tiny air pockets in the coil where corona might start.

After dipping, the varnish is oven dried for eight hours to achieve optimum dielectric strength.

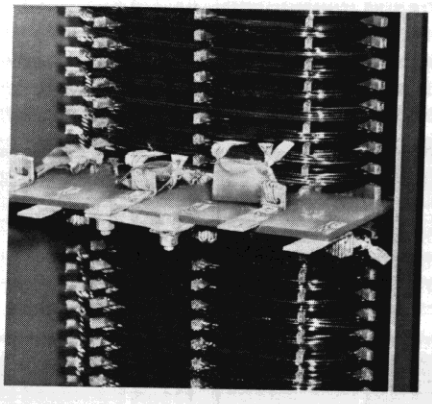
Cooling is accomplished in all totally enclosed non-ventilated dry transformers by generous cooling ducts in both the primary and secondary coils. When forced air cooling is required, the air is directed through the cooling ducts to achieve the forced air rating.

INSULATING MATERIAL

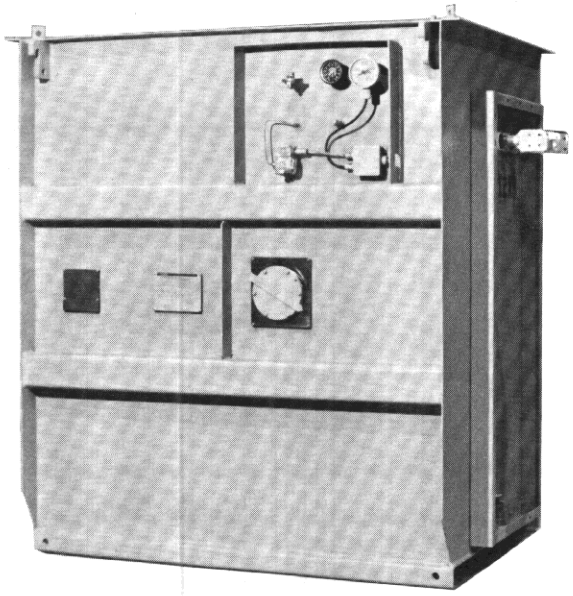
All insulating materials used have been thoroughly tested and proven to provide optimum transformer life and high service reliability. Insulating materials used are DuPont Nomex Aramid paper, high temperature polyester varnish and high temperature polyester glass laminate, recognized by UL as acceptable components in a 220°C insulation system. Ample air ducts are located strategically where they will cool most effectively, and furnish reliable insulation.

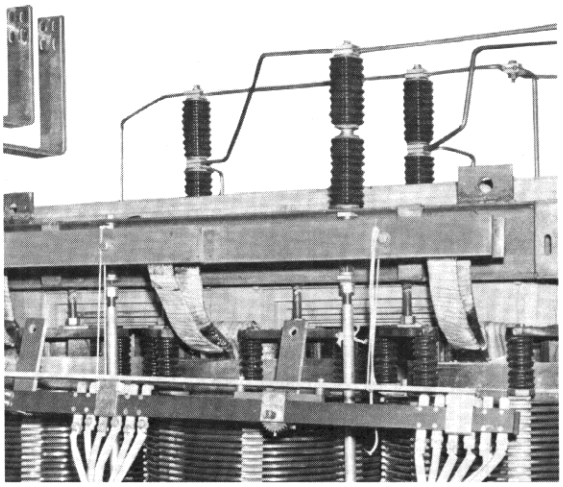
TAPS

Taps are applied on the face of the coil for link, or cable connection to provide for adjustment in the primary winding to accommodate system voltage.



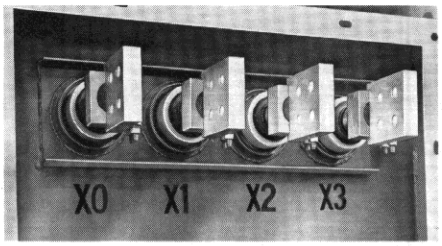
SEALED-DRY TRANSFORMERS



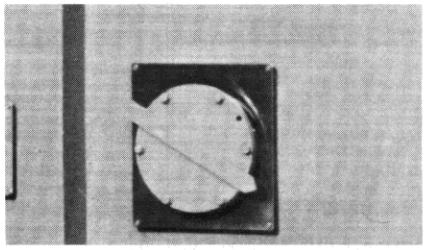


Core and coils—Sealed Dry Assembly

- Fluorocarbon gas
- Liquid filled dielectric levels
- Minimum maintenance
- Toxic resistant
- Fire and explosion resistant



Bushings



Tap Changer

DETAILS OF CONSTRUCTION

CORE CONSTRUCTION

The core construction for sealed-dry type transformers is similar to both the liquid-filled and ventilated-dry type transformers. The major exceptions being where a circular coil is applied.

Where a circular coil design is applied a cruciform core is used to achieve a high space factor.

COIL CONSTRUCTION

The coil construction for sealed-dry transformers is similar to the coil construction of the ventilated type transformers. Generally, circular coils are applied with disk type primary coils.

TAP CHANGER

A tap changer of the in-line type is supplied with an operating mechanism extending through the tank wall with a sealing means to prevent the loss of gas from the unit.

FLUOROCARBON GAS

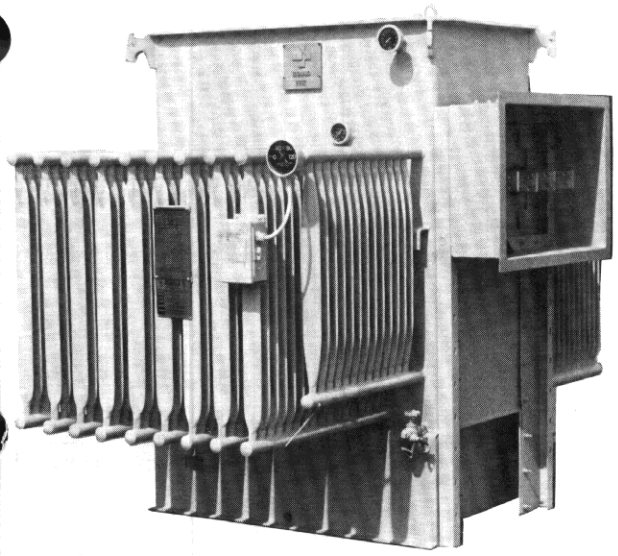
Fluorocarbon gas is applied as the dielectric medium for sealed dry type transformers. Such gases have a dielectric capability in excess of 2 times the dielectric capability of air. This high dielectric capability results in dielectric levels normally achieved in liquid-filled transformers.

In addition to being an excellent dielectric medium the gas has good heat transfer capability due to its higher molecular weight. In comparison to nitrogen the use of the fluorocarbon gas permits a smaller tank and a lighter unit for the same rating.

TANK

The tank of the sealed-dry type transformer is similar in construction to the liquid filled type. It, however, is designed to withstand 15 lbs. pressure or vacuum. Other features include; protective instrumentation, external stiffeners and welded bushings.

LIQUID-IMMERSED TRANSFORMERS



- Proven insulation system
- Low operating temperature
- Low sound level
- Lighter weight
- Less floor space
- Constant bushing height

ADDITIONAL FEATURES

Top Sampling Plug

Padlockable No Load Tap Changer

Mechanical Relief Device is — Optional

Welded Tank Cover

Pressure Vacuum Gauge (Optional)

Dial Type Thermometer

Magnetic Liquid Level Gauge

Lifting Hooks and Loops

High Voltage Sealed Cast Resin Bushing

Stainless Steel Diagrammatic Nameplate

LV and HV Close Couple Molding

Provision For Forced Air Cooling

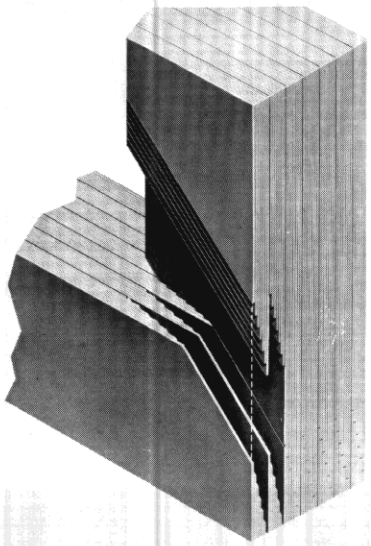
Upper Filter Press Connection (Not Visible)

One Inch Drain Valve With 3/8 Inch Sampler

Base

Copper Faced NEMA Ground Pad

DETAILS OF CONSTRUCTION



CORE CONSTRUCTION

The core of each I-T-E transformer is made of non-aging, high permeability, grain-oriented, cold-rolled, silicon steel specifically processed for optimum loss and noise performance.

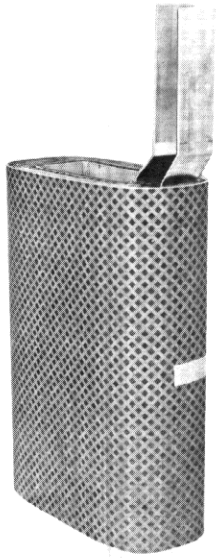
The thin gauge laminations are sheared with special high quality shear blades in such a manner that the flux path will be aligned with the axis of highest permeability in the steel. Each lamination is flat and free from burrs and is inorganically insulated on both surfaces to minimize eddy-current loss.

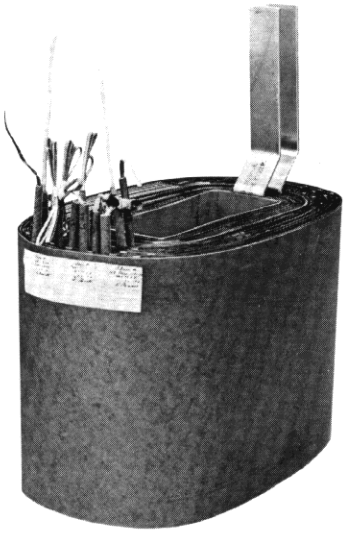
Core legs are assemblies of laminations with cross sections designed to accommodate the coils with the optimum combination of high space factor and coolant flow.

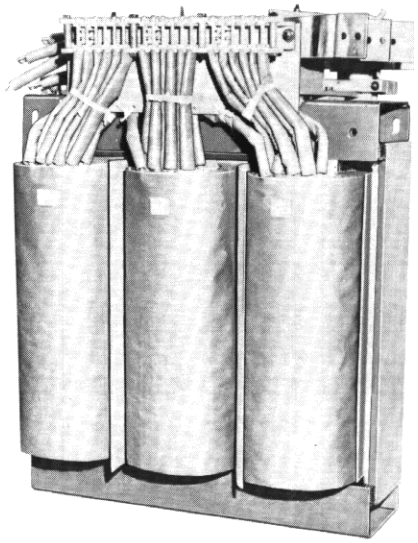
The upper and lower core yokes are rigidly clamped by welded assemblies of steel members consistent with bracing and supporting requirements. Core clamps are chemically cleaned to remove any dirt or impurities from the forming and welding operations. This assures that only clean, bright metal will be in contact with the cooling medium. Core clamps and all structural parts are insulated to prevent local circulating currents and are solidly bonded to ground and to the core to prevent development of potential in any part.

LIQUID-IMMERSED TRANSFORMERS

DETAILS OF CONSTRUCTION







COIL CONSTRUCTION

The coil is of rectangular construction with sheet wound aluminum secondary windings and insulated wire wound aluminum primary windings. This construction meets the following requirements:

1. Stresses: Axial short-circuit stresses are virtually eliminated by the use of sheet-wound secondary and wire wound primary windings with no interleaved components. Coils are, therefore, wound with the secondary coil nearest the core and supported by a strong insulating cylinder. The primary is wound directly over the secondary coil with a suitable insulating full-length barrier between the primary and secondary windings. The coil wire is wound tightly and uniformly thru a tension device to insure maximum short-circuit strength.
   Short circuit tests have been made on completed units in accordance with the latest test code for short circuit testing prepared by the IEEE Transformer Committee.
2. Cooling: The coils are equipped with cooling channels in both the high and low voltage windings in order to dissipate the heat generated in the coils. Sufficient cooling ducts are located throughout the coils to avoid hot spots in winding and to assure overload capability.

INSULATING MATERIAL

All insulating materials used have been thoroughly tested and proven with respect to their electrical and mechanical characteristics and are stable at operating temperatures and compatible with the cooling medium.

In liquid-filled transformers, the insulation system is thermally upgraded. It is chemically modified to resist the effects of high temperature. The improved insulation enables the new, compact transformers to maintain full load-carrying ability at their higher operating temperature without affecting life expectancy.

Thermally-upgraded pressboard insulation is used for coil spacers, both longitudinal and radial, as well as ends. It is also used between layers and between high- and low-voltage coils. The porosity of the insulating materials permits the insulating liquid to penetrate the insulating materials giving it a high dielectric strength.

TAP CHANGER

The externally operated tap changer provides positive sequence line voltage changes under no-load conditions. The in-line assembly features through-type stationary contacts rigidly supported by a molded plastic channel. Moving contacts are spring loaded, silver plated copper which move along the stationary line by means of a rack and pinion.

The design has no rivets, bolts or nuts, thus assuring the proper contact of current carrying parts when taps are changed.

TANK

The transformer tank is fabricated of heavy-gauge steel plates. A minimum number of plates are used to reduce the number of welded seams.

Formed structural members are welded to the side walls so that the complete tank will be sufficiently reinforced to withstand a test pressure 75% greater than normal operating pressure. The top of the tank is fully strengthened by a flange which secures the tank cover. An asbestos-type gasket is provided between the reinforced cover and the top flange and is compressed during the welding operation to prevent weld spatter from entering the tank. Lifting hooks are provided at the corners of the tank to permit the finished transformer to be handled by a crane.

Cooling tubes assure that the temperature rise of the liquid will not exceed the specified limit when the transformer is continuously operated at full load.

The entire tank is chemically cleaned before painting to remove any impurities from the forming and welding operation. Each tank is painted with a rust inhibiter prime coat and finished coat in accordance with ANSI standards.

A flange is provided on the primary and secondary sides of the transformer for bolting to the primary and secondary sections to provide an uninterrupted lineup of equipment without openings.

TRANSFORMER TESTING AND ACCESSORIES

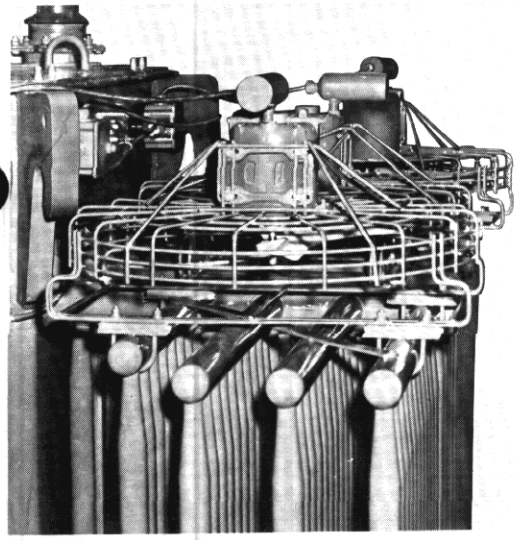
Throughout the manufacturing process and prior to shipment, all I-T-E transformers are thoroughly inspected and tested. The Switchgear Division's quality assurance standards ensure the operation of I-T-E transformers to be continuous and trouble-free wherever installed.

The following tests are made on all transformers. All tests are made in accordance with the latest revision of ANSI Test Code for Transformers.

- Quality control impulse test
- Induced potential tests
- Applied potential tests
- Resistance measurements of all windings on the rated voltage connections of each unit and at the tap extremes of one unit only of a given rating on an order.
- Ratio tests on the rated voltage connection and on all tap connections.
- Polarity and phase-relation tests on the rated voltage connection.
- No-load loss at rated voltage connection.
- Exciting current at rated voltage on the rated voltage connection.
- Impedance and load loss rated current on the rated v age connection of each and on the tap extremes one unit only of a given ra on an order.
- Temperature tests are m only on new designs. A rec of temperature test data m in accordance with ANSI s dards are not available o duplicate or essentially du cate unit.

Also, when a transformer is supp with fans, temperature data with fans operating are included.

PROVISIONS FOR FUTURE FORCED-AIR COOLING

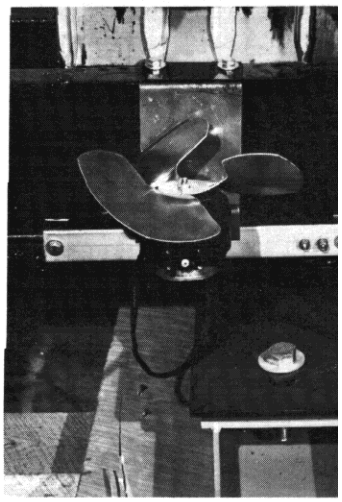


Typical Radiator Fan Installation—Liquid-Immersed Transformer.

All liquid-immersed transformers, 750kVA and above, and ventilated-dry transformers 500kVA and above, have provisions for the future installations of fans for forced-air cooled operation.

These provisions include:

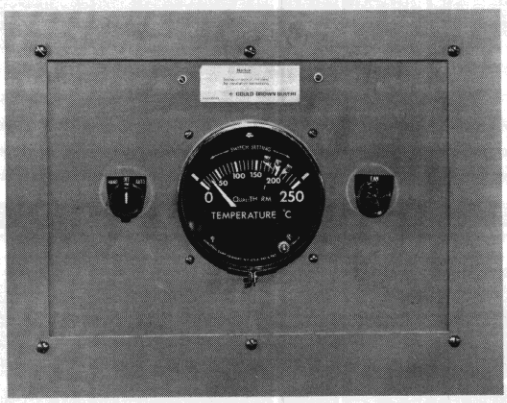
1. *Full forced-air cooled capacity in all* current-carrying parts, including high-and low-voltage bushings.
2. Provision for mounting the balance of required equipment in the field.
3. Provision for the future automatic control *of the fans as follows:*
   a. Liquid-immersed units—provision for incorporating a thermometer with contacts for control of the future fans from top liquid temperature.
   b. Ventilated-dry units—provision only for mounting winding-temperature relay for control of future fans.
4. Control Voltage 240V A.C.



Typical cooling-fan option ava on ventilated-dry and totally enc non-ventilated dry transformers.

OPTIONAL ACCESSORIES

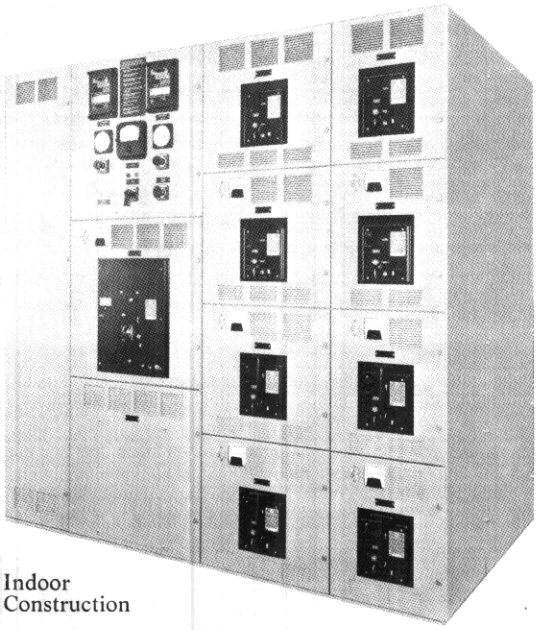
Winding-temperature equipment
Gas absorbers for askarel-filled transformers
Tap changer interlocks for liquid-immersed and sealed-dry transformers
Alarm contacts for:
  Thermometer
  Liquid-level gauges
  Pressure-relief device
Sudden-pressure relay on liquid-immersed transformers



Typical winding temperature indica

OUTGOING SECTION

LOW-VOLTAGE SWITCHGEAR



Indoor Construction

Weatherproof Walk-In Construction

Compact I-T-E low-voltage metal-enclosed, drawout switchgear features time-tested, field-proven manually or electrically operated stored-energy K-LINE® and K-DON® air-magnetic power circuit breakers. The standard design offers various size circuit breakers mounted in 4-high compartments (see page 30 for low-voltage switchgear arrangements). In addition, modern insulating materials with high strength-to-weight ratios allow significant reduction in weight and floor space.

INDOOR CONSTRUCTION

Free-standing, indoor units offer complete isolation of breaker and instrument compartments. The versatility of compartments, frames and breaker ratings enables meeting your exact application requirements. Notice the semi-flush circuit breaker handles do not project into the aisle, thereby reducing accidental breakage or false tripping. Also each feeder may be equipped with a panel-mounted ammeter and pushbutton phase selector for convenient reading.

WEATHERPROOF WALK-IN CONSTRUCTION

Weatherproof walk-in construction provides all-weather protection when the switchgear must be located outdoors. The same arrangement principles are used in weatherproof as in standard indoor construction. In addition, this construction provides approximately three feet of aisle space on the breaker side to protect equipment and personnel from inclement weather. Also provided are large areas at the top and bottom of each frame for cable entry. Large working area is provided in the rear compartment for pulling and connecting cables.

Standard outdoor construction provides:

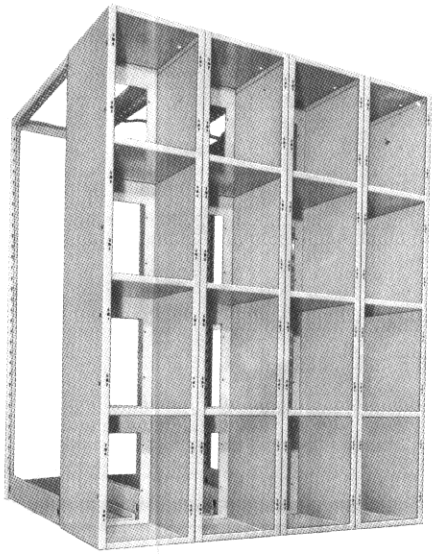
1. Manually-operated lifting device.
2. Filtered louvers and vents, front and rear.
3. Strip heaters to reduce condensation.
4. Convenience outlets and interior lighting.
5. Weatherproof gasketing throughout.

A control-power transformer may be mounted in an auxiliary compartment, if required, to furnish power to outlets and strip heaters.

TABLE 4 — SWITCHGEAR RATINGS

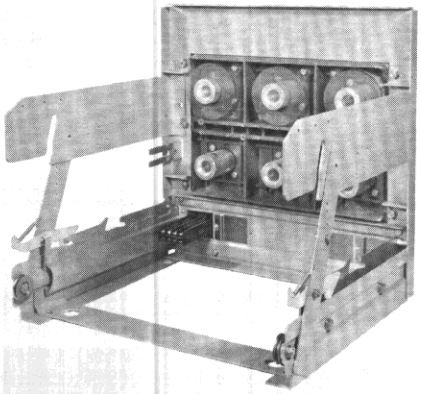
Switchboard Construction	① Circuit Breaker Type	Nominal Voltage Rating, V	Maximum Design Voltage, V	Maximum Continuous Current Rating, A	Insulation Levels, kV	Limit of Hottest Spot	
					Power Frequency Withstand (rms)	Temp. Rise (°C)	Total Temp. (°C)
Indoor	K-LINE	600	630	4000	2.2	65	105
Outdoor	K-DON	600	600	1600	2.2	65	105

① Available breaker ratings are listed on Page 18, Tables 5 and 6.



SWITCHGEAR FRAME

Individual frame consists of a bus and cable area and up to four circuit breaker compartments. Switchboards are assemblies of multiple individual frames. Each frame is welded in a fixture which assures rigid construction, strong enough to support switching equipment. Frames are erected and securely bolted to each other. This type of construction permits versatility in selecting unit sizes for shipment and duplicate manufacturing ensures complete interchangeability in field installations.



CIRCUIT BREAKER CRADLE

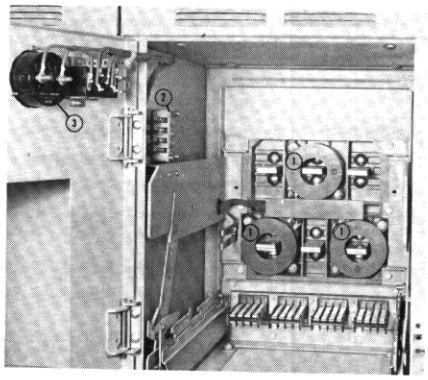
A cradle comprises main and secondary separable contacts, current transformers (if required) and all other drawout mechanisms in a complete jig-welded rigid assembly. There is no dependence upon the switchboard frame for any critical alignment. Any size cradle can be installed into any compartment of its own size or larger. Blank compartments not required for other functions may be converted to a circuit-breaker compartment by the installation of a cradle and necessary riser bus modifications.

CIRCUIT-BREAKER COMPARTMENT

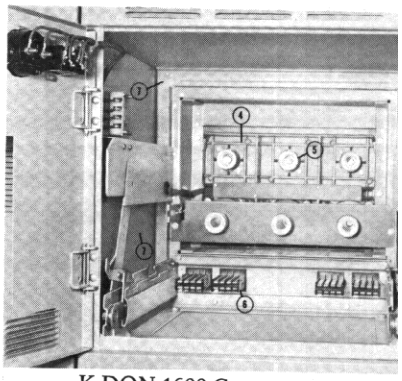
All individual circuit-breaker compartments are isolated from each other and from the bus area. Front door louvered grilles are scientifically designed to allow full air circulation. Hinged doors are flanged for greater rigidity. Hinges are completely concealed by being mounted inside the enclosure, and are adjustable for perfect door alignment. A removable pin within the hinge assembly provides easy door removal. Knurled panel screws fit easily into floating retainer nuts for quick, easy alignment. These screws offer the utmost in safety in keeping the doors securely closed even under the most severe fault conditions.

Control separable contacts are tiered, upper and lower, so you can mount twice as many within the narrower dimensions—as many as 32 in each compartment. This means auxiliary circuits for your use. Standardized wiring of circuit breakers and devices to particular terminals ma maintenance far easier. Notice that the control contacts are loca at the bottom where they are s They are front removable to make placement or modification easily complished from within the circ breaker compartment.

Fully-insulated, high-dielect epoxy-molded toroidal current tra formers are located on the station primary leads within the circu breaker compartment. Convenient cation and accessibility makes cha ing a minor maintenance procedu Standard low-voltage current tra formers have metering accuracies conformance with ANSI C37.20. C rent transformer short-circuiting blo has safe, convenient location. It placed at front of circuit-breaker co partment and can be easily reach with circuit breaker still in compa ment.

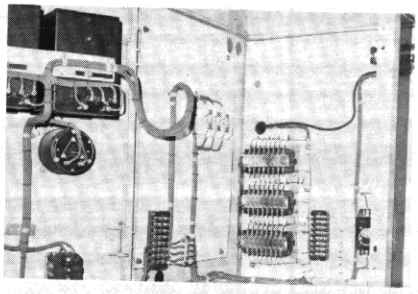


K-600 Compartment



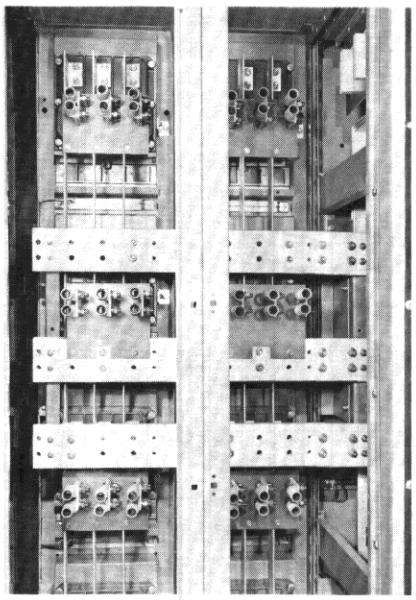
K-DON-1600 Compartment

① Current transformers are front mounted and easily accessible from the circuit-breaker compartment.
② Current transformer short-circuiting block is conveniently located behind circuit-breaker compartment door.
③ Feeder ammeter is located directly on feeder compartment door for easy reading and space saving. Rear view of ammeter is shown.
④ Modern polyester-glass insulation system is used throughout switc gear.
⑤ Stationary primary leads mate wi movable primary leads mounted circuit breaker.
⑥ Secondary disconnects are remo able from the front for ease accessibility.
⑦ Complete compartment isolation provided between each K-LINE or K-DON® circuit breaker ar main bus compartment.



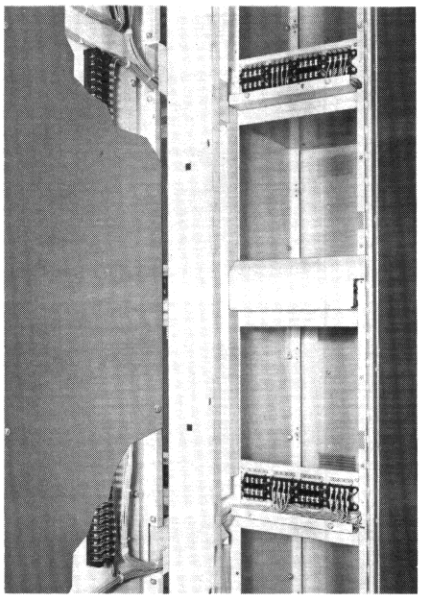
Low-Voltage Metal-Enclosed Switchgear with Auxiliary Instrument Compartment Showing Electrical Connections.

BUS AND CABLE COMPARTMENT



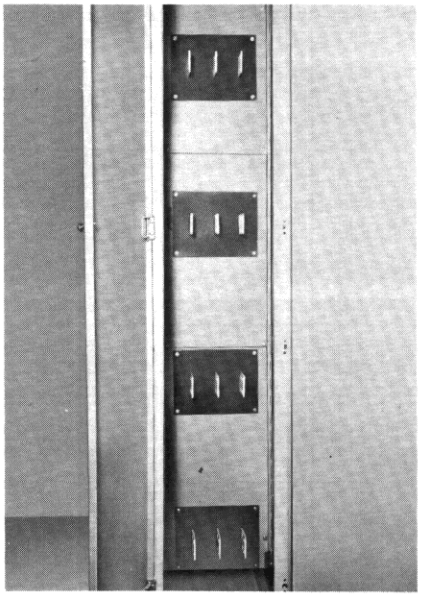
POLYESTER-GLASS INSULATION SYSTEM

All insulating parts of the switchgear are made of high-strength polyester glass. Each insulated part is specially designed in shape and strength to fulfill its part of a totally integrated insulation system.



ENCLOSED SECONDARY WIRING TROUGHS (optional)

All secondary wiring and terminal blocks located in the bus compartment are enclosed in completely covered metal troughs to afford complete isolation from the switchgear bus.



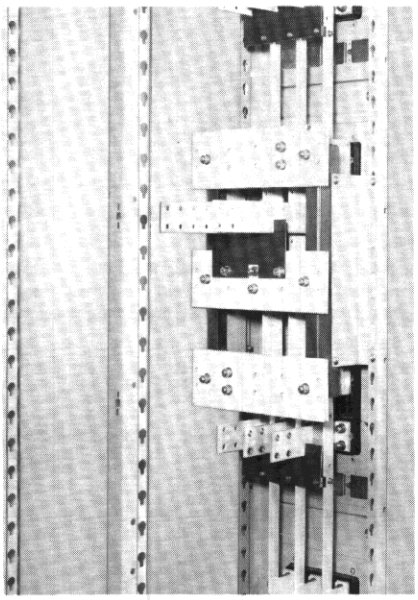
REAR BARRIERS (optional)

For those who prefer to have a completely isolated cable area, rear barriers are available. The primary leads are extended through slotted polyester-glass inserts which are mounted in a solidly-grounded metal isolating panel. Note that hinged rear doors are standard.

OVERHEAD LIFT DEVICE

For ease of handling K-LINE circuit breakers, a traveling overhead lift device can be provided. This device is supported from the front section of the switchgear assembly and will not affect any incoming power or control cables at the rear bus section. The hoist can be moved the full length of the switchgear and with the aid of a lifting yoke, the breaker can be lifted from the floor or from the completely withdrawn breaker cradle. Lifting power is provided through a removable hand-crank, worm-driven mechanism and sturdy flexible cable. Although the driving mechanism is designed for easy hand operation, the weight of the breaker cannot accidently move the mechanism even when the crank is unattended or removed.

Overhead Lift Device on Indoor Switchgear

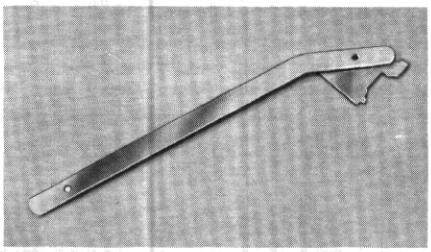


VERTICAL BUS ARRANGEMENT

The three-phase main horizontal bus is vertically arranged one above the other and is located as close to front of switchgear as possible, providing large area for auxiliary equipment and cable makeup. Vertical mounting of bus provides maximum ventilation, and freedom from dust. Bus is designed for an allowable temperature rise of 65°C above an average 40°C ambient. All insulating parts of the switchgear are made of *high-strength polyester-glass*. Each insulated part is specially designed in shape and strength to fulfill its part of a truly integrated insulation system. A section of the top sheet of each frame is removable to facilitate installation of overhead conduit and cable. All rear leads are easily accessible for simple connection with a minimum of cable bending.

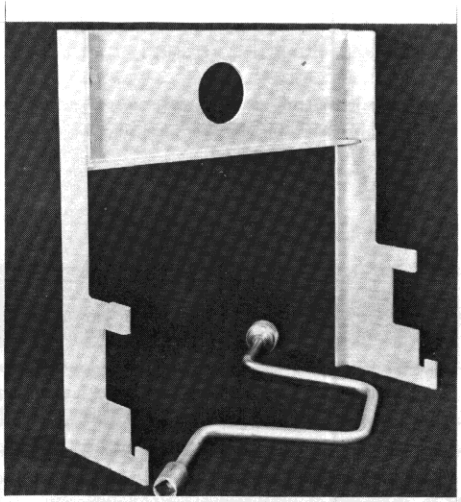
Aluminum bus is silver-plated and is braced against movement in any direction under all possible short-circuit conditions. Pre-slotted mounting members permit flexibility to add mounting supports when required in the field for incoming cables, etc. Vertical risers connecting breakers to the main bus are welded for space saving. The connections of the vertical risers to the main bus and breaker terminals are bolted.

ACCESSORIES



Spring-Charge Maintenance Handle

Each factory-assembled switchgear is shipped with circuit-breaker racking crank and lifting yoke as standard accessories. A maintenance handle for manual spring charging is included on electrically-operated breakers only.

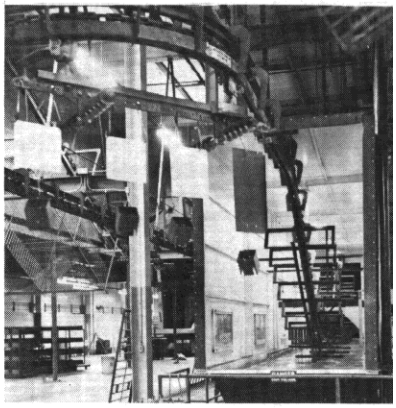


Circuit Breaker Racking Crank and Lifting Yoke.

A PAINT FINISH TO MATCH TRADITIONAL I-T-E QUALIT

- **Smooth, uniform paint finish**
- **Complete paint penetration**
- **Corrosion-resistant**
- **Electro-chemical bonding of pai to metal**
- **Long-lasting paint finish**

All standard low-voltage switc gear frames are painted by an au mated, industry-first electro-depositi paint process. This multi-stage clea ing and painting operation is au matically controlled to provide u form paint thickness throughout. T metal frame is completely immersed a huge, electrically charged "gr river" of light gray, ANSI #61, epo enamel paint. Current flow from pai to part immediately bonds the epo paint to every exposed surface of t metal. Termed "electrocoating", th process provides an attractive a durable paint finish of the high quality.



Switchgear Being Immersed in "Gr River"

The electrocoating process enta preparation of the metal and appli tion of the color coat. The metal ceives a series of alternate alkali cleansing and water rinse operatio followed by a phosphatizing tre ment. After the metal is properly p pared, the frame is immersed in lig gray, ANSI #61, epoxy enamel pa for a specified time period. Followi another water rinse, the paint fini is baked dry.

All standard switchgear fram and other metal work used in outdo switchgear are painted in the mann described. In addition, the weath proof enclosure for outdoor low-vo age switchgear also receives a spr application of dark gray, ANSI #2 baked acrylic enamel.

POWER CIRCUIT BREAKERS

TABLE 5 — K-LINE® POWER CIRCUIT BREAKER RATINGS

① Circuit Breaker Type	Maximum Continuous Current Rating, A	Interrupting Capacity, Symmetrical RMS Amperes		
		240 Volts	480 Volts	600 Volts
K-800	800	42,000	30,000	22,000
K-1600	1600	65,000	50,000	42,000
K-2000	2000	85,000	65,000	55,000
K-3000	3000	85,000	65,000	65,000
K-4000	4000	130,000	85,000	85,000
K-600S	600	42,000	30,000	22,000
K-1600S	1600	65,000	50,000	42,000
K-2000S	2000	85,000	65,000	55,000
K-3000S	3000	85,000	65,000	65,000
K-4000S	4000	130,000	85,000	85,000

① K-LINE breakers equipped with a POWER-SHIELD solid-state overcurrent trip device have their normal designations suffixed with an S.

K-LINE®

K-LINE circuit breakers have been developed for the protection of feeder circuits and for use as main breakers where the interruption requirements are within the ratings shown in Table 5.

This modern line of low-voltage, air-magnetic, drawout power circuit breakers offers a selection of either manually or electrically (motor charged) operated spring-closing mechanisms, which provide positive quick-make operation. K-LINE circuit breakers can be provided with either a direct-acting, electro-mechanical or a solid-state overcurrent trip device. They are compact and come equipped with many other features which are particularly adaptable to general low-voltage switchgear applications.

For application information on K-LINE circuit breakers, refer to pages 35 and 36.

K-DON®

The K-DON circuit breaker is a compact, versatile protective device which incorporates all of the features of the K-LINE circuit breaker and the current-limiting characteristics of the Amp-Trap† fuse. The current-limiting fuses are integrally mounted on, and physically connected in series with, the breaker. Each K-DON circuit breaker is equipped with an open fuse trip device to prevent single phasing. No external tripping power is required to operate the open fuse trip device.

The circuit breaker performs its normal function of time delay and instantaneous tripping throughout its entire range of interrupting capacity. When properly applied, the fuse takes over protection for currents at or above the circuit-breaker short-circuit current rating up to 200,000 amperes. For currents within the circuit-breaker interrupting capability, the fuse will not open unnecessarily thus saving nuisance replacements. This system affords vast flexibility in applying pin-point protection to any type of electrical apparatus. For application information on K-DON circuit breakers, refer to Pages 37-41.

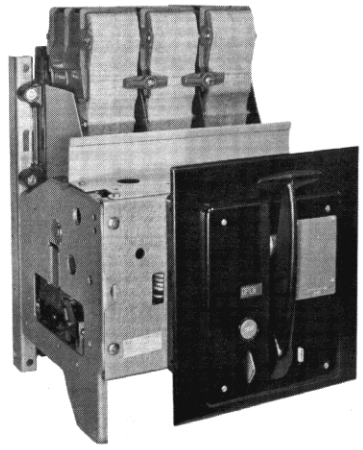
† Registered Trademark—Chase-Shawmut Co.

TABLE 6 — K-DON® POWER CIRCUIT BREAKER RATINGS①

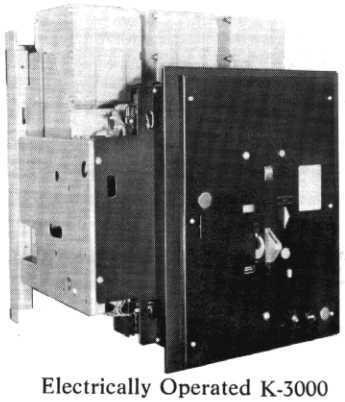
② Circuit Breaker Type	Maximum Continuous Current Rating, A	Interrupting Capacity, Symmetrical RMS Amperes
		240, 480, and 600 Volts
K-DON-800	800	200,000
K-DON-1600	1600	200,000
K-DON-800S	800	200,000
K-DON-1600S	1600	200,000

① Fused circuit breakers with 2000, 3000 and 4000A continuous current ratings are available with separately mounted, drawout, current-limiting fuses. Refer to Page 30 for arrangement information and Page 40 for application data.

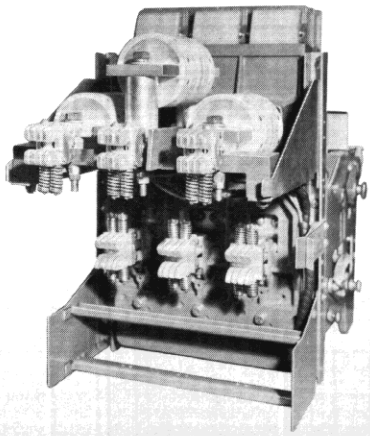
② K-DON breakers equipped with a POWER-SHIELD solid-state overcurrent trip device have their normal designations suffixed with an S.



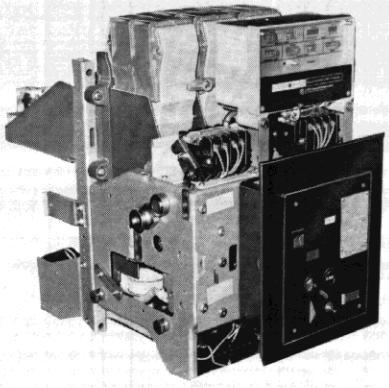
Manually Operated K-600



Electrically Operated K-3000

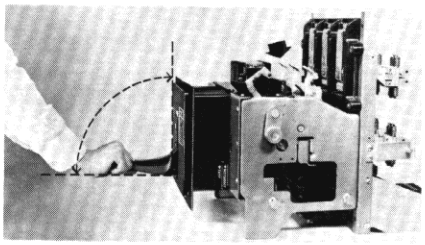


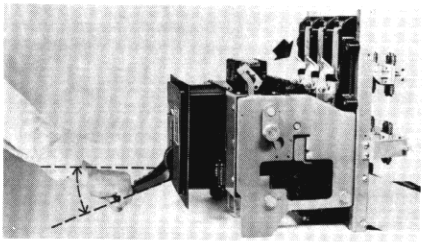
Rear View Manually Operated K-Don-600



Electrically Operated K-Don 1600S with SS5 Power Shield Unit

MANUAL STORED-ENERGY GIVES QUICK-MAKE, QUICK-BREAK OPERATION





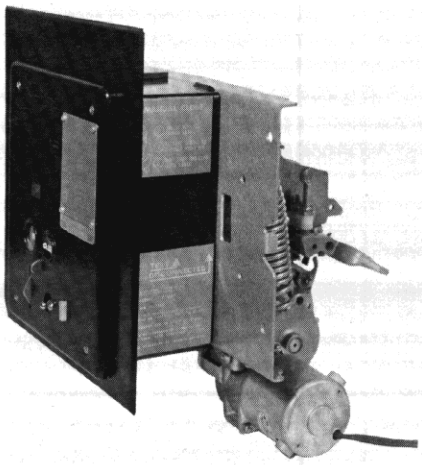
LESS UPKEEP, LONGER CONTACT LIFE

Manually-charged, stored-energy breakers offer many advantages to its users. Of primary importance is the added safety for operating personnel. This quick-make mechanism also provides longer contact and breaker life and increases the scope of application for manual breakers. K-LINE® breakers cannot be teased into the closed position. A pair of powerful springs actually close the contacts. For breakers with frame size ratings from 225 through 2000 amperes, the operator simply supplies energy to the device by pulling the semi-flush closing handle downward to approximately 100°. The initial 90° fully charges the closing springs and the remaining motion releases the spring energy to drive the contacts into the closed position by a smooth cam action. The fully-charged springs develop sufficient energy to close and latch the breaker safely under any conditions within the breaker rating. A flush-mounted manual trip button is located on the easily-accessible breaker escutcheon. It is also equipped with a hand-reset automatic trip indicator which provides for visual indication of automatic trip operation.

ELECTRICAL OPERATION

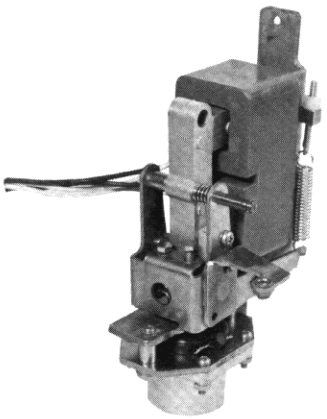
All K-LINE circuit breakers are also available with motor-charged, stored-energy closing mechanisms to be used when remote control or local electrical control is required. The normal control power required by this mechanism is only a fraction of the power requirement for a solenoid closing mechanism.

A fractional-horsepower motor with enclosed speed-reduction gears provides the closing energy. The high-torque, high-speed output easily charges the powerful closing springs. The springs are retained in a fully-charged condition until the energy is required for closing. Upon tripping, the springs are again recharged automatically by the mechanism. An emergency charging handle is provided for manual charging if control power is lost. A manual closing lever on the escutcheon permits simple manual close with the compartment door closed. All stored-energy springs are automatically discharged for safe breaker maintenance when the circuit breaker is racked to the disconnect position.

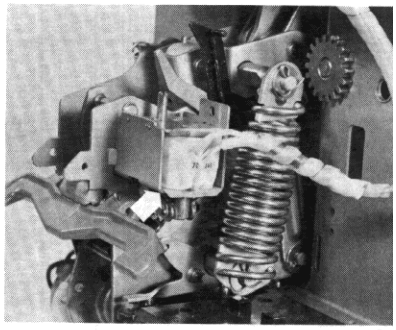


Electrically-Operating Mechanism

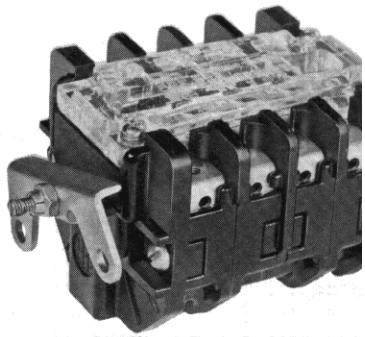
BREAKER COMPONENTS



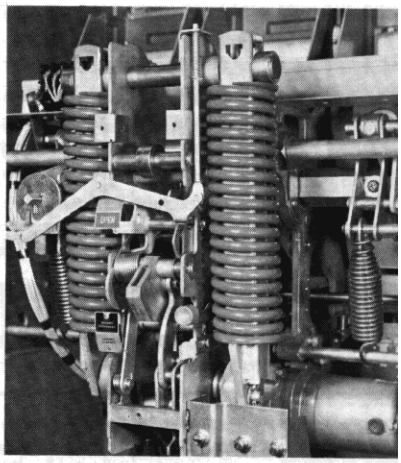
Undervoltage Trip Device



Shunt Trip Device



Auxiliary Switch

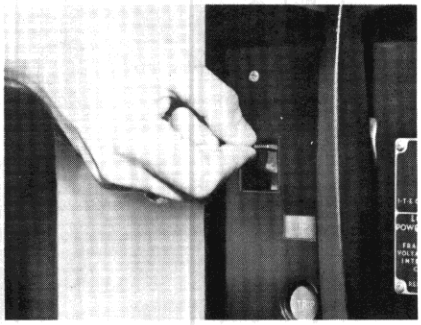


K-3000 Motor-Charged Stored-Energy Operating Mechanism

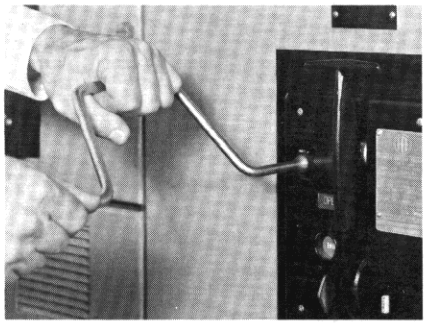
SAFE, EFFICIENT, CLOSED-DOOR DRAWOUT

The circuit-breaker compartment door need never be opened while moving the K-LINE® circuit breaker from the completely connected through test into the disconnected position. Unique construction reduces I-T-E switchgear to three basic components: frame, breaker and a removable cradle on which the breaker rolls for drawout. The mechanism permits racking the breaker into connected, test and disconnected positions without ever opening the compartment door. It facilitates testing and maintenance and promotes safe operation. A lift shutter is provided on the breaker escutcheon which permits insertion of a racking crank to move the breaker. It is completely interlocked, i.e., the shutter cannot be lifted while the circuit breaker is closed and the circuit breaker cannot be closed while the shutter is lifted. When open, the breaker can be padlocked in the connected, test or disconnected positions. When padlocked, the breaker cannot be closed or moved to any other position.

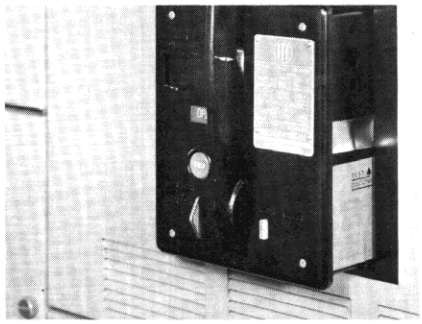
The extendable escutcheon mounted on the circuit breaker slides through an opening into the compartment door while the spring-loaded cover plate surrounding the escutcheon is held in place by the door. Visual indication on the side of the breaker denotes all three positions. Compartment doors may be opened, if desired, when the breaker is in any position. To remove the breaker from its compartment, it must be racked to the fully-disconnected position, the door opened and the breaker pulled manually to the fully-withdrawn position while it is supported by extended sliding rails. After release of the safety latch, the breaker may be lifted directly from the rails by means of an overhead lift device and moved with a transfer truck or be handled completely with a combination lift device and transfer truck.



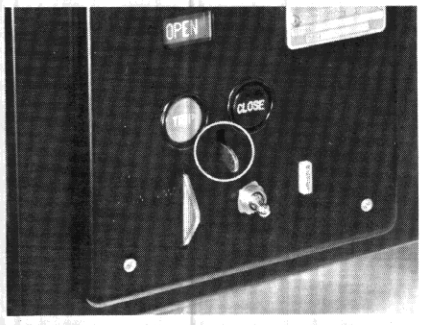
LIFT SHUTTER must be raised to insert breaker racking crank. It cannot be raised when breaker contacts are closed.



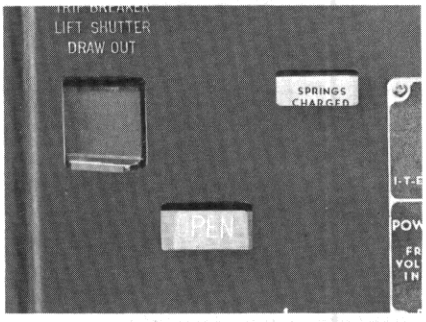
INSERT CRANK to move breaker between positions. Crank cannot be inserted without raising lift shutter.



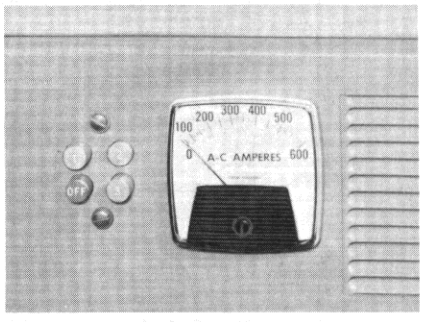
READ BREAKER POSITION from target on the right side of escutcheon. When breaker is in disconnected, test or connected positions, lift shutter will close. Breaker contacts cannot be closed until lift shutter is closed.



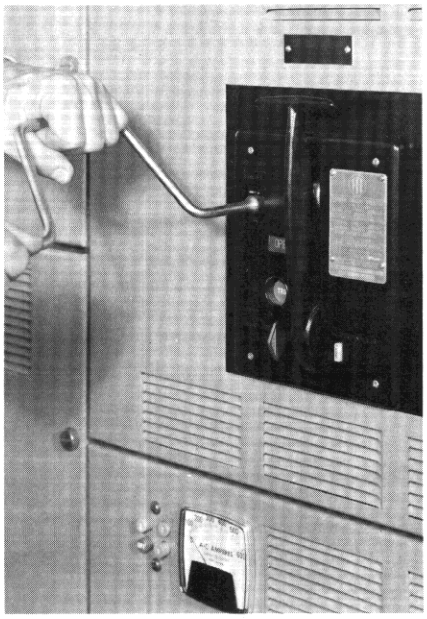
MANUAL CLOSING LEVER. All electrically operated breakers can be closed manually with the compartment door closed, if control power is lost, by simply pulling the closing lever. Closing springs can also be charged manually with a hand lever.

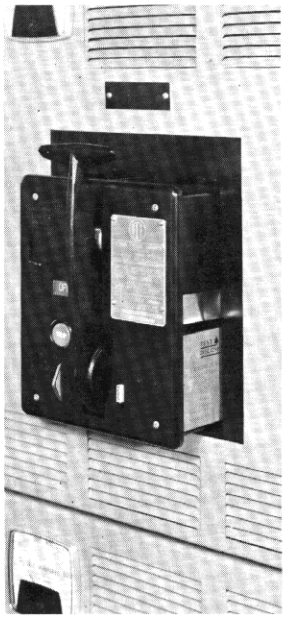


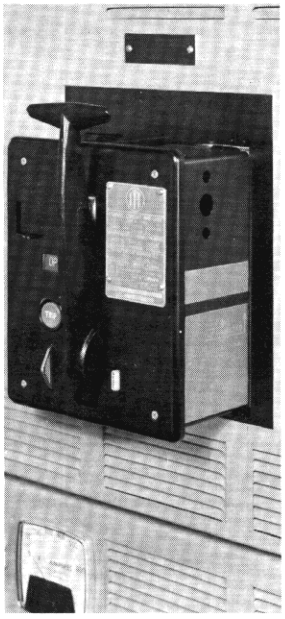
SPRING-CHARGED INDICATOR shows condition of stored-energy springs on electrically-operated breakers.
OPEN-CLOSED INDICATOR visually shows position of breaker contacts directly on front of escutcheon.

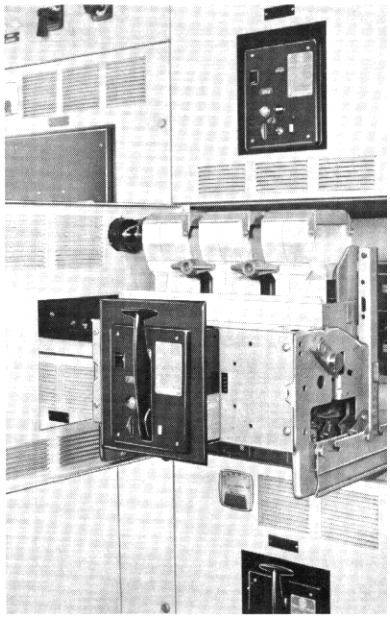


FEEDER AMMETER. Each feeder compartment can be equipped with a door-mounted ammeter and push-button switch for easy, convenient reading and space saving.

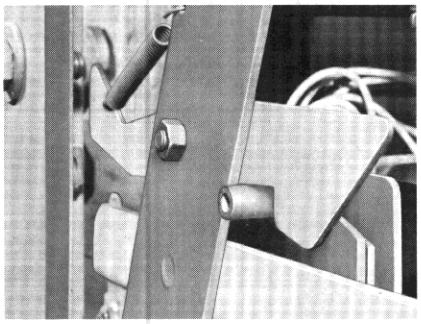




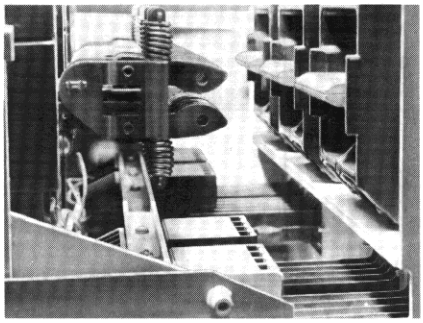




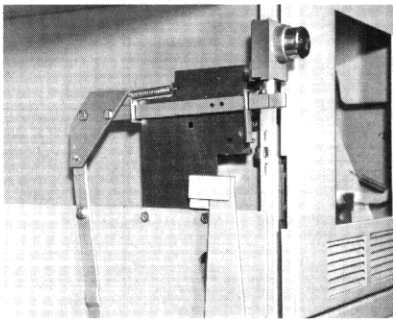
CONNECTED ..... TEST ..... DISCONNECTED ..... FULLY WITHDRAWN .....



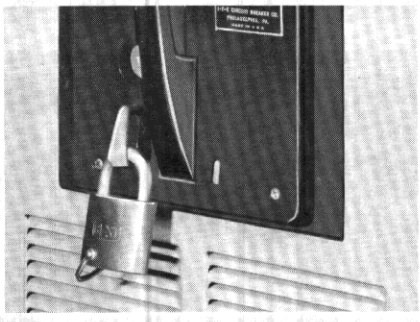
RAIL LATCH prevents breaker from rolling off track when breaker is fully withdrawn. Latch must be released to lift breaker from rails.



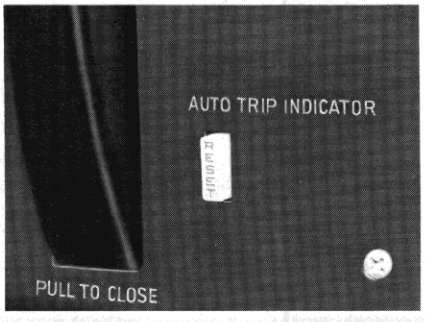
PRIMARY, SECONDARY AND GROUND CONTACTS on the circuit breaker mate sequentially in a straight-line motion with counterparts within the switchgear. This insures proper breaker operation at each position.



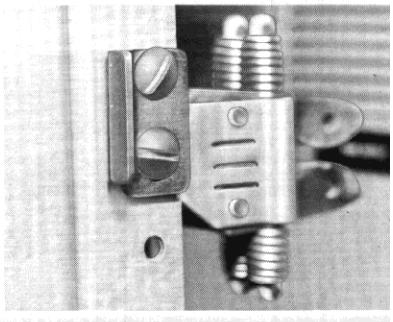
KIRK™ KEY INTERLOCKS offer unlimited number of interlocking rangements between all componer of the switchgear. They are partic larly adaptable to sequential ope tions or prevention of unauthoriz operation.



PADLOCK PROVISION. The circuit breaker, when open, can be padlocked (with up to three locks) in all three positions. When padlocked, it cannot be closed or moved to any other position.



AUTOMATIC-TRIP INDICATOR gives visual indication when the breaker has tripped from a fault or other overcurrent conditions.



INTERFERENCE KEY on the breal mates with slot on cradle allow only the proper rated breaker to inserted into the compartment. It virtually impossible to insert a lov rating into any compartment.

OD—ELECTRO-MECHANICAL OVERCURRENT TRIP DEVICE

K-LINE® type OD electro-mechanical overcurrent trip devices have been designed to provide dependable performance with virtually noiseless and vibration-free operation. I-T-E low-voltage power circuit breakers equipped with this rugged device are available in any desired combination of long-time delay, short-time delay and instantaneous tripping. Each overload is individually calibrated, tested and certified by Quality Control to assure "as designed" performance and service.

OD-3 and OD-300 Dual-Magnetic Direct-Acting Trip Device

The OD-3 and OD-300 are fully adjustable, dual-magnetic overcurrent trip devices. They employ a dual armature. One is connected to an oil-displacement dashpot to provide long-time delay. A second armature provides instantaneous trip characteristics. The overload on each pole has independent adjustment for long-time delay pick-up, instantaneous pick-up, and the amount of time delay. It is a self-contained, direct-acting, electro-mechanical device which depends on its own circuit for tripping power. No external tripping power is required.

Expanded-range calibration is incorporated to provide a greater number of usable calibrated long-time pick-up settings. Conventional trip devices provide only two calibrated pick-up settings (80% and 100%) which may be used continuously without excessive overheating. Table 59, page 43, shows the increased number of calibrated long-time pick-up settings within 100% of the continuous current rating of each trip coil. This feature permits a user to select a device with a trip coil rating which provides adequate protection for present power requirements and also permits an increase in capacity by means of simple adjustments.

A wide range of adjustment makes this rugged unit ideal for protection of motors and equipment which require close protection.

Production units have been subjected to more than 4,000,000 welding type pulse test cycles without failure—thus proving a long-life design! OD-3 and OD-300 units now in service have proven themselves in many difficult application including heavy-duty welding circuits.

OD-4 and OD-400 Dual-Selective Direct-Acting Trip Devices

The OD-4 and OD-400 direct-acting trip devices combine the fluid-displacement type time delay with mechanical-escapement time delay to provide a composite time-delay device in which it is possible to closely control the time-delay over a range of current values from normal load current to the full interrupting current rating.

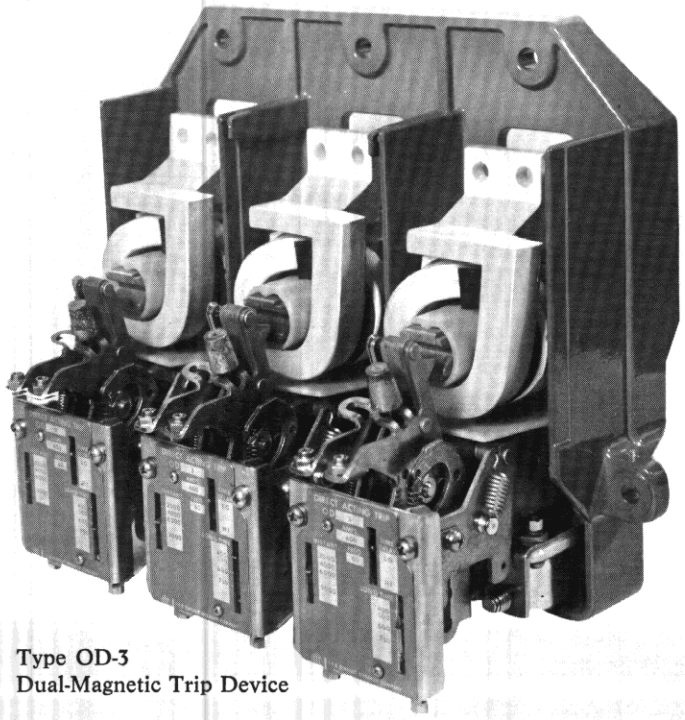
This allows the direct-acting trip devices of circuit breakers in series to be set so as to permit selective tripping of the circuit breaker closest to the fault. Thus maximum continuity of electrical service may be provided where such continuity is mandatory.

EASY TO ADJUST

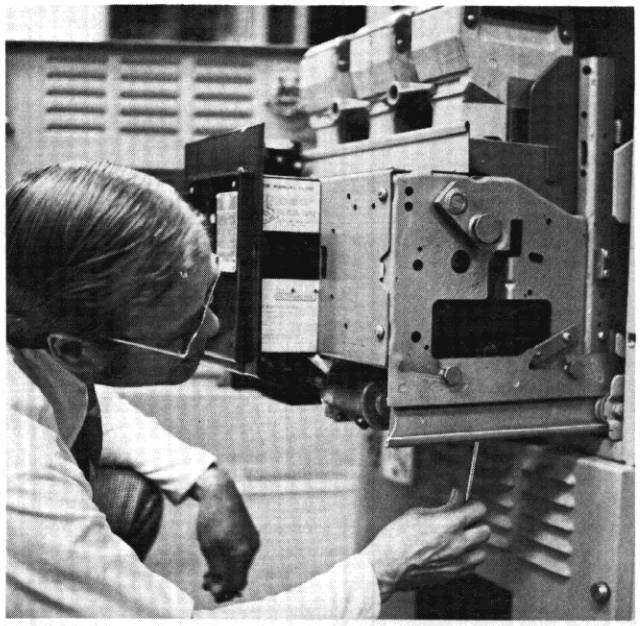
Trip devices are clearly visible and within easy reach from the front of the circuit breaker. Even on electrically-operated circuit breakers, they are readily accessible to the operator for quick, easy adjustment.

EASY TO SERVICE

The three-phase overcurrent trip device assembly is mounted on a one-piece, impact-resistant polyester-glass molding for breaker sizes up to K-600. On larger size breakers the overcurrent trip device assembly consists of three individual units. If repair or replacement is required, the assembly is easily removed from the back of the breaker. Associated devices need not be disturbed.



Type OD-3
Dual-Magnetic Trip Device



Adjusting and servicing OD device is simple and convenient.

POWER-SHIELD® – SOLID-STATE OVERCURRENT TRIP DEVICE

GENERAL INFORMATION

POWER-SHIELD is a three-phase solid-state, overcurrent trip device designed for low-voltage power system protection against damage caused by overload and short-circuit conditions. It can be integrally mounted on K-LINE® and K-DON® low-voltage power circuit breakers. The logic assembly of the POWER-SHIELD system is mounted on the shelf above and behind the breaker escutcheon for easy accessibility to the control panel. POWER-SHIELD is suitable for application on low-voltage circuits rated up to 600V ac, 50/60 Hertz. Available standard types and their related trip functions are shown in Table 61 page 44.

The POWER-SHIELD solid-state overcurrent trip system consists of current sensors, logic assembly, magnetic latch release and interconnecting wiring. There are two current sensors mounted on the breaker lower base molding around each primary conductor. One sensor supplies the logic assembly with a signal current proportional to the primary current, and is referred to as the signal sensor. The other sensor, designated the power supply sensor, supplies the power required to operate the magnetic-latch release and solid-state circuitry. The logic assembly contains the circuitry and various tap-blocks used to set the overcurrent trip levels and time delays. A transparent cover is provided over the tap blocks. The magnetic-latch release is similar in function to a shunt-trip device, but is powered by the fault current through the power-supply sensors, and is actuated by the logic assembly system.

SIMPLE TAP CHANGING

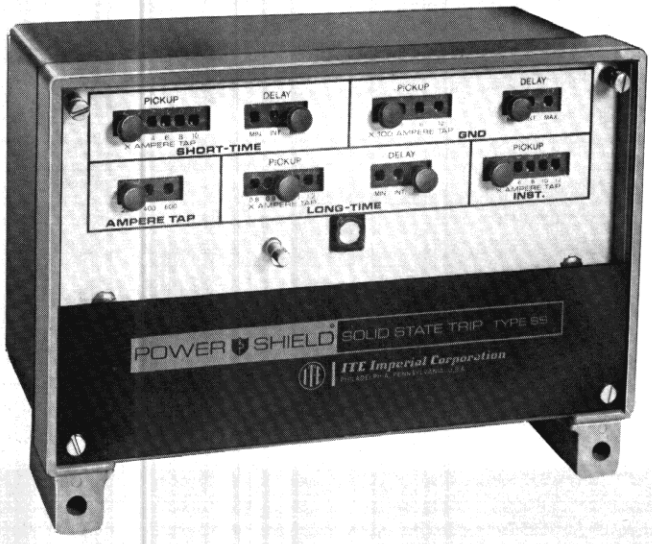
The wide rating range of each device, coupled with its simplified field adjustment, allows almost unlimited load growth within each breaker frame size. Only seven different sizes are required for the full range of 35 thru 4000 amperes (see page 44). Field setting is accomplished by insertion of tap plugs into the front of the logic unit. All settings are made in this fashion, including the **ampere tap** which selects the continuous rating of the current sensor. This setting is shown directly in primary amperes, giving the user a positive indication of the continuous current rating of his circuit breaker. The long-time, short-time and instantaneous functions are then adjusted by tap plugs which are a percentage of this ampere tap setting. In addition, three time-delay bands, minimum, intermediate and maximum can be selected for both the long-time and short-time functions. All time-current curves are straight lin asymptotic at the pick-up point to p duce optimum coordination with ot protective devices. Coordination made even more positive by the w separation between all time-de bands.

Optional ground and/or short tin instantaneous operation indicators a available.

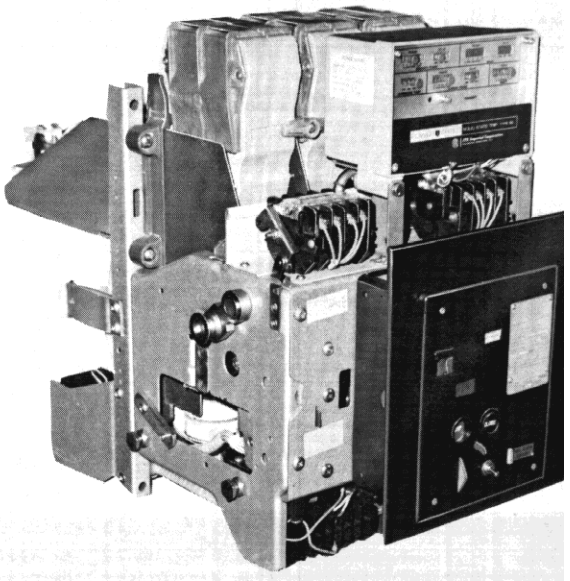
Also available as an option is alarm contact for remote indicatio

GROUND-FAULT PROTECTIO

POWER-SHIELD is available w multiple ampere taps for a wi range of pick-up currents. The grou function can be included in the lo assembly for those applications which it is desirable to protect t system against faults to ground. The are often damaging arcing faults whi result in current magnitudes below t pick-up of the long-time trip functio 3-wire applications with ground p tection do not require any additio sensors. For 4-wire applications, o ground sensor is remotely mount around the neutral conductor and wired to the logic assembly through breaker secondary disconnect. T ground function is tap selected direc in amperes, and is independent of t ampere tap setting.



Front view of SS-5G POWER-SHIELD logic assembly.



Front view of K-DON-1600 S electrically-operated breal equipped with SS-5 POWER-SHIELD unit.

GROUND-SHIELD® - SOLID-STATE GROUND FAULT PROTECTION

GROUND-SHIELD is the registered family trademark for a variety of solid-state relay systems designed to protect electrical distribution circuits and electrical loads from the damage caused by the inadvertent flow of ground-fault currents. Three (3) systems are offered: (1) **GR-5** and **GR-200,** (2) **GRM**—motor circuit applications, and (3) **GRD**—three-phase differential.

The GR-5 and GR-200 GROUND-SHIELD Systems offer fast, sensitive protection against ground-faults including destructive, low-magnitude, arcing ground-faults in solid and resistance grounded distribution systems. They consist of a special-design, core-balancing current transformer (sensor) and a low-burden, solid-state ground relay.

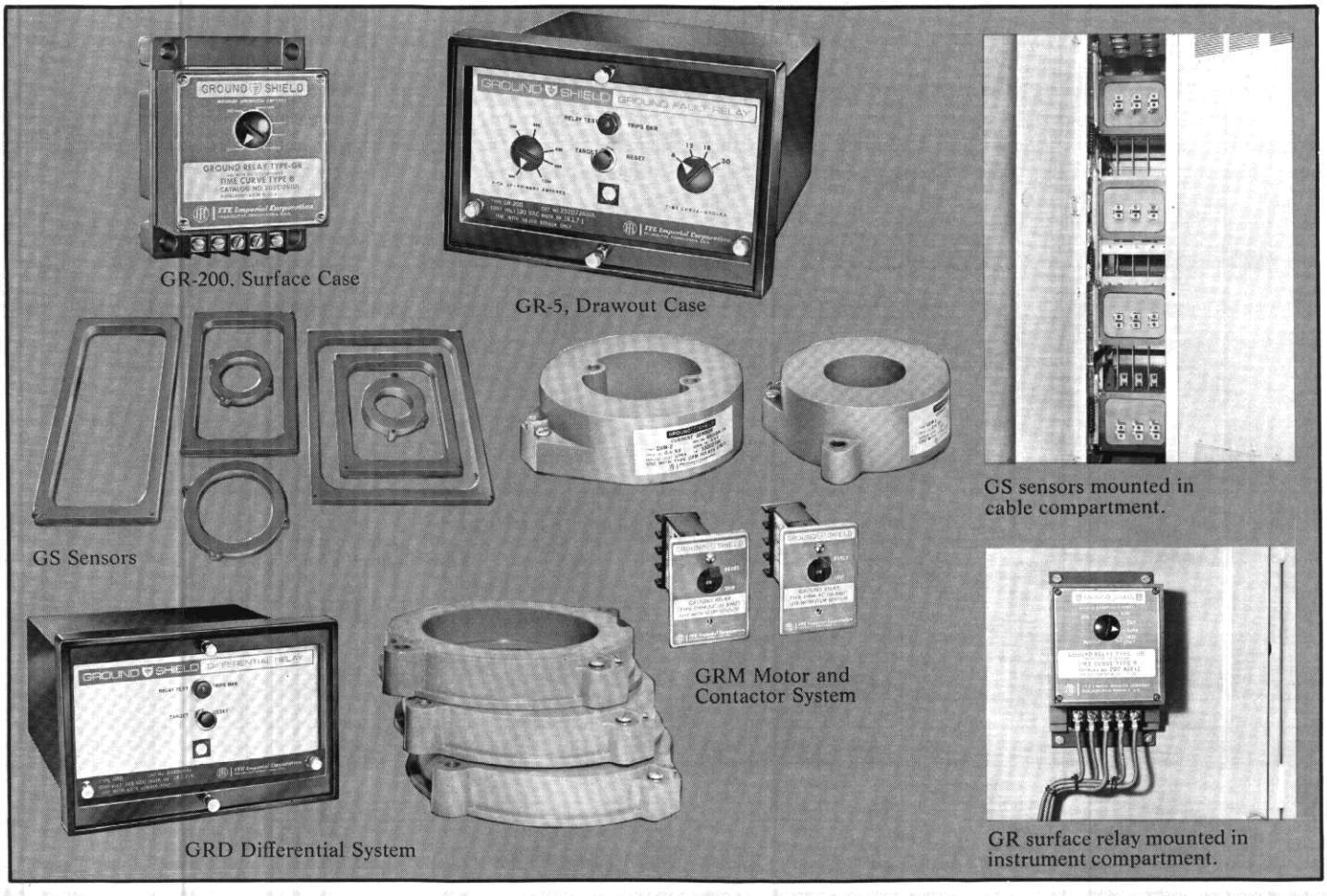
The ground sensors are available with small or large-window configurations designed to enclose all phase and neutral bus or cable conductors. These sensors will respond only to ground-fault currents. Balanced or unbalanced load currents, two-phase or three-phase short circuits not involving a ground return conductor, will have no effect on the sensor. Two (2) pickup ranges are available, one with 5 ampere minimum sensitivity, and one with 200 ampere minimum sensitivity. The 5A system (GR-5 relay) with 5-50A pickup adjustment (special pickup ranges of 2-40A and 20-200A are also available) is used for protection of individual loads such as motors and transformers. On high-resistance grounded systems the 5-50A relay is used for both circuit and load protection. The 200 ampere system (GR-200) relay with 200-1200A pickup adjustment is used for circuit protection.

The 5A system provides five time-current curves of definite time shape. Four time-current curves are available for the 200A system. All relay calibrations are in primary amperes. Tripping of the desired breaker (coordination) is obtained by applying relays with successively faster curves progressing from source to load circuits. Relays are available for surface mounting and semi-flush panel mounting.

GRM System offers fast, sensitive and inexpensive protection against ground faults in individual motor starter and contactor circuits (type GRM-NC) and electrical distribution systems using molded-case circuit breakers with shunt trips (type GRM-FC).

The system consists of a special small diameter current transformer (sensor) and an instantaneous, mechanically latched ground relay with a 10 ampere sensitivity. The ground sensor, which encircles all phase conductors, comes in 2″ (GSM-1) and 3″ (GSM-2) inside diameters.

GRD Differential System provides fast, sensitive protection against phase-to-phase or phase-to-ground faults occurring in 3-phase motors, generators, reactors, etc. This system consists of three solid-core current sensors type GS-5 and one 3-phase, solid-state ground differential relay type GRD, which operates the shunt-trip device on the circuit breaker. The ground differential relay and the associated current sensors are connected in a self-balancing scheme. The GROUND-SHIELD differential system has a sensitivity of 2 amperes primary fault current, operates in 2 cycles, and is significantly more economical than comparable conventional differential relays operated from current transformers.



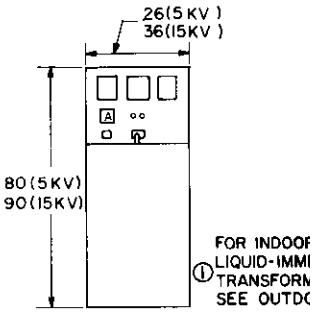
FEATURES OF STORED-ENERGY K-LINE® AND K-DON® CIRCUIT BREAKERS

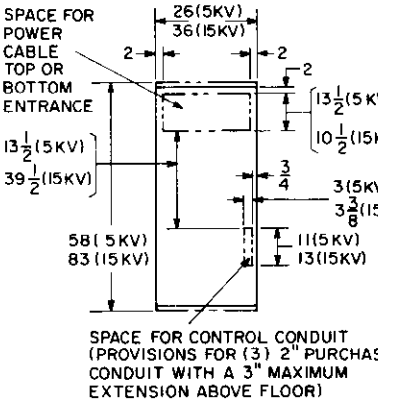
	STANDARD FEATURES INCLUDE:	K-800 K-1600 K-2000	K-3000 K-4000	K-DON-800 1600	K-800S K-1600S K-2000S	K-3000S K-4000S	K-DON- K-DON-1
MANUALLY OPERATED	Springs charged and breaker closed with manual handle	X	No	X	X	No	
	Springs charged only with manual handle	No	X	No	No	X	
	Manual close lever—door closed	No	X	No	No	X	
	Springs-charged indicator	No	X	No	No	X	
ELECTRICALLY OPERATED	Springs charged with motor—after trip	X	X	X	X	X	
	Electrical closing release	X	X	X	X	X	
	Manual close lever—door closed	X	X	X	X	X	
	Shunt-trip device	X	X	X	X	X	
	Control relay	X	X	X	X	X	
	Charging-motor disconnect switch	X	X	X	X	X	
	Springs-charged indicator	X	X	X	X	X	
	Secondary disconnects (operating and test position)	X	X	X	X	X	
	4-Contact auxiliary switch	X	X	X	X	X	
	Provision for manual spring charge	X (Door Open)	X (Door Closed)	X (Door Open)	X (Door Open)	X (Door Closed)	(O
MANUALLY OR ELECTRICALLY OPERATED	Manual trip button	X	X	X	X	X	
	Breaker contact-position indicator	X	X	X	X	X	
	Breaker racking-position indicator	X	X	X	X	X	
	Racking interlock (breaker must be open prior to racking)	X	X	X	X	X	
	Positive racking stops	No	X	No	No	X	
	Padlock hasp—up to three locks (locks breaker trip-free and in position)	X	X	X	X	X	
	Breaker interchangeability interlock	X	X	X	X	X	
	Direct-acting overcurrent trip devices (dual-magnetic, other combinations, except dual-selective)	X	X	X	No	No	
	Solid-State overcurrent trip device (long-time and instantaneous, SS-3)	No	No	No	X	X	
	Automatic trip indicator (overcurrent and undervoltage trip)	X	X	X	X	X	
	Primary disconnects—(operating position only)	X	X	X	X	X	
	Ground disconnect—(operating and test position only)	X	X	X	X	X	
	Manual slow-close provision	X	X	X	X	X	
	Actuator to discharge springs on withdrawal from switchboard	X	X	X	X	X	
	Amp-trap, current-limiting fuses	No	No	X	No	No	
	Anti-single-phase device	No	No	X	No	No	
ADDITIONAL OPTIONAL FEATURES (E.O. or M.O. except as noted)	Local electrical trip button—(on escutcheon)	X	X	X	X	X	
	Shunt trip with 4-contact auxiliary switch (2 spares)—M.O. only	X	X	X	X	X	
	Dual-selective, direct-acting overcurrent trip device	X	X	X	No	No	
	Solid-State overcurrent trip device (Dual-Selective, SS-4 and SS-5)	No	No	No	X	X	
	Operation indicator (target) and load alarm for solid-state trip	No	No	No	X	X	
	Mechanical lockout on automatic trip (reset by indicator)						
	—Overcurrent and undervoltage trip	X	X	X	X	X	
	—Overcurrent alone (special trip for undervoltage)	X	X	X	X	X	
	Alarm switches—1 N.O. and 1 N.C. (reset by indicator)						
	—Overcurrent and undervoltage trip	X	X	X	X	X	
	—Overcurrent alone (special trip for undervoltage)	X	X	X	X	X	
	Auxiliary switches—spares						
	—4 or 8 Contacts—E.O. only	X	X	X	X	X	
	—4, 8 or 12 Contacts—M.O. only	X	X	X	X	X	
	Undervoltage-trip device						
	—Instantaneous	X	X	X	X	X	
	—Time delay—Adjustable 0 - 15 sec.	X	X	X	X	X	
	Operation counter	X	X	X	X	X	
	Remote electrical-close release—M.O. only	No	X	No	No	X	
	Wiring change to charge springs when breaker closes	X	X	X	X	X	
	Hinged door interlock—door locked when breaker closed	X	X	X	X	X	
	Mechanical-transfer interlock—two breakers using flexible cable arrangement	X	X	X	X	X	
	Additional secondary disconnects up to 32 maximum total	X	X	X	X	X	
	Secondary disconnects—operating and/or test position only	X	X	X	X	X	
	Key interlocks—switchboard mounted—2 maximum	X	X	X	X	X	
STANDARD ACCESSORIES	Racking crank	X	X	X	X	X	
	Lifting yoke	X	X	X	X	X	
	Maintenance spring-charge handle—E.O. only	X	X	X	X	X	
	Slow-close bracket	No	X	No	No	X	
OPTIONAL ACCESSORIES	Transfer and lift truck	X	X	X	X	X	
	Overhead lift device—(standard outdoor)	X	X	X	X	X	
	Floor dolly	X	X	X	X	X	
	Test set for solid-state trip	No	No	No	X	X	

DIMENSION

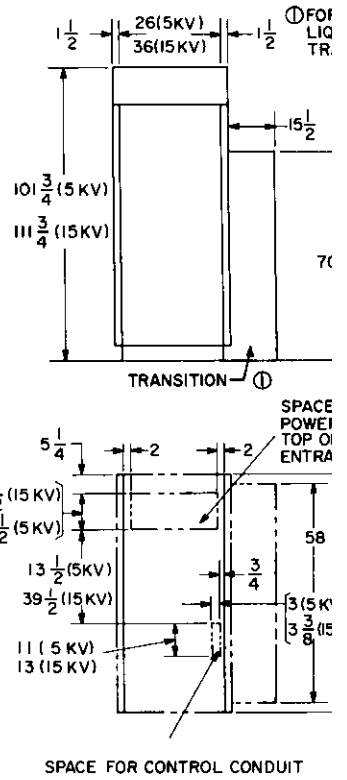
METAL-CLAD SWITCH

Indoor





Outdoor



INCOMING LINE SECTION

OIL CUTOUTS
Indoor — Outdoor

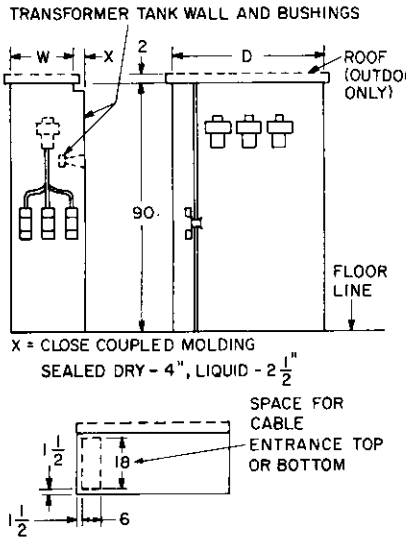
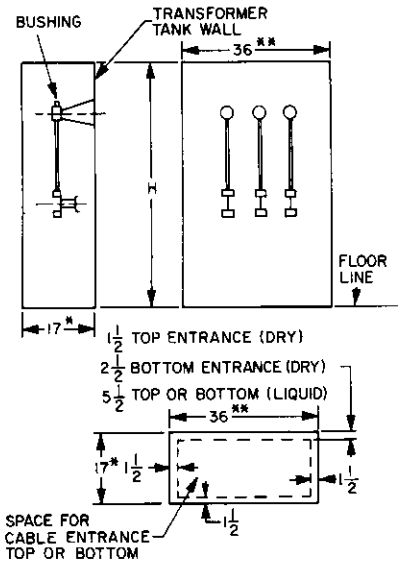


TABLE 7 — OIL CUTOUTS

Device	Liquid		Ventilated and Sealed-Dry	
	W	D	W	D
5 kV — 100, 200A	22½	48	21	48
5 kV — 300A 15 kV — 100, 200A	44½	58	43	58

AIR TERMINAL CHAMBER
Indoor — Outdoor

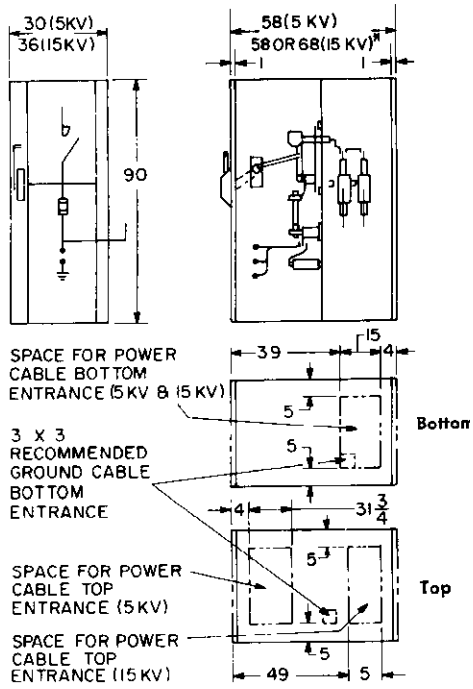


*ADD 1" ON ALL VENTILATED-DRY TRANSFORMERS
**WHEN USED WITH VENTILATED-DRY TRANSFORMER - MATCH TRANSFORMER DEPTH

TABLE 8 — AIR TERMINAL CHAMBER

Trsfr. Dim.		Liquid H	Sealed-Dry H	Vent.-Dry H
kVA	kV	Top or Bott Entrance	Top or Bott Entrance	Top or Bott Entrance
500 to 2500	5 or 15	94	110	90

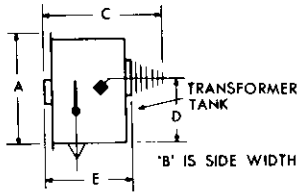
AIR INTERRUPTER SWITCH—Indoor



*DOUBLE POTHEAD TOP ENTRANCE

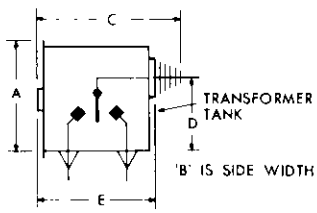
LIQUID SWITCHES
Indoor — Outdoor

TWO POSITION



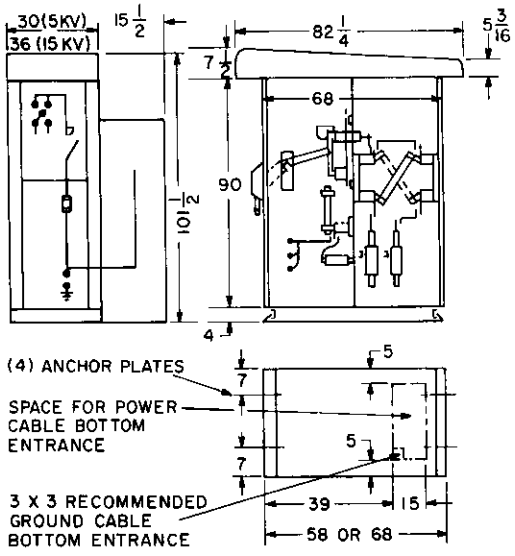
kV	A	B	C	D	E
5	21⅛	30½	23	13¾	17⅜
15	26	34½	24	16¼	18⅜

THREE POSITION

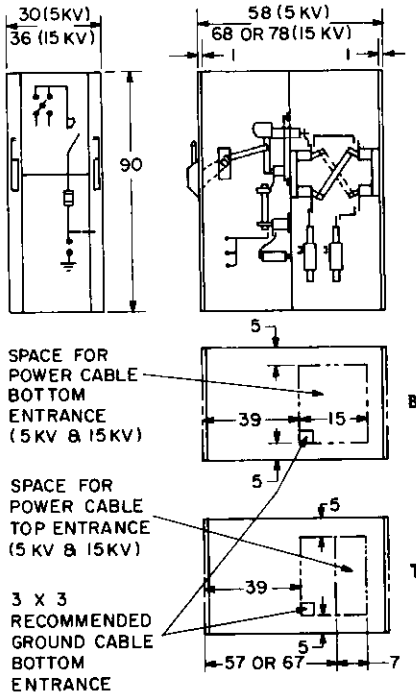


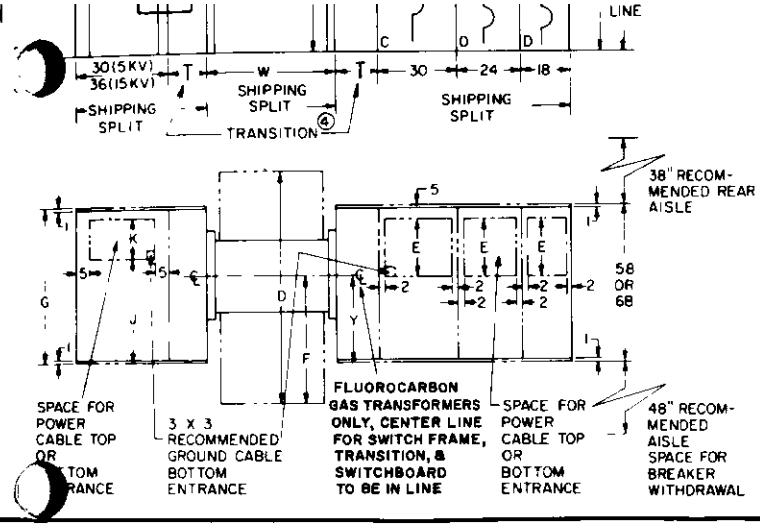
kV	A	B	C	D	E
5	22⅛	28	25¾	14¾	20¼
15	26	32	28¾	17¼	23⅛

SELECTOR SWITCH—Outdoor



SELECTOR SWITCH—Indoor





① Incoming Section (15kV) must be 68" deep when furnished with 2 - 3/c potheads for top entrance.
② When main bus is over 4000 amperes, consult I-T-E district sales office.
③ K4000 (2-45" high compartments) breaker located in bottom compartment.
④ Transition units are supplied assembled to the Incoming Line Section and Outgoing Section.

2000		61	105
2500		65	112

* For 208Y/120 volts application, add 8".
Δ For 8% impedance, add 4½".

VENTILATED-DRY—Indoor

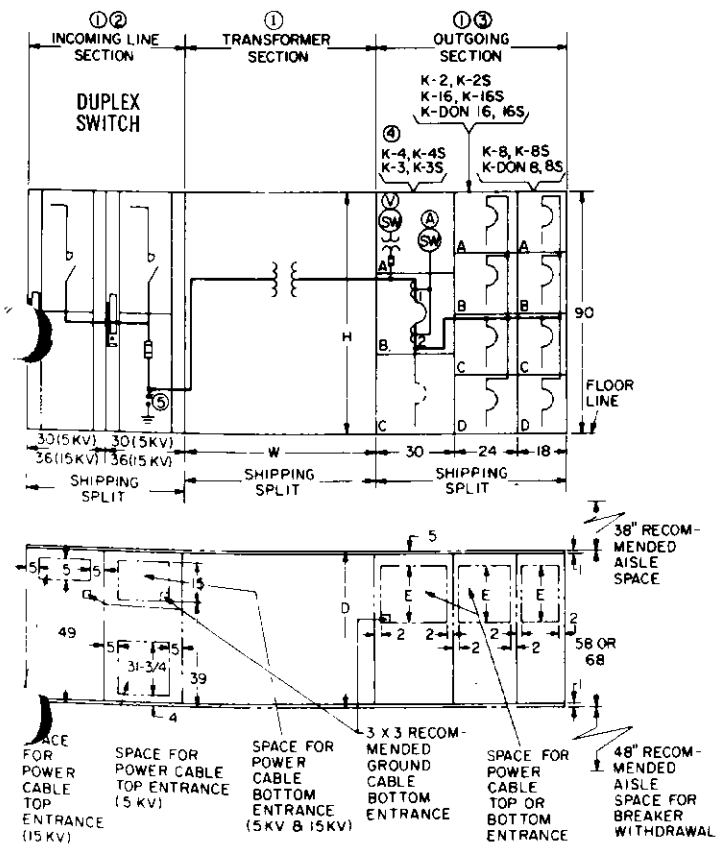


TABLE 13 — VENTILATED-DRY TRANSFORMER 150°C RISE

kVA	Incoming Section	Dimensions, in.		
		W†	H	D
500	5 kV or 15 kV	78	90	58
750				
1000		90	90	
1500			102	
2000				
2500		112	108	

† An 18" wide transition unit must be supplied when no main breaker is used.

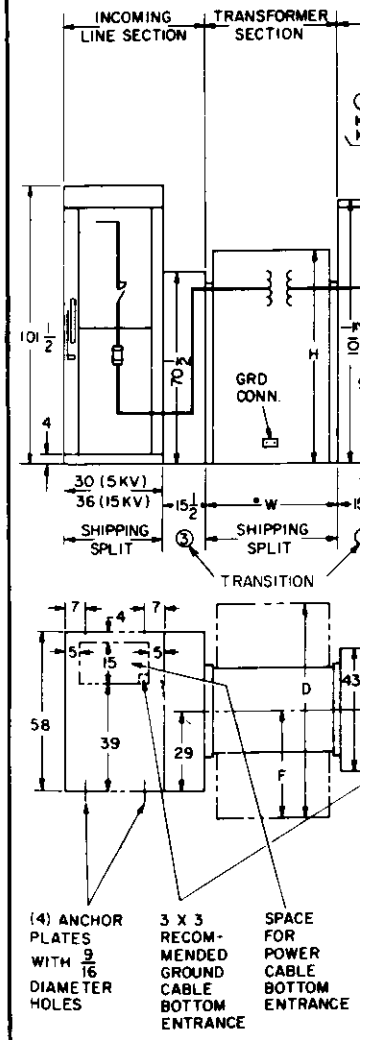
TABLE 14 — LOW-VOLTAGE SWITCHGEAR

Circuit Breaker Type	Frame Width Inches	"E" DIMENSION, in.							
		Without Main Bus Barrier		With Main Bus Barrier		Feeder with Ground or Neutral Sensor		Neutral 3φ4w with Main Bus Barrier†	
		Switchgear Depth, in.							
		58	68	58	68	58	68	58	68
K3 & K3S, K4 & K4S	30	21*	31*	12	22	—	17½	7½	17½
K2 & K2S, K16 & K16S	24	21	31	12	22	—	17½	7½	17½
K8 & K8S	18	21	31	12	22	—	17½	7½	17½
K-DON 16 & 16S	24	16½	26½	—	17½	—	13	—	13
K-DON 8 & 8S	18	16½	26½	—	17½	—	13	—	13

* With bottom entrance to K-3000 in compartment C, subtract 6".
† For main breaker unit or with K-3000 in compartment C.

① Incoming, Transformer and Outgoing Sections will always have their fronts aligned.
③ Incoming Section (15 kV) must be 68" deep when furnished with 2—3/c potheads for top entrance.
③ When main bus is over 4000 amperes, consult I-T-E district sales office.
④ K-4000 (2-45" high compartments) breaker located in bottom compartment.
⑤ Distribution-type lightning arresters are always required.

LIQUID (OIL & SILIC



WEIGHTS▲

INCOMING LINE SECTION

TABLE 18 — PRIMARY DEVICE WEIGHTS, LBS.

Type Primary Device	Depth, in.				3 Fuses	3 L.A.	1-3/c 3-1/c Pothead
	Indoor		Outdoor				
	58	68	58	68			
5 kV Unfused Switch	900	1000	1350	—	200	50	100
15 kV Unfused Switch	1200	1300	1800	—			
5 kV Unfused Selector	1100	1200	1550	—			
15 kV Unfused Selector	—	1600	—	2250			
Air Terminal Chamber	400						
Liquid Switches	2-Position		3-Position				
5 kV	450		500				
15 kV	515		640				
Oil Fused Cutout 5 kV—100, 200A	900						
Oil Fused Cutout 5 kV—300A 15 kV—100, 200A	1300						

TRANSFORMER SECTION

TABLE 20 — TRANSFORMER WEIGHTS, LBS.

Transformer Type	Volts, kV	TRANSFORMER kVA					
		500	750	1000	1500	2000	2500
Ventilated-Dry	5 or 15	3200	4200	5100	6700	8100	13000
Liquid-Silicone	5 or 15	4300	5700	6500	8500	9400	11500
Liquid-Oil							
Sealed-Dry	5 or 15	6300	7600	9000	12400	15400	19000

TABLE 19 — METAL-CLAD SWITCHGEAR WEIGHTS, LBS.

Circuit Breaker Type	Cont. Current, A	Breaker Weight	Depth		End Panels
			Indoor	Outdoor	
			58″	65″	
5HK75	1200	550	1325	1690	545
5HK250	1200	560	1325	1690	
5HK250	2000	580	1458	1823	
5HK350	1200	750	1400	1790	590
5HK350	2000	760	1533	1923	
			83″	90″	775
7.5HK500	1200	995	2170	2675	
7.5HK500	2000	1005	2411	2916	
15HK500	1200	925	2170	2675	
15HK500	2000	1005	2411	2916	
			91″	98″	835
15HK750	1200	1345	2260	2778	
15HK750	2000	1355	2501	3019	
AUXILIARY EQUIPMENT					
5HK–Potential transformer, drawout unit with 3 PT's—216 lbs.					
15HK–Potential transformer, drawout unit with 3 PT's—515 lbs.					
5 & 15 kV–Stationary-mounted, control-power transformers to 15 kVA—305 lbs.					
5HK–Drawout fuse unit—160 lbs.					
15HK–Drawout fuse unit—295 lbs.					

OUTGOING SECTION

TABLE 21 — LOW-VOLTAGE SWITCHGEAR WEIGHTS, LBS.

Type Unit	Frame Width, Inches	Switchgear Depth, in.			
		Indoor		Outdoor	
		58	68	97¾	107¾
K-800 & 8S	18	750	850	1300	1420
K-DON 8 & 8S		900	1000	1450	1570
*K-16 & 16S, K-2 & 2S, K-DON 16 & 16S	24	1000	1200	1650	1880
*K-3 & 3S, K-4 & 4S	30	1550	1750	2300	2535
		1600	1800	2350	2585
Auxiliary Units (Bus Transition) Includes Bus	18	700	800	1250	1370
	24	800	900	1450	1580
	30	900	1000	1650	1785
End Panels	1½	—		1000 Per Swbd	1125 Per Swbd
Overhead Lifting Device	—	100 Per Switchboard			
†Terminal Block Pans	—	110			
Main Bus Barriers	18	65			
	24	90			
	30	110			

*Switchgear only. Does not include breakers. For breaker weights, see Table 23.
†For electrically operated circuit breakers.

TABLE 22—TRANSITION UNIT WEIGHTS, LBS.

14″		15½″	
Switchgear Depth		Indoor	Outdoor
58″	68″		
400	450	425	475

TABLE 23—CIRCUIT BREAKER WEIGHTS, LBS.

Type	Manual Operation	Electrical Operation
K-8 & 8S	112	133
K-16 & 16S	185	206
K-2 & 2S	204	225
K-DON 8 & 8S	142	163
K-DON 16 & 16S	264	285
K-3 & 3S	520	548
K-4 & 4S	533	561

ARRANGEMENTS – OUTGOING SECTION

TWO-HIGH

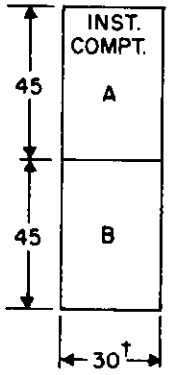


TABLE 24

Each 30" Wide x 45" High Compartment Can Be Fitted With	
Quan.	**Type**
1	K-4000 Compt. B
1*	Drawout Fuse Compt. A
1	KP, HP, HR, CP or CR (KP & HP PLUG-IN ONLY)
2	HM or CM
4	KM, HK or CJ
6	JJ, JL, HJ or HL
12	FJ or CE
20	EF, EH or HE

* Fuse size 6000A, 4000A maximum continuous current rating.
† Power Co. metering compt. 40".

THREE-HIGH

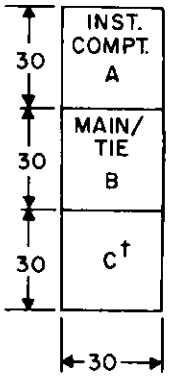


TABLE 25

Each 30" Wide x 30" High Compartment Can Be Fitted With	
Quan.	**Type**
1*	K-2000 Compt. C
1*	K-3000 Compt. C
1	K-3000 Compt. B
1*	Drawout Fuses Compt. B
1	KP, HP, HR, CP or CR (KP & HP PLUG-IN ONLY)
2	KM, HM, CJ or CM
4	JJ, JL, HJ or HL
8	FJ or CE
12	EH, EF or HE

* When used with drawout fuse units.
Fuse sizes 3000-4000A (K-2000).
Fuse sizes 4000-6000A (K-3000).
3000A maximum continuous current rating.
† Can be equipped with any lower rated breaker.

FOUR-HIGH

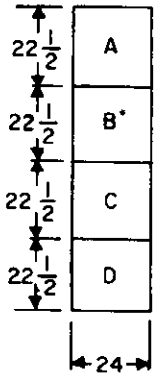


TABLE 26

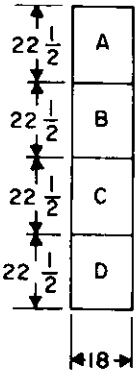
Each 24" Wide x 22½" High Compartment Can Be Fitted With	
Quan.	**Type**
1	K-16
1	KD-16
1	K-2
1	KP, HP or HR (KP & HP Plug-in only)
2	JJ, JL, KM, HJ, HK, HL, CJ
4	FJ or CE
8	EF, EH or HE

LEGEND

K-8 = K-800 & K-800S
K-16 = K-1600 & K-1600S
K-2 = K-2000 & K-2000S
KD-8 = K-DON-800 & K-DON-800S
KD-16 = K-DON-1600 & K-DON-1600S

NOTES:
All frames may be fitted with the same size circuit breaker in each compartment except as follows:
1—Only one K-2000 breaker in each 24" wide frame.
***2—Main and Tie must be located in compartment B.**

TABLE 27



Each 18" Wide x 22½" High Compartment Can Be Fitted With	
Quan.	**Type**
1	**K-8**
1	**KD-8**
1	JJ, JL, KM, HJ, HK, HL or CJ
3	FJ or CE
6	EF, EH or HE

Preferred arrangement for the same size breakers in each 18" or 24" W compartment is as follows:

No. of same size circuit breakers	Compartment
1	B
2	B, C
3	B, C, D

TABLE 28 — K-8, K-16 AND K-2 ARRANGEMENTS

Compt.	Type Breaker													
A	K-16	K-8	K-8	K-8	K-16	K-8	K-8	—	—	—	—	—	—	—
B	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	—	—
C	K-16	K-16	K-16	K-8	K-16	K-16	K-6	K-16	K-16	K-6	K-16	K 6	K-2	K-2
D	K-16	K-16	K-8	K-8	—	—	—	K-16	K-6	K-6	—	—	K-16	K-6

TABLE 29 — K-8 AND K-16 ARRANGEMENTS

Compt.	Type Breaker								
A	K-8	K-8	K-8	K-8	K-8	—	—	—	
B	K-16	K-16	K-16	K-16	K-16	K-16	K-16	—	K-16
C	K-16	K-16	K-6	K-16	K-6	K-16	K-8	K-16	K-8
D	K-16	K-8	K-8	—	—	K-8	K-8	K-8	—

TABLE 30 — KD-8 AND K-16 ARRANGEMENTS

Compt.	Type Breaker								
A	KD-8	KD-8	KD-8	KD-8	KD-8	—	—	—	—
B	K-16	K-16	K-16	K-16	K-16	K-16	K-16	—	K-16
C	K-16	K-16	KD-8	K-16	KD 8	K-16	KD-8	K-16	KD-8
D	K-16	KD-8	KD-8	—	—	KD-8	KD-8	KD-8	—

TABLE 31 — KD-8 AND KD-16 ARRANGEMENTS

Compt.	Type Breaker								
A	KD-8	KD-8	KD-8	KD-8	KD-8	—	—	—	—
B	KD-16	KD-16	KD-16	KD-16	KD-16	KD-16	KD-16	—	KD-16
C	KD-16	KD-16	KD-8	KD-16	KD-8	KD-16	KD-8	KD-16	KD-8
D	KD-16	KD-8	KD-8	—	—	KD-8	KD-8	KD-8	—

TABLE 32—K-16, K-2 AND KD-8 ARRANGEMENTS

Compt.	Type Breaker								
A	KD-8	KD-8	KD-8	KD-8	KD-8	—	—	—	—
B	K-2	K-2	K-2	K-2	K-2	K-2	K-2	K-2	—
C	K-16	K-16	KD-8	K-16	KD-8	K-16	KD-8	KD-8	K-2
D	K-16	KD-8	KD-8	—	—	KD-8	KD-8	—	KD-8

METAL-ENCLOSED BUS DUCT

I-T-E low-voltage metal-enclosed bus duct is available in continuous current ratings of 600A through 3000A at 600 volts. Standard construction includes silver-plated aluminum bus mounted on polyester-glass bus supports. Outdoor bus duct is weatherproofed and is provided with heaters to reduce condensation.

- Indoor or outdoor construction
- 3- or 4-wire
- Polyester-glass bus supports
- Silver-plated aluminum bus
- Removable access cover

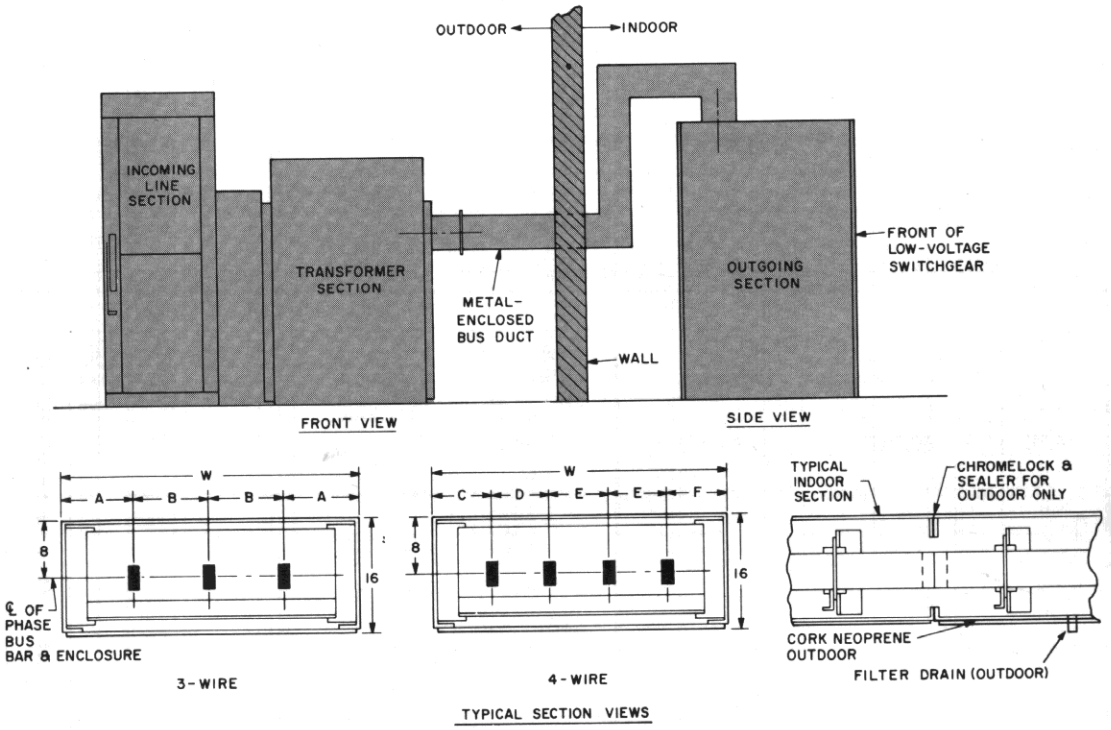


TABLE 33 — INDOOR-OUTDOOR 600-3000 Amperes

Type	Dimensions							Current Rating, A	Housing Material	Removable Cover
	W	A	B	C	D	E	F			
3-Wire	22	6	5	—	—	—	—	600-2500 3000*	12 Ga. Steel	600-1600A 12 Ga. Steel
4-Wire 50%–100% Neutral	27	—	—	6	5	5	6	600-2500 3000*	12 Ga. Steel	
4-Wire Split Phase 50% Neutral	39	—	—	6	7	9	8	3000	11 Ga. Steel	2000-3000A ⅛" Aluminum
4-Wire Split Phase 100% Neutral	43	—	—	8	9	9	8	3000	11 Ga. Steel	
3-Wire Split Phase	34	8	9	—	—	—	—	3000	11 Ga. Steel	⅛" Aluminum

* Copper only

TABLE 33A—WEIGHTS

Capacity (Amps)	Weights (lbs/3 Phase Ft)					
	Aluminum Bus			Copper Bus		
	3-Wire	4-Wire 50% NEUT.	4-Wire 100% NEUT.	3-Wire	4-Wire 50% NEUT.	4-Wire 100% NEUT.
600	40	45	45	44	50	50
800	41	46	46	48	54	55
1000	41	46	47	46	53	54
1200	41	46	48	49	56	58
1600	46	51	53	55	63	66
2000	42	46	48	62	69	76
2500	50	56	59	70	78	86
3000	63	69	77	85	95	107

SELECTION AND APPLICATION

INCOMING LINE SECTION

AIR INTERRUPTER SWITCHES

TABLE 34 — AIR INTERRUPTER SWITCH RATINGS (Fused or Unfused)

Voltage Rating				Current Rating				Interrupting Life on Close-Open Duty Cycle Number of Interruptions					Fault Closing With Spring Operator	
Nominal kV	Max. Design kV	Withstand 60 Cycle kV	Withstand Impulse kV	Continuous Current, A	At kV	10 Cycle Momentary Rms Asym. kA	4 Sec. Short-Time Rms Sym. kA	At kV	Power Factor	200A	400A	600A	Unfused Rms Asym. kA *	Fused
4.8	5.5	19	60	600 1200	5.5	61	38	5.5	0.8	1000	1000	750	40	Fuse Interrupting Rating
7.2/13.8	14.5	36	95	600 1200	14.5			14.5		800	400	300		

* 61 kA is available.

TABLE 35 — CL-14 CURRENT-LIMITING FUSE RATINGS, (50/60 Hertz) Non-Disconnect Type

Max. Design, kV	System, kV	Interrupting Amperes Rms Sym.	Interrupting Amperes Asym.	Nom. Equiv. 3-Phase MVA	Max. Cont. Current Single Barrel	Max. Cont. Current Double Barrel	Max. Cont. Current Triple Barrel
5.5	2.4 4.16 4.8	60,000	96,000	250 430 500	10E Thru 400E	—	—
15.5	6.9 7.2 11.5 12.0 12.47 13.2 13.8 14.4	40,000	64,000	480 500 800 830 860 910 955 1000	10E Thru 100E	125E	150E 200E

TABLE 36A — POWER FUSE SELECTION① *

System kV, L-L		2.4				4.16				4.8				6.9				7.2			
Transformer		I	Fuse Size			I	Fuse Size			I	Fuse Size			I	Fuse Size			I	Fuse Size		
kVA②	Impedance③	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.
112.5	4.5	27	30E	40E	65E	16	20E	20E	30E	14	20E	20E	30E	9	15E	15E	20E	9	15E	15E	20E
150	4.5	36	40E	50E	80E	21	25E	30E	40E	18	25E	25E	40E	12	15E	20E	25E	12	15E	20E	25E
225	4.5	54	65E	80E	100E	31	40E	40E	65E	27	30E	40E	50E	19	25E	25E	40E	18	20E	25E	40E
300	5.0	72	80E	100E	125E	42	50E	65E	80E	36	40E	50E	80E	25	30E	40E	50E	24	30E	40E	50E
500	5.0	120	150E	200E	200E	69	80E	100E	125E	60	65E	80E	100E	42	50E	65E	80E	40	50E	65E	80E
750	5.75	180	200E	250E	300E	104	125E	150E	150E	90	100E	125E	150E	63	80E	100E	100E	60	80E	80E	100E
1000	8.0	241	300E	—	300E	139	200E	200E	200E	120	150E	—	150E	84	100E	—	100E	80	100E	—	100E
1000	5.75	241	300E	400E	400E	139	200E	200E	250E	120	150E	200E	200E	84	100E	125E	150E	80	100E	125E	150E
1500	5.75	361	400E	—	—	208	250E	300E	400E	180	200E	250E	300E	126	150E	200E	200E	120	150E	200E	200E
2000	5.75	482	—	—	—	278	400E	400E	400E	241	300E	400E	400E	167	200E	—	200E	160	200E	200E	200E
2500	5.75	602	—	—	—	348	400E	—	—	300	400E	400E	400E	209	—	—	—	201	—	—	—
3000	5.75	722	—	—	—	416	—	—	—	362	400E	—	—	251	—	—	—	241	—	—	—

① Minimum fuse size shown will clear transformer magnetizing inrush current. 133% fuse size permits overload operation of transformer up to 133% of rating. Maximum fuse size provides transformer fault protection for phase-phase, 3-phase and phase-ground faults on secondary windings of standard 3-phase transformers. Suffix E denotes NEMA standard fuse rated 30°C rise above 40°C average ambient.

② The self-cooled kVA rating of the transformer as shown above should be used in selection of fuse size on forced-air cooled transformer applications. Also, on such applications, the 133% fuse size must be chosen for proper coordination.

③ Per cent impedance on self-cooled kVA base.

***When selecting a CL-14 fuse as a replacement for a CL-13, it is important to carefully check these selection tables. Although the CL-14 and CL-13 are physically interchangeable, several internal changes have resulted in either larger or smaller fuse "E" rating requirements at several kVA and voltage ratings.**

TABLE 36B– POWER FUSE SELECTION① *

System kV, L-L	11.5					12.0				12.47				13.2				13.8				14.4			
Transformer		I	Fuse Size			I	Fuse Size			I	Fuse Size			I	Fuse Size			I	Fuse Size			I	Fuse Size		
kVA②	Imp.③	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max.	F.L.	Min.	133%	Max
112.5	4.5	5.7	10E	10E	10E	5.4	10E	10E	10E	5.2	10E	10E	10E	4.9	10E	10E	10E	4.7	10E	10E	10E	4.5	10E	10E	10E
150	4.5	7.5	10E	10E	15E	7	10E	10E	15E	7	10E	10E	15E	6.6	10E	10E	15E	6.2	10E	10E	15E	6	10E	10E	10E
225	4.5	11.3	15E	15E	25E	10.8	15E	15E	20E	10.4	15E	15E	20E	9.8	10E	15E	20E	9.4	15E	15E	20E	9	15E	15E	20E
300	5.0	15.1	20E	20E	30E	14.4	20E	20E	30E	14	15E	20E	30E	13	15E	20E	30E	12.6	15E	20E	25E	12	15E	20E	25E
500	5.0	25.1	30E	40E	50E	24	30E	40E	50E	23	25E	30E	50E	22	25E	30E	50E	21	25E	30E	40E	20	25E	30E	40E
750	5.75	37.7	50E	50E	80E	36	40E	50E	80E	35	40E	50E	65E	33	40E	50E	65E	32	40E	50E	65E	30	40E	40E	65E
1000	8.0	50.3	65E	80E	80E	48	65E	65E	80E	46	50E	65E	65E	44	50E	65E	65E	42	50E	65E	65E	40	50E	65E	65E
1000	5.75	50.3	65E	80E	100E	48	65E	65E	100E	46	50E	65E	80E	44	50E	65E	80E	42	50E	65E	80E	40	50E	65E	80E
1500	5.75	75.4	100E	100E	125E	72	80E	100E	125E	70	80E	100E	125E	66	80E	100E	100E	63	80E	100E	100E	60	65E	80E	100E
2000	5.75	101	125E	150E	150E	96	125E	150E	150E	92	100E	125E	150E	88	100E	125E	150E	84	100E	125E	150E	80	100E	125E	150E
2500	5.75	126	125E	200E	200E	120	150E	200E	200E	116	150E	150E	200E	109	125E	150E	150E	105	125E	150E	150E	100	125E	150E	150E
3000	5.75	151	200E	200E	200E	144	200E	200E	200E	139	200E	200E	200E	131	150E	200E	200E	125	150E	200E	200E	120	150E	200E	200E

* ①②③ See notes at bottom of page 32.

FUSE CURVES

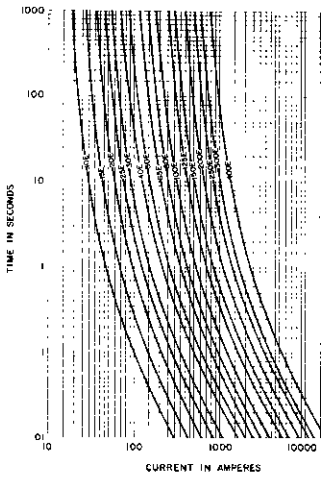


Figure 1—Minimum Melt Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 4.8KV.

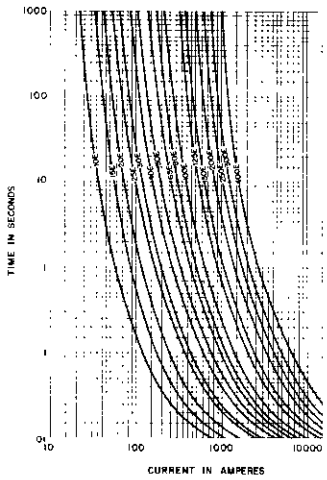


Figure 2—Total Clearing Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 4.8KV.

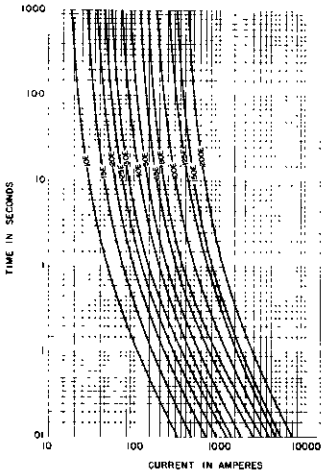


Figure 3—Minimum Melt Time-Current Characteristic Curves. For Type CL-14 Current-Limiting Fuse Units—Voltage Rating 14.4KV.

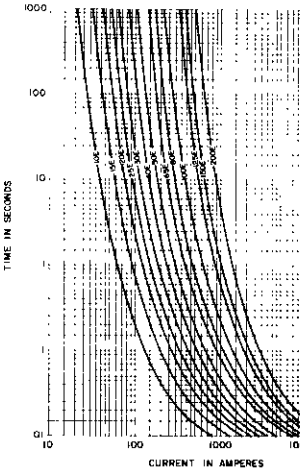


Figure 4—Total Clearing Ti Current Characteristic Cur For Type CL-14 Current-Lir ing Fuse Units—Voltage Rat 14.4KV.

OIL CUTOUTS

TABLE 37 — FUSE INTERRUPTING RATINGS

Nominal Full Winding Voltage	Fuse Interrupting Rating		kVA Limitations	
	Amperes (rms) Asymmetrical	Equivalent MVA Symmetrical	Fused	Unfused
2.4	10,000	42	500	750
4.16	10,000	72	750	1000
13.8	4,000	99	1000	2000

METAL-CLAD SWITCHGEAR

For application information, see Bulletin 8.2-1

LIQUID SWITCH

TABLE 38 — RATINGS

Voltage Rating, kV	Maximum Continuous Current Rating, A	Interrupting Capacity, A	
		Oil-filled	Askarel-filled
5	400	400	①
15	400	400	①

① When liquid switch is askarel-filled, it has no interrupting capacity. It can break magnetizing currents of up to 10A for five times without replacement.

TRANSFORMER SECTION

TABLE 39 — STANDARD TRANSFORMER RATINGS

TYPE	Primary Voltage Delta	kVA 3-Phase Fan-Cooled	kVA 3-Phase Fan-Cooled	SECONDARY VOLTAGE 208Y/120 240 delta	SECONDARY VOLTAGE 480Y/277 480 delta	Standard Impedance* % IZ	NEMA Sound Level, db Self-Cooled	NEMA Sound Level, db Forced-Air Cooled
Ventilated-Dry and Totally Enclosed Non-Ventilated	2400	112½	—	x	x	3.0‡	50	—
	4160	150	—	x	x	3.5‡	50	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	667	x	x	5.0	60	67
	12000	750	1000	x	x	5.75	64	67
	12470	1000	1333	x	x	5.75	64	68
	13200	1000	1333	—	x	8.0	64	68
	13800	1500	2000	—	x	5.75	65	69
		2000	2666	—	x	5.75	66	71
		2500	3333	—	x	5.75	68	71
Sealed-Dry Gas-Filled 150°C Rise †	2400	300		x	x	5.0	57	—
	4160	500		x	x	5.0	59	—
	4800	750		x	x	5.75	63	—
	6900	1000		x	x	5.75	63	—
	7200	1000	—	—	x	8.0	63	—
	12000	1500		—	x	5.75	64	—
	12470	2000		—	x	5.75	65	—
	13200	2500		—	x	5.75	66	—
	13800							
Liquid-Immersed Oil or Silicone 65°C Rise †	2400	112½	—	x	x	2.25‡	55	—
	4160	150	—	x	x	3.0‡	55	—
	4800	225	—	x	x	4.5	55	—
	6900	300	—	x	x	5.0	55	—
	7200	500	—	x	x	5.0	56	—
	12000	750	862	x	x	5.75	58	67
	12470	1000	1150	x	x	5.75	58	67
	13200	1000	1150	—	x	8.0	58	67
	13800	1500	1725	—	x	5.75	60	67
		2000	2300	—	x	5.75	61	67
		2500	3125	—	x	5.75	62	67

* Standard impedance tolerance is ±7½%. † For application where the average ambient temperature is 30°C.

‡ Transformers with impedances of 4.0% or less are designed to withstand 25 times normal current for two seconds.

TABLE 40 — LIGHTNING ARRESTERS

kV Rating of Arrester	Line to Line kV Ungrounded System	Line to Line kV Grounded System
Station and Intermediate Type ①		
3	2.4	4.16
6	4.8	7.2
9	7.2	12.47
12	11.5	13.8
15	13.8	18.0
Distribution Type ②③		
4.5	4.5	6.0
6	6.0	9.0
9	9.0	12.8
12	12.0	15.0
15	15.0	18.0

① For use with liquid-immersed transformers

② For use with sealed-dry transformers.

③ Distribution type arresters with special characteristics are furnished as standard on ventilated-dry transformers.

TABLE 41 — TEMPERATURE GUARANTEES

Transformer Type	Ambient*	Rise†	Hot Spot Rise
Liquid-immersed	30°C	65°C	80°C
Ventilated-dry	30°C	150°C	180°C
Non-ventilated dry	30°C	150°C	180°C
Sealed-dry	30°C	150°C	180°C

Altitudes must not exceed 1000 meters or 3300 feet.

* The temperature of the cooling air (ambient temperature) must not exceed 40°C and the average temperature of the cooling air for any 24-hour period must not exceed 30°C.

† Degrees rise is the average winding temperature rise by resistance. See NEMA Standard TR-1 and ANS C57.12.00.

TABLE 42 — DIELECTRIC TESTS

Transformer Type	Voltage Class, kV	Applied Test 60 Cycle All kVA Ratings	Basic Impulse Levels 1.2 x 50 ms	Induced Test 7200 Cycles, All kVA Ratings
Liquid-Immersed or Sealed-Dry	1.2	10 kV	30 kV	Twice normal voltage
	2.5	15 kV	45 kV	
	5.0	19 kV	60 kV	
	8.66	26 kV	75 kV	
	15.0	34 kV	95 kV	
Ventilated-Dry and Totally Enclosed Non-Ventilated	1.2	4 kV	10 kV	Twice normal voltage
	2.5	10 kV	20 kV	
	5.0	12 kV	25 kV	
	8.66	19 kV	35 kV	
	15.0	31 kV	50 kV	

TABLE 43 — STANDARD HIGH-VOLTAGE TAPS

Rated Voltage	Rated kVA HV Taps, Volts			
2400	2520	2460	2340	2280
4160	4360	4260	4055	3950
4800	5040	4920	4680	4560
6900	7245	7070	6730	6555
7200	7560	7380	7020	6840
12000	12600	12300	11700	11400
12470	13095	12780	12160	11845
13200	13860	13530	12870	12540
13800	14400	14100	13500	13200

OUTGOING SECTION—K-LINE® CIRCUIT BREAKERS

TABLE 44 — K-LINE CIRCUIT BREAKER RATINGS

① Circuit Breaker Type	A-C Volts	Frame Size, A	Symmetrical Interrupting Rating With		Sym-metrical Close and Latch & 30-Cycle Short-Time Rating, A
			Instan-taneous Trip, A	Delayed Trip, A	
K-800	208 and 240	800	42,000	22,000	22,000
K-1600		1,600	65,000	50,000	50,000
K-2000		2,000	85,000	55,000	55,000
K-3000		3,000	85,000	65,000	65,000
K-4000		4,000	130,000	85,000	85,000
K-800	480	800	30,000	22,000	22,000
K-1600		1,600	50,000	50,000	50,000
K-2000		2,000	65,000	55,000	55,000
K-3000		3,000	65,000	65,000	65,000
K-4000		4,000	85,000	85,000	85,000
K-800	600	800	22,000	22,000	22,000
K-1600		1,600	42,000	42,000	42,000
K-2000		2,000	55,000	55,000	55,000
K-3000		3,000	65,000	65,000	65,000
K-4000		4,000	85,000	85,000	85,000

① Recommended maximum continuous current rating of largest feeder breaker in per cent of transformer (self-cooled) rated current, when primary power fuses are included is 40% for current-limiting type and 50% for non-current-limiting type

TABLE 45 — K-LINE S CIRCUIT BREAKER RATING

① Circuit Breaker Type	A-C Volts	Frame Size, A	Symmetrical Interrupting Rating With		Sym-metrical Close and Latch & 30-Cycle Short-Time Rating, A
			Instan-taneous Trip, A	Delayed Trip, A	
K-800S	208 and 240	800	42,000	22,000	22,000
K-1600S		1,600	65,000	50,000	50,000
K-2000S		2,000	85,000	55,000	55,000
K-3000S		3,000	85,000	65,000	65,000
K-4000S		4,000	130,000	85,000	85,000
K-800S	480	800	30,000	22,000	22,000
K-1600S		1,600	50,000	50,000	50,000
K-2000S		2,000	65,000	55,000	55,000
K-3000S		3,000	65,000	65,000	65,000
K-4000S		4,000	85,000	85,000	85,000
K-800S	600	800	22,000	22,000	22,000
K-1600S		1,600	42,000	42,000	42,000
K-2000S		2,000	55,000	55,000	55,000
K-3000S		3,000	65,000	65,000	65,000
K-4000S		4,000	85,000	85,000	85,000

① Recommended maximum continuous current rating of lar feeder breaker in per cent of transformer (self-cooled) ra current, when primary power fuses are included is 40% current-limiting type and 50% for non-current-limiting type.

TABLE 46—CIRCUIT BREAKER CONTROL-POWER REQUIREMENTS

Circuit Breaker Type	Nominal Control Voltage	Average Closing-Motor Current, A	Shunt-Trip Current, A	Closing-Relay Current, A		Closing-Circuit Voltage Range, Volts	Trip-Circuit Voltage Range, Volts	Recommen Control Cir Fuse Size,
				Anti-Pump	Release			
K-800, S K-1600, S K-DON-800 K-DON-1600 K-DON-800S K-DON-1600S	120 V ac 240 V ac 48 V dc 125 V dc 250 V dc	10 5 25 10 5	6.5 1.15 3.14 1.3 .65	.15 .075 .11 .06 .03	1.5 .75 1.33 .7 .3	104-127 208-254 38-56 100-140 200-280	50-127 208-254 28-56 70-140 140-280	10 10 15 10 10
K-3000, S and K-4000, S	120 V ac 240 V ac 48 V dc 125 V dc 250 V dc	10 5 25 10 5	10.0 1.84 5.0 2.0 1.0	.15 .075 .11 .06 .03	4.0 1.84 5.0 2.0 1.0	104-127 208-254 38-56 100-140 200-280	50-127 208-254 28-56 70-140 140-280	10 10 15 10 10

TABLE 47—UNDERVOLTAGE TRIP DEVICE

Nominal Control Voltage	Current at Rated Volts, A	Minimum Pick-up Voltage Value, Volts	Dropout Voltage Value, Volts	
			Minimum	Maximum
120 V ac	0.50	102	36	72
240 V ac	0.20	204	72	144
480 V ac	0.10	408	144	288
48 V dc	0.32	41	15	29
125 V dc	0.20	106	38	75
250 V dc	0.10	212	75	150

SELECTION OF LOW-VOLTAGE POWER CIRCUIT BREAKERS IN LOW-VOLTAGE DRAWOUT SWITCHGEAR†

SELECTION OF BREAKER TRIPPING CHARACTERISTICS

The degree of service continuity available from a low-voltage distribution system depends on the degree of coordination between circuit-breaker tripping characteristics.

Three methods of tripping coordination are in general use, each representing a different degree of service continuity and of initial cost.

These methods, or systems, combine breaker ratings and tripping characteristics as follows:

FULLY-RATED SYSTEM

A fully-rated system is one in which both the main and feeder breakers have adequate interrupting capacity for the fault current available at the point of application.

All breakers are equipped with long-time delay and instantaneous overcurrent trips. Ordinarily only the breaker nearest the fault will open. The main breaker will trip, however, when the fault current exceeds its instantaneous trip setting, and service continuity may be lost.

CASCADED SYSTEM

A cascaded system is one in which only the main breaker has adequate interrupting capacity. Not recommended.

SELECTIVE SYSTEM

A selective system is one in which both the main and feeder breakers have adequate interrupting capacity for the fault current available at the point of application.

The main breaker is equipped with overcurrent trip devices having long-time delay and short-time delay functions. The feeder breakers are equipped with overcurrent trip devices having long-time delay and instantaneous functions unless they are required to be selective with other protective devices nearer the load. In this case, the feeders are equipped with trip devices having both long-time and short-time delay.

In a selective system, only the breaker nearest the fault trips. Service continuity is thus maintained through all other breakers.

The main breaker trips only on a bus fault.

The selective system offers a maximum of service continuity, with a slightly higher initial cost than the fully-rated or cascaded systems.

SELECTION OF BREAKER TYPE

The following three basic factors determine the selection of a breaker after a decision has been reached on the type of system required:

System voltage and frequency
Continuous current
Available fault current

† Selection and application information is for low-voltage power circuit breakers equipped with OD direct-acting, electro-mechanical overcurrent trip devices. In general, however, these application rules apply to breakers with POWER-SHIELD® solid-state overcurrent trip devices except for differences in available ampere taps and long-time, short-time and instantaneous pick-up settings.

USE OF APPLICATION TABLES

Application Tables 48A and 48B provide for proper selection of the circuit-breaker type required. They should be used as follows:

Use Table 48A for a fully-rated system
Use Table 48B for a selective system

Having chosen the right table, refer to that part of it which covers the system voltage.

Look for the horizontal line listing an available fault current nearest the one required at the point of application (let the nearest one be higher, rather than lower than the exact fault current needed).

Then select the circuit-breaker type listed where the Available Fault Current line crosses the vertical column headed with the wording: Load Continuous Current Rating.

TABLE 48A—FULLY RATED SYSTEM (Electro-Mechanical Trip Device Only)

Manually-charged, stored-energy-closed circuit breakers may be applied within their 600 v, 480 v, or 240 v interrupting rating, provided their instantaneous trips are set below their short-time ratings.
Note: For solid-state trip devices any available amp tap may be used regardless of voltage within the short circuit current rating of the circuit breaker.

System Voltage and Frequency	Available Fault Current, Symmetrical RMS Amperes	Load Continuous Current Rating
501 to 630V 25-60 Hertz	14000	K-800 / K-1600 / K-2000 / K-3000 / K-4000
	22000	
	42000	
	55000	
	65000	
	85000	
251 to 500V 50-60 Hertz	22000	K-800 / K-1600 / K-2000 / K-3000 / K-4000
	30000	
	50000	
	65000	
	85000	
Up to 250V 50-60 Hertz	25000	K-800 / K-1600 / K-2000 / K-3000 / K-4000
	42000	
	65000	
	85000	
	130000	

Load Continuous Current Rating: 15 20 30 40 50 70 90 100 125 150 175 200 225 250 300 350 400 500 600 800 1000 1200 1600 2000 2500 3000 4000

TABLE 48B—SELECTIVE SYSTEM (Electro-Mechanical Trip Device Only)

The manually-charged, stored-energy-closed circuit breakers with delayed trip may be applied within their short-time ratings.
Note: For solid-state trip devices any available amp tap may be used regardless of voltage within the short circuit current rating of the circuit breaker.

System Voltage and Frequency	Available Fault Current, Symmetrical RMS Amperes	Short-Time Delay Band	Load Continuous Current Rating
Up to 600V 50-60 Hertz	14000	Minimum Intermediate Maximum	K-800 / K-1600 / K-2000 / K-3000 / K-4000
	22000	Minimum Intermediate Maximum	K-800 / K-1600 / K-2000 / K-3000 / K-4000
	42000*	Minimum Intermediate Maximum	K-1600 / K-2000 / K-3000 / K-4000
	55000	Minimum Intermediate Maximum	K-2000 / K-3000 / K-4000
	65000	Minimum Intermediate Maximum	K-3000 / K-4000
	85000	Minimum Intermediate Maximum	K-4000

Load Continuous Current Rating: 75 100 125 150 175 200 225 250 300 350 400 500 600 800 1000 1200 1600 2000 2500 3000 4000

K-DON® CIRCUIT BREAKERS

TABLE 49 — K-DON BREAKER RATINGS

Circuit Breaker Type	Frame Size, A	Voltage A C	Maximum Continuous Current, A	Maximum Interrupting Symmetrical Rating, Rms Amperes*	Range of Circuit Breaker Pickup, A	Amp-trap Continuous Rating, A
K-DON-800 K-DON-1600	800 1600	up to 600 up to 600	800 1600	200,000 200,000	70-800 120-1600	300-1200 300-2500
K-DON-800S K-DON-1600S	800 1600	up to 600 up to 600	800 1600	200,000 200,000	70-800 200-1600	300-1200 600-2500

* Ratings shown are instantaneous trip settings.

The following step by step procedure is to be used as a guide for proper circuit breaker and fuse selection.

A. CIRCUIT-BREAKER SELECTION

1—Determine the system short-circuit capacity in symmetrical rms amperes.

2—Determine from Table 50 columns 3, 4 and 5 respectively the approximate continuous current rating and the time-delay and instantaneous overcurrent trip settings.

3—Select from Tables 51* or 52, columns 1, 2, 3 and 4 respectively the frame size, proper coil rating, time-delay and instantaneous settings as follows:

(a) When there is a choice of breaker frame size larger will provide maximum flexibility in case load growth.

(b) The coil rating should be equal to or greater than value determined in Table 50, column 3.

(c) Time-delay setting should be set at a value nea to that determined in Table 50, column 4.

(d) Instantaneous setting should be set at a value nea to that determined in Table 50, column 5. Howe this value may have to be adjusted downward to ordinate with Amp-trap to be selected in step B.

*Table 51 is to be used for K-DON breakers with electro-mechanical ove rent trip devices; Table 52 is for K-DON breakers with solid-state overcu trip device.

†Registered Trademark—Chase-Shawmut Co.

TABLE 50 — CIRCUIT-BREAKER APPLICATION

1		2	3	4	5
Type of Application		Purpose of Circuit Breaker	Continuous Current Rating of Circuit Breaker	Settings of Overcurrent Trip Device	
				Time Delay	Instantaneo
Service entrance (general)		(a) To protect source transformer windings from overheating, due to overload of fault current flow. (b) To protect circuit conductors from effects of overcurrent flow. (c) To provide safe and rapid means for connecting and disconnecting of load circuit.	Based upon 125% of the transformer current rating	125% of the transformer current rating	1000% of circuit-breal current rati
Service feeder (general)		(a) To protect circuit conductors from effects of overcurrent flow. (b) To protect connected electrical equipment from effects of fault current flow.	Based upon 115% of estimated load current	115% of estimated load current	1000% of circuit-breal current rati
BRANCH CIRCUITS (GENERAL)	Individual motor circuit	(a) To protect motor windings from overheating due to overcurrent or fault current flow. (b) To protect circuit conductors and other connected electrical equipment from overload or fault current flow. (c) To provide safe and rapid means of connecting and disconnecting motor circuit.	Based upon 115% of rated full-load current of motor	115% of rated full-load current of motor	1000% of circuit-breal current rati
	Group motor circuit	(a) To protect circuit conductors from overheating. (b) To protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. (c) To provide safe and rapid means of connecting and disconnecting common motor circuit from supply source.	Based upon 115% of largest motor full-load current plus sum of other motor currents	100% of circuit-breaker current rating	1000% o circuit-breal current rati
	Combined motor and lighting circuit	(a) To protect circuit conductors from overheating. (b) To protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. (c) To provide safe and rapid means of connecting and disconnecting common load circuit from supply source.	Based upon 115% of largest motor full-load current plus sum of other motor and lighting load currents	100% of circuit-breaker current rating	1000% o circuit-brea current rati
	Lighting circuit	(a) To protect circuit conductors from effects of overload or fault current flow. (b) To provide safe and rapid means of connecting and disconnecting lighting circuit from supply source.	Based upon 125% of estimated maximum lighting current	100% of circuit-breaker current rating	1000% o circuit-brea current rati

K-DON® CIRCUIT BREAKERS

B. AMP-TRAP† SELECTION

Table 51 or 52 is to be used for selecting the correct fuse sizes to coordinate with the instantaneous setting of the overload device to provide proper coordination between the circuit breaker and fuse. It was developed to provide the greatest range of coordination possible, taking advantage of maximum fuse sizes whose let-thru current can be withstood by the circuit breaker.

Figure 6, Page 41, is a second aid in the selection of the proper Amp-Trap fuse sizes. However, Fig. 6 is not to be used as the only criterion if, as in the case of molded-case circuit breakers, there is an I^2t limitation in the equipment to be protected by the fuse (See Figure 7).

There are two basic considerations in selecting an Amp-Trap fuse size.

1—The peak let-thru current must not exceed 2.3 times the symmetrical short-circuit withstand of the equipment to be protected by the K-DON circuit breaker.

a. If the equipment protected by the circuit breaker has a symmetrical short-circuit withstand rating at least equal to that of the circuit breaker,* fuse size selection may be made by using Table 51 or 52.

b. If the equipment protected by the circuit breaker has a symmetrical short-circuit withstand rating less than the circuit breaker, Fig. 6 must be used to determine the maximum fuse size.

Draw a vertical line on Fig. 6 representing the available symmetrical RMS amperes. Establish the intersection of this line with the peak amperes that the equipment is capable of withstanding. The fuse size represented by the fuse let-thru curve passing below this intersection is the maximum fuse size that should be used. Of course, the smallest fuse size, consistent with coordination, provides the best protection.

2—The second consideration is that the fuse size coordinates with the circuit-breaker overload time-current characteristic. Proper application of Table 51 or 52 and their associated notes will assure coordination and, therefore, avoid needless fuse replacements for current levels within the interrupting rating of the breaker.

For application using special instantaneous settings, a breaker-fuse coordination curve should be drawn.

Fuse curves are normally plotted with time as the ordinate and current in amperes as the abscissa. However, the abscissa of the overcurrent device time-current curves is the ratio of actual current to current tap or to coil rating or to pickup setting. There are so many combinations of settings as to render it completely impractical to publish general coordination curves for fuses and overcurrent trip devices.

When it is desired to plot specific coordination curves, the following procedure is suggested.

a. Replot the overcurrent device curve using actual amperes as the abscissa based on pick-up settings selected. The curves may be moved right or left to accommodate settings not plotted on published curves. A transparent overlay is helpful in this procedure.

b. Enter the fuse melting time-current curve from Figure 7, Page 41, on this newly plotted overcurrent device curve and examine for proper coordination.

c. When fuse size is dictated by protection needs, the fuse curve should be plotted first and the overcurrent device settings are then determined by trial and error, by replotting the overcurrent device curves.

NOTES:

① Maximum allowable fuse sizes listed in Tables 51 or 52 are based on an available RMS symmetrical short-circuit current of 200kA. If available current is less than 200kA larger fuse sizes may be used based on let-thru of Figure 6 as illustrated in the following table. **Note that this does not apply to K-DON breakers equipped with solid-state trip.**

Frame Size	800	800	1600
Avail. kA	130	85	100
Max. Fuse Size, Amps.	1600	2000	3000

② When fused circuit breakers are used on high-inrush circuits such as motor starting, for extended periods, the maximum allowable fuse size from Tables 51 or 52 should be used regardless of instantaneous setting. Otherwise these fuses and other unblown fuses, after a short-circuit, may have melting times less than "when new". In this case, fuse replacement should be considered if the coordination is critical.

C. APPLYING LOW-VOLTAGE POWER CIRCUIT BREAKERS WITH SEPARATELY MOUNTED CURRENT LIMITING FUSES

(Note that this applies to the K-2000, K-3000 and K-4000 only. Lower rated breakers (not K-225) will be coordinated in the same manner as the K-DON breakers in Tables 51 or 52.

The interrupting capability of the proper combination of low-voltage power circuit breakers and current-limiting fuses is appreciably higher than the capability of the circuit breaker alone. The following guidelines are offered for combining Chase-Shawmut Amp-Trap current-limiting fuses, NEMA Class L, with modern I-T-E low-voltage power circuit breakers:

1—Avoid or at least minimize overlap of time-current characteristics (fuse vs. overcurrent device) at currents less than the circuit-breaker interrupting rating to keep needless fuse blowing to a minimum. Adding a short-time element often helps to obtain coordination.

2—The total clearing time of the fuse must be equal to or less than the total clearing time of the circuit breaker at a current equal to the interrupting rating of the circuit breaker at the voltage of the application.

3—The peak let-through current of the fuse must not exceed 2.3 times the withstand rating of the circuit breaker.†

4—The fuses should preferably be on the source side of the circuit breaker. When this is not possible, the two should be located as close as practical to each other, and the installation should minimize the exposure to a fault between the breaker and the fuse.

NOTE:

In order to obtain selective protection when fuses are applied in series, it is necessary that the fuse nearer the source have a current rating at least two times that of the fuse nearer the load, providing that both fuses are Chase-Shawmut Class L. The two-times ratio is applied to fuse ratings up to 2000A, but for fuse ratings of 2500A to 6000A the ratio may be reduced to 1½ times.

† Registered Trademark—Chase Shawmut Co.

* K-DON-600, 42,000A Sym; K-DON-1600, 65,000A Sym.

† K-2000 — 85,000A, Sym.
K-3000 — 130,000A, Sym.
K-4000 — 130,000A, Sym.

TABLE 51 —
K-DON COORDINATION (ELECTRO-MECHANICAL OD-3)

Circuit Breaker Type	Breaker Coil Rating, A	Long-Time Pickup Settings, A	Instantaneous Pickup Settings,③ A	Coordinating Fuse Size, A (See Note 1) Min.	Max.
1	2	3	4	5	
K-DON-800	125	70, 90, 100, 125 or 160	450	300	800
			800	300	800
			1200	400	800
			1900	600	800
	225	120, 150, 175, 200, 225 or 285	750	300	1200
			1500	400	1200
			2400	600	1200
			3400	1000	1200
	400	250, 300, 350, 400 or 500	1250	400	1200
			2000	600	1200
			4000	1200	1200
			6000	See Note 2	
	600	400, 500, 600 or 750*	2500	800	1200
			4000	1200	1200
			6000	See Note 2	
			9000	See Note 2	
	800	400, 500, 600, 800 or 1000	2500	800	1200
			5000	1200	1200
			8000	See Note 2	
			12000	See Note 2	
K-DON-1600	225	120, 150, 175, 200, 225 or 285	750	300	1600
			1500	400	1600
			2400	600	1600
			3400	1000	1600
	400	250, 300, 350, 400 or 500	1250	400	2500
			2000	600	2500
			4000	1200	2500
			6000	1600	2500
	800	400, 500, 600, 800 or 1000	2500	800	2500
			5000	1600	2500
			8000	2500	2500
			12000	See Note 2	
	1600	800, 1000, 1200, 1600 or 2000*	5000	2500	2500
			10000	2500	2500
			16000	See Note 2	
			24000	See Note 2	

*Setting above maximum breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

TABLE 52 —
K-DON COORDINATION (SOLID-STATE SS-3)

Circuit Breaker Type		Breaker AMPERE TAP Settings, A	Long-Time Pickup Settings, (X Ampere Tap) A	Instantaneous Pickup Settings, (X Ampere Tap) A	Coordinating Fuse Size, A (See Notes 1 & 5) Min.	Max.
1		2	3	4	5	
K-DON-800S	SENSOR RANGE	50, 70, 100	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	300	1200
		150	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	300	1200
					400	1200
		225	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	400	1200
					600	1200
	SENSOR RANGE	250	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	600	1200
					800	1200
		300	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	600	1200
					800	1200
		400	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	800	1200
					1000	1200
		600	0.7, 0.8, 0.9, 1.0, 1.1†	4, 5, 6, 8, 10 or 12	1200	1200
					See Note 2	
		800	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	See Note 2	
K-DON-1600S	SENSOR RANGE	250	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	600	2500
					800	2500
		400	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	800	2500
					1000	2500
		600	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	1200	2500
					1600	2500
	SENSOR RANGE	600	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	1200	2500
					1600	2500
		1000	0.7, 0.8, 0.9, 1.0, 1.1	4, 5, 6, 8, 10 or 12	2000	2500
					2500	2500
		1600	0.7, 0.8, 0.9, 1.0, 1.1†	4, 5, 6, 8, 10 or 12	2500	2500
					See Note 2	

† Setting above maximum ampere tap rating and breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

NOTES TO TABLES 51 AND 52:

① The minimum fuse size column indicates the minimum fuse size that will coordinate with the instantaneous trip setting directly along side it at the 100% long-time pickup setting. Even though a lower fuse size might appear to coordinate by use of minimum or intermediate time bands or lower instantaneous setting or lower long-time pickup setting, a fuse size lower than listed is not recommended.

③ The maximum fuse for the frame size will not coordinate with the instantaneous trip setting listed. (See Note 4.)

④ The instantaneous setting selected should not be less than five nor more than fifteen times the long-time pickup setting selected.

④ When the selected settings and indicated fuse size will not coordinate, th following applies:

a. Determine the degree of overlap by drawing a breaker-fuse coordin tion curve.

b. If the degree of overlap is not deemed critical (low probability of nee less fuse blowing), accept the overlap.

c. If the degree of overlap is deemed critical, utilize a short-time dela element in conjunction with the long-time and instantaneous elemen to achieve coordination.

⑤ For the solid-state device the coordinating fuse size is based on the amper tap setting. If a higher tap setting is planned for future load growth, th maximum fuse size for the sensor range should be used to maintain prop coordination.

Tables 53 and 54 can be used along with the notes of Table 51 and 52 to assure coordination. Table 53 is to be used when applying separately fused circuit breakers with electro-mechanical overcurrent trips.

TABLE 53 —
COORDINATION OF SEPARATELY MOUNTED FUSES AND BREAKERS (Electro-Mechanical)

Circuit Breaker Type	Breaker Coil Rating, A	Long-Time Pickup Settings, A	Instantaneous Pickup Settings, A	Coordinating Fuse Size (See Table 51, Note 1) Min.	Max.
K-2000	2000	1200, 1600, 1800, 2000 or 2500*	10,000	3000	3000
			15,000	See Note A	
			20,000	See Note A	
			30,000	See Note A	
K-3000	3000	1600, 2000, 2500, 3000 or 3800*	10,000	4000	6000
			20,000	6000	6000
			28,000	See Table 51, Note 2	
			36,000	See Table 51, Note 2	
K-4000	4000	2000, 3000, 3500, 4000 or 5000*	20,000	6000	6000
			30,000	See Table 51, Note 2	
			40,000	See Table 51, Note 2	
			48,000	See Table 51, Note 2	

* Setting above coil rating is available for coordination, if needed, but is not thermally self protecting.

Table 54 is for separately fused circuit breakers with solid-state overcurrent trip devices.

TABLE 54 —
COORDINATION OF SEPARATELY MOUNTED FUSES AND BREAKERS (Solid-State)

Circuit Breaker Type		Breaker AMP-ERE TAP Set. A	Long-Time Pickup Settings, (X Ampere Tap) A	Instantaneous Pickup Settings, (X Ampere Tap) A	Coordinating Fuse Size (See Table 51, Note 1) Min.	Max.
K-2000S	SENSOR RANGE	800	0.7, 0.8,	4, 5, 6, 8, 10, 12	2000	3000
		1200	0.9, 1.0,	4, 5, 6, 8, 10, 12	3000	3000
		2000	1.1†	4, 5, 6	3000	3000
		2000		8, 10, 12	See Note A	
K-3000S		2000	0.7, 0.8,	4, 5, 6, 8, 10, 12	5000	6000
		3000	0.9, 1.0,	4, 5, 6, 8	6000	6000
		3000	1.1†	10, 12	See Table 51, Note 2	
K-4000S		3000	0.7, 0.8,	4, 5, 6, 8	6000	6000
		3000	0.9, 1.0,	10, 12	See Table 51, Note 2	
		4000	1.1†	4, 5, 6	6000	6000
		4000		8, 10, 12	See Table 51, Note 2	

† Setting above maximum ampere-tap rating is available for coordination, if needed, but is not thermally self protecting.

A. Maximum fuse sizes listed are based on an available RMS symmetrical short-circuit current of 200kA. However, if the available current is only 115kA, a 4000A fuse may be used with the K-2000S breaker frame size for coordination with a higher instantaneous setting.

To illustrate the use of Fig. 6—Amp Trap Let-Thru Curves, assume a fault current of 80,000 Amp symmetrical using a 300 Amp current-limiting fuse. Enter table at 80,000 Amp sym. and project to the intersection of this line with the curve for the 300 Amp fuse; then project this point horizontally to a value of 30,000 peak let-thru amp. To obtain the fault current let-thru amp sym., divide the peak let-thru value by 2.3.

$$\frac{30{,}000}{2.3} = 13043 \text{ Amp sym.}$$

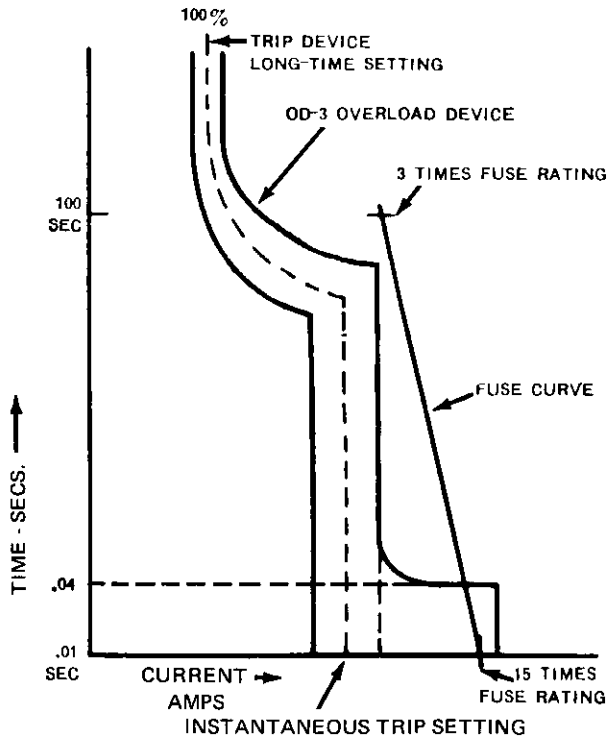


Figure 5—Typical Breaker Amp-Trap Coordination Curve

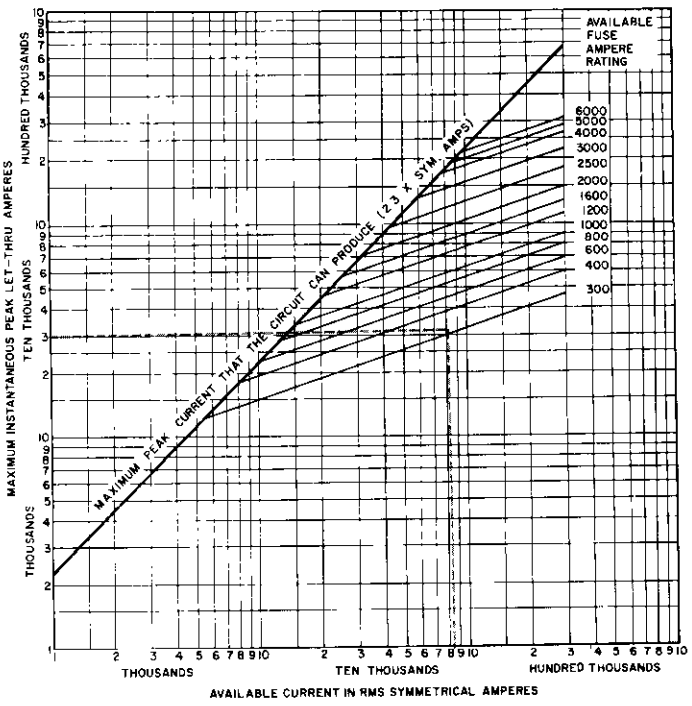


Figure 6—Amp-Trap Let Thru Curves

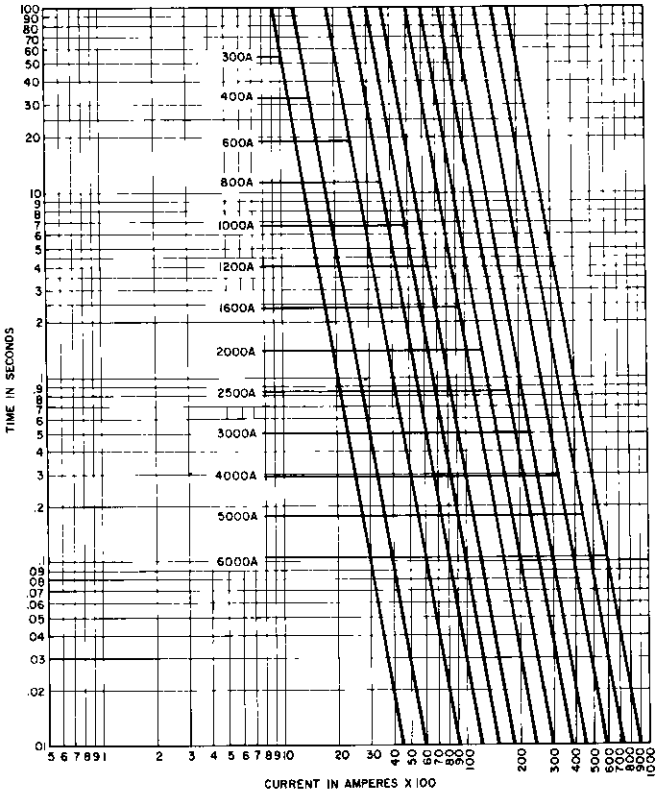


Figure 7—Melting Time-Current Characteristic Curves

TABLE 55— PROTECTION OF MOLDED-CASE CIRCUIT BREAKERS IN SWITCHGEAR, MOTOR CONTROL CENTERS AND PANELBOARDS*

Molded Case Circuit Breaker		K-DON-800		K-DON-1600	
Type	Trip Rating, A	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A
EF	15-100	225	300	—	—
FJ	70-150	400	400	—	—
	175-225			400	400
JL	70-125	600	1000	800	1000
	150-225				
	250-400				
KM	250-275	600	1000	800	1000
	300-800	—	—		
HE	15-50	600	800	—	—
	70-100			800	800
HJ	125	600	1200	800	1200
	150-175				
	225-400				
HM	400-800	—	—	800	1200

TABLE 56— PROTECTION OF LOW-IMPEDANCE BUS DUCT SYSTEMS*

Bus Duct	K-DON-800		K-DON-1600	
Ampere Rating	Maximum Coil Rating, A	Maximum Amp-Trap Rating, A	Maximum Coil Rating, A	Maxim Amp-T Rating
		Plug-In Type		
225	400	300	—	—
400	600	1200	—	—
600	600	2500	800	250
800	—	—	1600	250
1000	—	—	1600	250
1200	—	—	1600	250
1350	—	—	1600	250
1600	—	—	1600	250
		Feeder-Type		
800	—	—	1600	250
1000	—	—	1600	250
1200	—	—	1600	250
1350	—	—	1600	250
1600	—	—	1600	250

*Based on available short-circuit current of 100,000 amperes at 480 volts. For available fault currents above 100,000 amperes symmetrical, consult I-T-E district sales o

OD—ELECTRO-MECHANICAL OVERCURRENT TRIP DEVICE

GENERAL-PURPOSE, DUAL-MAGNETIC DIRECT-ACTING OVERCURRENT TRIP DEVICE (OD-3 AND OD-300)

This device combines long-time delay (50-125% of coil rating) and instantaneous (500-1500% of coil rating). It can be used in almost any feeder application including welding and motor circuits.

DUAL-SELECTIVE, DIRECT-ACTING OVERCURRENT TRIP DEVICE (OD-4 AND OD-400)

This device combines long-time delay (80-160% of coil rating) and short-time delay (400-1000% of coil rating). Its prime application is for use on selective-tripping systems where service continuity is of major significance.

SPECIALIZED-SELECTIVE AND GENERAL-PURPOSE, DUAL-MAGNETIC DIRECT-ACTING OVERCURRENT TRIP DEVICES (OD-5, OD-500, OD-6 AND OD-600)

The OD-5 and OD-500 combine long-time delay (80 to 160% of coil rating), short-time delay (400-1000% of coil rating) and instantaneous (500-1500% of coil rating). The OD-5 and 500 is a modified selective device. The addition of the instantaneous trip allows it to be applied above the short-time rating while sacrificing only a minor degree of selectivity.

The OD-6 and OD-600 are similar to the OD-3 and OD-300 general-purpose devices except for the more limited range of the long-time pickup.

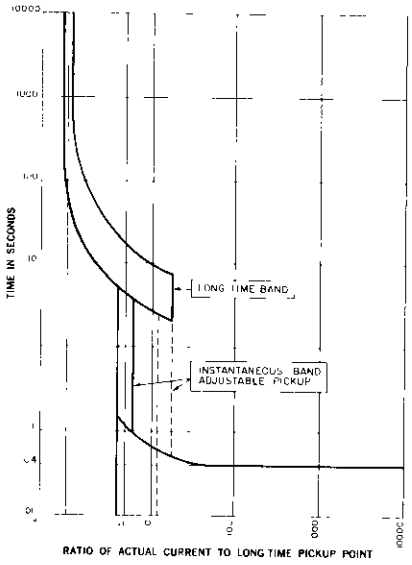


Figure 8—General Purpose Types OD-3 and OD-300

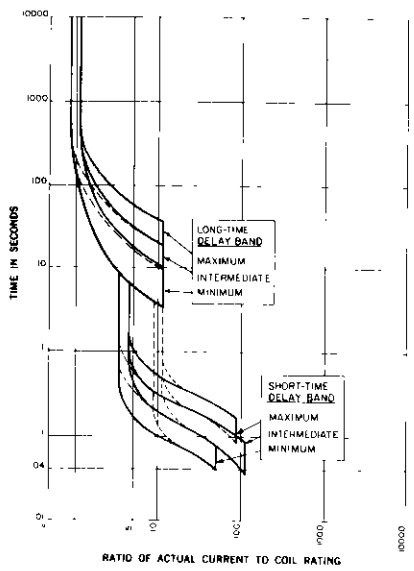


Figure 9—Dual Selective Types OD-4 and OD-400

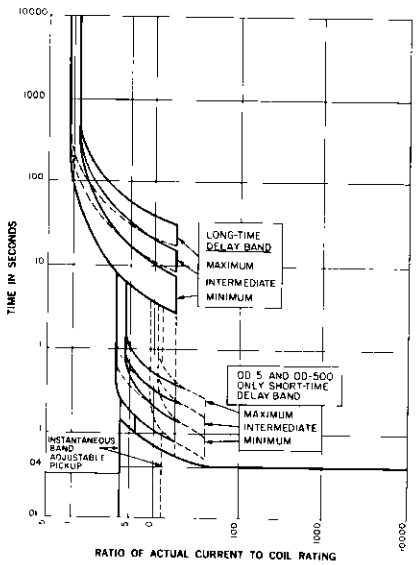


Figure 10—Specialized Selective Types OD-5, 500 and OD-6, 600

Note: Each individual OD device operates within ±10% of its pickup setting. This narrow ±10% band will always fall within the wider bands shown in Figures 8, 9, and 10.

TABLE 57 — OD ELECTRO-MECHANICAL APPLICATION PARAMETERS

Circuit Breaker Type	A-C Volts	Frame Size, A	Direct-Acting Trip Devices				
			Maximum Coil Rating, A	Minimum Coil Ratings with			
				Inst. Trip, A (OD-3)	Delayed Trip (OD-4)		
					Minimum Band, A	Intermediate Band, A	Maximum Band, A
K-800	208 and 240	800	800	225	150	150	250
K-1600		1,600	1,600	400	300	300	500
K-2000		2,000	2,000	800	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000
K-800	480	800	800	125	150	150	250
K-1600		1,600	1,600	400	300	300	500
K-2000		2,000	2,000	400	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000
K-800	600	800	800	40	150	150	250
K-1600		1,600	1,600	225	300	300	500
K-2000		2,000	2,000	400	300	300	500
K-3000		3,000	3,000	3000	3000	3000	3000
K-4000		4,000	4,000	4000	4000	4000	4000

TABLE 58 —
DUAL-MAGNETIC, DUAL-SELECTIVE AND INSTANTANEOUS ELECTRO-MECHANICAL OVERCURRENT-TRIP-DEVICE CHARACTERISTICS

Circuit Breaker Type	Trip Device Type	Characteristic		
		Long-Time	Short-Time *	Instantaneous
K-800 K-1600 K-2000	OD-3	50-125%		500-1500%
	OD-4	80-160%	400-1000%	
	OD-5	80-160%	400-1000%	500-1500%
	OD-6	80-160%		500-1500%
	OD-7			500-1500%
	OD-8			80-250%
K-3000 K-4000	OD-300	50-125%		500-1200%
	OD-400	80-160%	400-1000%	
	OD-500	80-160%	400-1000%	500-1200%
	OD-600	80-160%		500-1200%
	OD-700			500-1200%
	OD-800			80-250%

* Special 200-500% short-time pick-up settings for specialized coordination applications are also available.

TABLE 60 —
TYPES OD-4, 400 THRU OD-8, 800 COIL RATINGS

Circuit Breaker Type	OD-4,400① Coil Ratings, A
K-800	150 175 200 225 250
K-800 K-1600 K-2000	300 350 400 450 500 600 800
K-1600 K-2000	1000 1200 1600
K-2000	2000
K-3000	2500 3000
K-4000	4000

Circuit Breaker Type	OD-5,500, 6,600, 7,700 and 8,800 Coil Ratings, A②
K-800	30 40 50 70 90 100 125
K-800 K-1600	150 175 200 225 250
K-800 K-1600 K-2000	300 350 400 450 500 600 800
K-1600 K-2000	1000 1200 1600
K-2000	2000
K-3000	2500 3000
K-4000	4000

①Refer to Table 57 for application parameters.
②Refer to I-T-E district sales office for application parameters.
* Adjustable down to 1600A.

TABLE 59 —
TYPE OD-3 AND OD-300 DUAL-MAGNETIC ELECTR MECHANICAL OVERCURRENT-TRIP-DEVICE PICK-POINTS

Circuit Breaker Type	Maximum① Continuous Coil Rating, A	Adjustable Long-Time Delay Pickup Points, A	Adjustable Instantaneo Pickup Point
K-800	40	20 25 30 40 50	150 250 400 600
K-800	70	40 50 60 70 90	250 500 750 1100
K-800	125	70 90 100 125 160	450 800 1200 1900
K-800 K-1600	225	120 150 175 200 225 285	750 1500 2400 3400
K-800 K-1600 K-2000	400	250 300 350 400 500	1250 2000 4000 6000
K-800	600	400 500 600 750*	2500 4000 6000 9000
K-800 K-1600 K-2000	800	400 500 600 800 1000	2500 5000 8000 12000
K-1600 K-2000	1600	800 1000 1200 1600 2000*	5000 10000 16000 24000
K-2000	2000	1200 1600 1800 2000 2500*	10000 15000 20000 30000
K-3000	3000	1600 2000 2500 3000 3800*	10000 20000 28000 36000
K-4000	4000	2000 3000 3500 4000 5000*	20000 30000 40000 48000

① Refer to Table 57 for application parameters.
* Setting above maximum breaker frame size is available for coordinatic needed, but is not thermally self-protecting.

POWER-SHIELD® —SOLID-STATE TRIP DEVICE

Figure 11—General Purpose (SS-3) Time-Current Characteristics

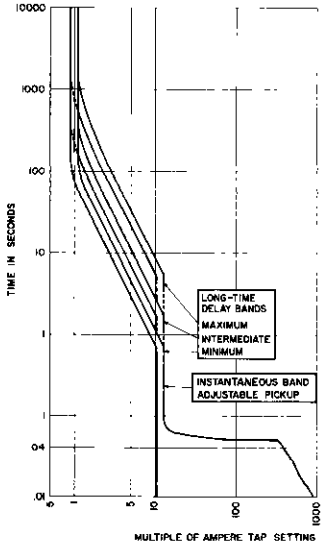


Figure 12 — Dual Selective (SS-4 and SS-5) Time-Current Characteristics

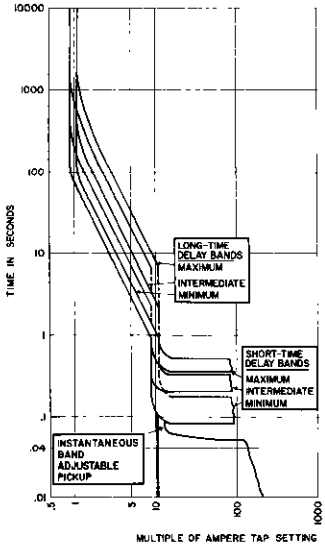


Figure 13 — Ground Time-Current Characteristics

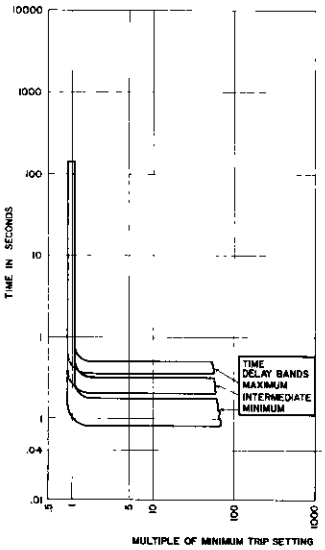


Figure 14—General Purpose (SS-13) Time-Current Characteristics (special)

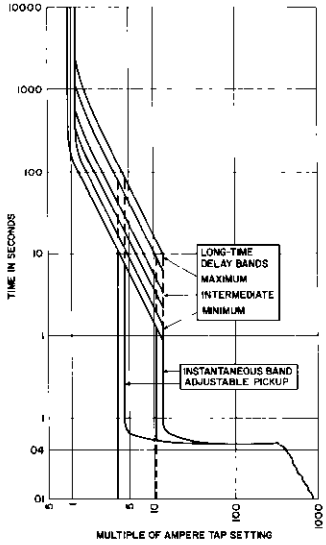


TABLE 61 — STANDARD TYPES

Type *	Designation	Trip Functions
SS-3:	General Purpose	Long-time; Instantaneous
SS-4:	Dual Selective	Long-time; Short-time
SS-5:	Triple Selective	Long-time; Short-time; Instantaneous
SS-3G	—	Same as SS-3, with Ground (3- or 4-wire)
SS-4G	—	Same as SS-4, with Ground (3- or 4-wire)
SS-5G	—	Same as SS-5, with Ground (3- or 4-wire)

* Special longer long-time delays (SS-13, SS-14, SS-15) are also available for special coordination.

TABLE 63 — TIME-DELAY CHARACTERISTICS

Trip Function	Time-Delay Band	Time Delay
Long-Time *	Maximum	15 seconds†
	Intermediate	5 seconds†
	Minimum	2 seconds†
Short-Time	Maximum	0.35 seconds§ (21 cycles)
	Intermediate	0.20 seconds§ (12 cycles)
	Minimum	0.08 seconds§ (4.8 cycles)
Instantaneous	Maximum	No
	Intermediate	Intentional
	Minimum	Delay
Ground	Maximum	0.35 seconds§ (21 cycles)
	Intermediate	0.20 seconds§ (12 cycles)
	Minimum	0.08 seconds§ (4.8 cycles)

† Measured at six (6) times ampere-tap setting and at the lower limit of maximum, intermediate or minimum long-time time delay bands.

§ Measured at the lower limit of maximum, intermediate, or minimum short-time and ground time delay bands at any point above pick-up.

* Special long-times for SS 13, 14 and 15 are 30, 10 and 4 seconds.

TABLE 62 — PHASE AMPERE TAP AND GROUND PICK-UP RANGES

Circuit Breaker Type		Available Ampere Tap Settings, A	Pick-Up Range† Long-Time	Short-Time	Instantaneous	Ground Amperes
			Times Ampere Tap Setting			
K-800S	Sensor Range	50	0.7	2	4	
		70	0.8	3	5	100
		100	0.9	4	6	300
		150	1.0	6	8	600
		225	1.1*	8	10	1200
		250		10	12	
		400				
		600				
		300				200
		600				400
		800				600
						1200
K-1600S		250	0.7	2	4	100
		400	0.8	3	5	300
		600	0.9	4	6	600
			1.0	6	8	1200
			1.1*	8	10	300
		600		10	12	600
		1000				900
		1600				1200
K-2000S		800	0.7	2	4	300
		1200	0.8	3	5	600
		2000	0.9	4	6	900
			1.0	6	8	1200
			1.1*	8	10	
				10	12	
K-3000S		2000	0.7	2	4	500
		3000	0.8	3	5	800
			0.9	4	6	1000
			1.0	6	8	1200
			1.1*	8	10	
				10	12	
K-4000S		3000	0.7	2	4	500
		4000	0.8	3	5	800
			0.9	4	6	1000
			1.0	6	8	1200
			1.1*	8	10	
				10	12	

* Setting above maximum ampere tap rating and breaker frame size is available for coordination, if needed, but is not thermally self-protecting.

† The tolerance on all calibrated pick-up settings for long-time, short-time, instantaneous and ground functions is ±10% through the temperature range of −20°C to 55°C.

GROUND-SHIELD® GROUND-FAULT PROTECTION APPLICATION

TIME-CURRENT CHARACTERISTICS

The time-current curves shown in Figures 15 & 16 are designed to provide maximum protection against ground faults with minimum disturbance to unfaulted circuits. Use GR-5 relay for all individual loads (such as motors and transformers) and for high-resistance grounded systems. Use GR-200 relay for main, feeder and branch circuits on solidly or low-resistance ground systems.

INTERRUPTER TYPES

Common interrupting devices which can be used with ground-fault relays are (1) high-voltage power circuit breakers, (2) low-voltage power circuit breakers, (3) molded-case circuit breakers, (4) service protectors, (5) contactors, and (6) certain load-break, switch-fuse combinations. First, care should be taken to insure that the switch interrupting rating is sufficient to handle ground faults of all magnitudes which would be cleared faster than the associated fuse maximum clearing curve. Also, it is necessary that the interrupter switch be equipped with a fast shunt-tripping mechanism and ability to interrupt the ground fault within several cycles from energization of trip coil. Circuit breaker and fuse combinations equipped with shunt-trip coils are well adapted to the GROUND-SHIELD Protection System.

BASIC NEED FOR GROUND-SHIELD

The basic need for ground-fault protection in low-voltage systems is illustrated in Figure 17. Shown is a 1000 kVA service transformer with a 1600-ampere main breaker (with typical long-time and short-time characteristics) and fuse. A 1500A ground fault (Point I) on the 480Y/277 grounded neutral system would not be detected by this breaker. A 4000A ground fault (Point II) could persist for about 33 seconds even if the minimum long-time band were used. An 8,000 ampere grou fault (Point III) would be cleared within about .2 to .4 s onds by the short-time device, assuming it is present, oth wise, between 8 to 20 seconds would elapse before the fault cleared. For the assumed 8,000A fault, even though the c rent values are the calculated result using all source, circ and arc impedances, the actual RMS current values passi through the circuit breaker can be considerably lower. This because of the spasmodic nature of the fault caused by (1) elongating blow-out effects, (2) physical flexing of cables a some bus structures due to mechanical stresses, (3) self-cle ing attempts and arc re-ignition, and (4) shifting of the terminals from point to point on the grounded enclosure well as on the faulted conductors for non-insulated constr tion). All of these effects tend to reduce the RMS value fault currents. Figure 17 also illustrates that a ground fa which would normally produce 8,000A under stabilized c ditions and which results in an effective value of only 400 (Point II) would have a max. clearing time of 33 seconds stead of the normally expected max. of .4 seconds.

Other fault interrupting devices such as fuses (Note fr Figure 17 that a 1600A fuse takes 5 minutes to clear a 400 fault) which have far slower operating times as low fault c rents, have even a greater need for supplementary grou fault protection. Most of these devices have time-current ch acteristics which delay tripping for about 100 seconds for fa currents 200% to 300% of normal continuous-current rati

Note the interrupting time for a curve C, GR-200 re would be about .2 seconds on a 4000 ampere ground fault a less than .4 seconds on a 1500 ampere ground fault.

GROUND-SHIELD ground fault sensing and relaying equipment is UL listed.

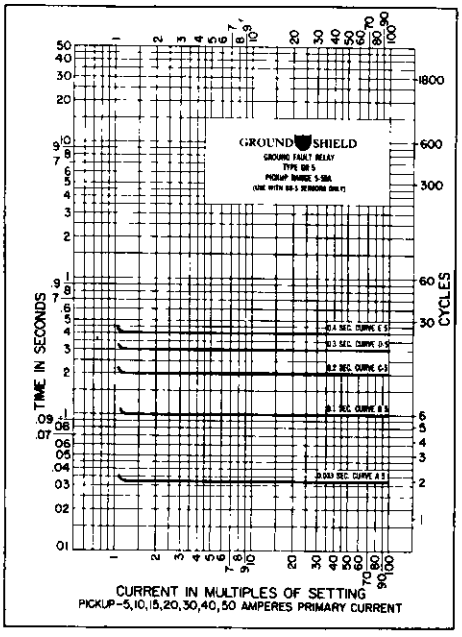


Figure 15—GR-5 Time-Current Characteristics
Standard pick-up range, 5-50A
Optional pick-up range, 2-40A or 20-200A

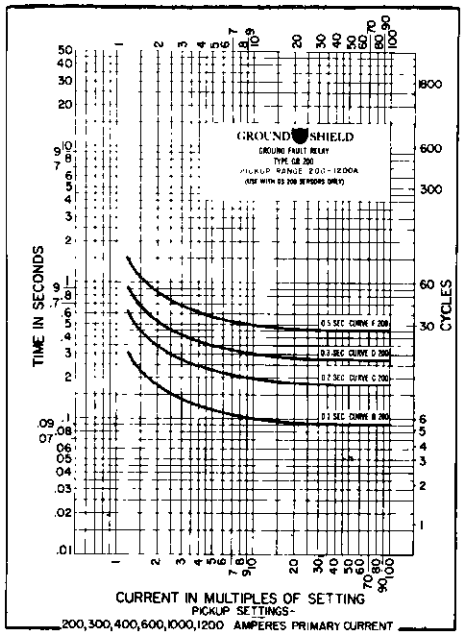


Figure 16—GR-200 Time-Current Characteristics
Standard pick-up range, 200-1200A
Optional pick-up range, 120-1200A

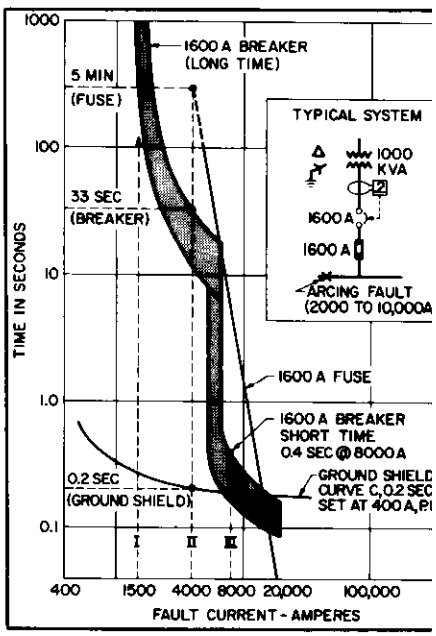


Figure 17—Ground-Shield System Coordination Curves

Note: For complete application information on I-T-E GROUND-SHIELD, refer to I-T-E Bulletin 18.1.4.

MOLDED-CASE CIRCUIT BREAKERS

TABLE 64 — MOLDED-CASE BREAKER RATINGS

Max. Amperes A-C Max. Voltage	Circuit Breaker Frame	Current Continuous Amperes	A-C Volts	Maximum Interrupting Rating Sym. Rms Amperes	3-Pole Circuit Breaker (not including mounting) Size, Inches
100 Amp 480 Volt	EH†	15–150	240 480	18,000 14,000	W 4½ H 6 D 3 19/32
100 Amp 600 Volt	EF†	15–100	240 480 600	18,000 14,000 14,000	W 4½ H 6 D 3 19/32
	HE†	15–100	240 480 600	65,000 25,000 18,000	W 4½ H 6 D 3 19/32
	CE† Cordon	15–100	240 480 600	200,000 200,000 100,000	W 4½ H 9 D 4 5/16
225 Amp 600 Volt	FJ†	70–225	240 480 600	22,000 18,000 14,000	W 4½ H 10 D 4 1/16
400 Amp 600 Volt	JJ†	250–400	240 480 600	42,000 30,000 22,000	W 9 H 11 D 4 1/16
	JL*	70–400	240 480 600	42,000 30,000 22,000	W 9 H 11 D 4 1/16
	HJ	125–400	240 480 600	65,000 35,000 25,000	W 9 H 11 D 4 1/16
	CJ Cordon	125–400	240 480 600	200,000 200,000 100,000	W 9 H 15 3/16 D 5 7/16
450-600 Amp 600 Volt	LL	450-600	240 480 600	42,000 30,000 22,000	W 9 H 11 D 4 1/16
	HL	450-600	240 480 600	65,000 35,000 25,000	W 9 H 11 D 4 1/16
800 Amp 600 Volt	KM	250–800	240 480 600	42,000 30,000 22,000	W 9 H 15½ D 4 1/16
	HM	400–800	240 480 600	65,000 35,000 25,000	W 9 H 22 D 5¾
	CM Cordon	400–800	240 480 600	200,000 200,000 100,000	W 9 H 26 29/32 D 6⅞
1200 Amp 600 Volt	KP	600–1200	240 480 600	42,000 30,000 22,000	W 9 H 15½ D 4¾
1200 Amp 600 Volt	HK	700–1200	240 480 600	65,000 50,000 42,000	W 9 H 15½ D 4¾
1600 Amp 600 Volt	HP	600–1600	240 480 600	65,000 50,000 42,000	W 9 H 15½ D 4¾
	CP Cordon	600-1600	240 480 600	200,000 200,000 100,000	W 9 H 21 7/16 D 4¾
2000 Amp 600 Volt	HR	1800–2000	240 480 600	65,000 50,000 42,000	W 9 H 15½ D 4¾
	CR Cordon	1800–2000	240 480 600	200,000 200,000 100,000	W 9 H 21 7/16 D 4¾

† Non-interchangeable trip.
* 70, 90 and 100 ampere breakers have interrupting ratings of 30,000 amperes asymmetrical, 25,000 amperes symmetrical at 240 volts ac; 25,000 amperes asymmetrical, 22,000 amperes symmetrical at 480 and 600 volts ac

TABLE 65A
LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 208 VOLTS
(ELECTROMECHANICAL OR SOLID-STATE TRIP)

Transformer Rating, 3-ph kVA and Impedance Per Cent	Primary System Max. Short-Circuit kVA	Normal Load Continuous Current, A	Short-Circuit Current Total RMS Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended		
						M*	I	S
			Transformer Alone	Motor Load‡	Combined	Main Breaker	Feeder with Instant. Trip	Feeder with Selective Trip
112.5 2.25%§	50,000	312	13,160	600	13,770	K-800	K-800	K-800
	100,000		13,480		14,080			
	150,000		13,640		14,240			
	250,000		13,760		14,330			
	500,000		13,840		14,440			
	Unlimited		13,870		14,470			
150 3.00%§	50,000	416	11,280	800	12,080	K-800	K-800	K-800
	100,000		11,580		12,380			
	150,000		11,640		12,440			
	250,000		11,820		12,620			
	500,000		12,000		12,800			
	Unlimited		13,870		14,670			
225 4.5%	50,000	625	12,640	1200	13,840	K-1600	K-800	K-800
	100,000		13,120		14,320			
	150,000		13,360		14,560			
	250,000		13,600		14,800			
	500,000		13,760		14,960			
	Unlimited		13,890		15,090			
300 5.0%	50,000	834	14,880	1700	16,580	K-1600	K-800	K-800
	100,000		15,680		17,380			
	150,000		16,000		17,700			
	250,000		16,240		17,940			
	500,000		16,400		18,100			
	Unlimited		16,680		18,380			
500 5.0%	50,000	1388	23,120	2800	25,920	K-1600 †	K-800	K-1600
	100,000		25,200		28,000			
	150,000		26,000		28,800			
	250,000		26,640		29,440			
	500,000		27,200		30,000			
	Unlimited		27,760		30,560			
750 5.75%	50,000	2080	28,640	4200	32,840	K-3000	K-800	K-1600
	100,000		32,000		36,200			
	150,000		33,360		37,560			
	250,000		34,400		38,600			
	500,000		35,280		39,480			
	Unlimited		36,170		40,370			
1000 5.75%	50,000	2780	35,840	5600	41,440	K-3000	K-800	K-1600
	100,000		41,120		46,720			
	150,000		43,360		48,960		K-1600	
	250,000		45,200		50,800			
	500,000		46,720		52,320			K-2000
	Unlimited		48,350		53,950			

TABLE 65B — 240 VOLTS

112.5 2.25%§	50,000	271	9,600	1100	10,700	K-800	K-800	K-800
	100,000		11,680		12,780			
	150,000		11,840		12,940			
	250,000		11,920		13,020			
	500,000		12,020		13,120			
	Unlimited		12,050		13,150			
150 3.00%§	50,000	361	11,280	1400	12,680	K-800	K-800	K-800
	100,000		11,460		12,860			
	150,000		11,650		13,050			
	250,000		11,800		13,200			
	500,000		11,910		13,310			
	Unlimited		12,030		13,430			
225 4.5%	50,000	541	10,930	2200	13,130	K-800 †	K-800	K-800
	100,000		11,460		13,660			
	150,000		11,630		13,830			
	250,000		11,790		13,990			
	500,000		11,990		14,190			
	Unlimited		12,020		14,220			
300 5.0%	50,000	722	12,880	2900	15,780	K-1600	K-800	K-800
	100,000		13,600		16,500			
	150,000		13,920		16,820			
	250,000		14,080		16,980			
	500,000		14,320		17,220			
	Unlimited		14,440		17,340			
500 5.0%	50,000	1203	20,080	4800	24,880	K-1600	K-800	K-1600
	100,000		21,840		26,640			
	150,000		22,560		27,360			
	250,000		23,120		27,920			
	500,000		23,600		28,400			
	Unlimited		24,060		28,860			
750 5.75%	50,000	1804	24,960	7200	32,160	K-2000 †	K-800	K-1600
	100,000		27,760		34,960			
	150,000		28,880		36,080			
	250,000		29,920		37,120			
	500,000		30,640		37,840			
	Unlimited		31,380		38,580			
1000 5.75%	50,000	2406	31,120	9600	40,720	K-3000	K-800	K-1600
	100,000		35,680		45,280			
	150,000		37,520		47,120		K-1600	
	250,000		39,120		48,720			
	500,000		41,360		50,960			K-2000
	Unlimited		41,840		51,440			

*§†† See Page 49 for note references.

TABLE 66 — LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 480 VOLTS (ELECTROMECHANICAL OR SOLID-STATE TRIP)

Transformer Rating, 3-ph kVA and Impedance Per Cent	Primary System Max. Short-Circuit kVA	Normal Load* Continuous Current, A	Short-Circuit Current Total RMS Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended		
						M*	J	S
			Transformer Alone	100% Motor Load	Combined	Main Breaker	Feeder with Instant. Trip	Feeder with Selective Trip
112.5 2.25%§	50,000	135	5,720	500	6,220	K-800	K-800	K-800
	100,000		5,840		6,340			
	150,000		5,880		6,380			
	250,000		5,960		6,460			
	500,000		6,000		6,500			
	Unlimited		6,000		6,500			
150 3.0%§	50,000	180	5,400	700	6,100	K-800	K-800	K-800
	100,000		5,790		6,490			
	150,000		5,865		6,565			
	250,000		5,895		6,595			
	500,000		5,955		6,655			
	Unlimited		6,000		6,700			
225 4.5%	50,000	271	5,460	1100	6,560	K-800	K-800	K-800
	100,000		5,720		6,820			
	150,000		5,800		6,900			
	250,000		5,900		7,000			
	500,000		5,960		7,060			
	Unlimited		6,020		7,120			
300 5.0%	50,000	361	6,480	1400	7,880	K-800	K-800	K-800
	100,000		6,800		8,200			
	150,000		6,960		8,360			
	250,000		7,040		8,440			
	500,000		7,120		8,520			
	Unlimited		7,220		8,620			
500 5.0%	50,000	601	10,000	2400	12,400	K-800	K-800	K-800
	100,000		10,960		13,360			
	150,000		11,280		13,680			
	250,000		11,600		14,000			
	500,000		11,840		14,240			
	Unlimited		12,020		14,420			
750 5.75%	50,000	902	12,400	3600	16,000	K-1600	K-800	K-800
	100,000		13,840		17,440			
	150,000		14,480		18,080			
	250,000		14,960		18,560			
	500,000		15,360		18,960			
	Unlimited		15,690		19,290			
1000 5.75%	50,000	1203	15,600	4800	20,400	K-1600	K-800	K-800
	100,000		17,920		22,720			
	150,000		18,800		23,600			
	250,000		19,600		24,400			K-1600
	500,000		20,240		25,040			
	Unlimited		20,920		25,720			
1000 8.0%	50,000	1203	12,030	4800	16,830	K-1600	K-800	K-800
	100,000		13,350		18,150			
	150,000		13,980		18,750			
	250,000		14,315		19,115			
	500,000		14,555		19,355			
	Unlimited		15,040		19,840			
1500 5.75%	50,000	1804	20,640	7200	27,840	K-2000 †	K-800	K-1600
	100,000		24,960		32,160			
	150,000		26,800		34,000		K-1600	
	250,000		28,480		35,680			
	500,000		29,840		37,040			
	Unlimited		31,370		38,570			
2000 5.75%	50,000	2406	24,720	9600	34,320	K-3000	K-1600	K-1600
	100,000		30,560		40,160			
	150,000		34,080		43,680			
	250,000		36,720		46,320			
	500,000		38,960		48,560			
	Unlimited		41,840		51,440		K-2000	K-2000
2500 5.75%	50,000	3010	27,900	12000	39,900	K-4000	K-1600	K-1600
	100,000		36,300		48,300			
	150,000		40,400		52,400			K-2000
	250,000		44,500		56,500		K-2000	
	500,000		48,100		62,100			K-3000
	Unlimited		52,350		64,350			

*§‡† See Page 49 for note references.

TABLE 67 — LOW-VOLTAGE POWER CIRCUIT BREAKER APPLICATION — 600 VOLTS (ELECTROMECHANICAL OR SOLID-STATE TRIP)

Transformer Rating, 3-ph kVA and Impedance Per Cent	Primary System Max. Short-Circuit kVA	Normal Load Continuous Current, A	Short-Circuit Current Total RMS Symmetrical Amperes			Minimum Frame Size Air Circuit Breaker Recommended		
						M*	I	S
			Transformer Alone	100% Motor Load	Combined	Main Breaker	Feeder with Instant. Trip	Feeder with Selective Trip
112.5 2.25%§	50,000 100,000 150,000 250,000 500,000 Unlimited	108	4,580 4,680 4,720 4,760 4,780 4,800	400	4,980 5,080 5,120 5,160 5,180 5,200	K-800	K-800	K-800
150 3.00%§	50,000 100,000 150,000 250,000 500,000 Unlimited	144	4,500 4,650 4,695 4,740 4,770 4,800	600	5,100 5,250 5,295 5,340 5,370 5,400	K-800	K-800	K-800
225 4.5%	50,000 100,000 150,000 250,000 500,000 Unlimited	217	4,380 4,590 4,670 4,730 4,770 4,820	900	5,280 5,490 5,570 5,630 5,670 5,720	K-800 †	K-800	K-800
300 5.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	289	5,160 5,450 5,560 5,640 5,710 5,780	1200	6,360 6,650 6,760 6,840 6,910 6,980	K-800	K-800	K-800
500 5.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	481	8,020 8,740 9,020 9,250 9,430 9,620	1900	9,920 10,640 10,920 11,150 11,330 11,520	K-800	K-800	K-800
750 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	722	9,960 11,110 11,550 11,930 12,240 12,560	2900	12,860 14,010 14,450 14,830 15,140 15,460	K-1600	K-800	K-800
1000 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	962	12,410 14,250 14,980 15,640 16,170 16,730	3800	16,210 18,050 18,780 19,440 19,970 20,530	K-1600	K-800	K-800
1500 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1444	16,500 19,920 21,390 22,740 23,870 25,110	5800	22,300 25,720 27,190 28,540 29,670 30,910	K-2000	K-1600	K-1600
2000 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1924	19,730 24,830 27,180 29,370 31,280 33,630	7700	27,430 32,530 34,880 37,070 38,980 41,330	K-2000 †	K-1600	K-1600
2500 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2406	22,380 29,160 32,430 35,640 38,500 41,840	9600	31,980 38,760 42,030 45,240 48,100 51,440	K-3000	K-1600 K-2000	K-1600 K-2000

* The transformer main secondary breakers are in most cases determined by continuous current instead of fault current. For this reason breakers in the M column are usually larger than those listed in the I column. The values listed in the M column allow a breaker continuous rating approximately 25% above the transformer self-cooled full-load current. If the transformer has a fan cooled rating a main secondary breaker larger than indicated by column M may be required.

§ Short-circuit currents are calculated with impedances shown applying to liquid-immersed transformers only. Refer to Table 39, Page 34, for ventilated-dry type impedances.

‡ Motor load contribution for 208 volts is based on 50%. 240 volt application table is based on 100% motor load contribution.

† These circuit breakers are applied at less than 25% above transformer full-load rating. If 25% is required, use the next larger frame size.

SHORT-CIRCUIT CURRENTS IN LOW-VOLTAGE SYSTEMS

To determine the interrupting-capacity requirements of low-voltage, air-magnetic power circuit breakers it is necessary to obtain information, at the point of application, of the short-circuit condition of every part of a distribution system. A set of 32 curves (available on request) provides a graphical means of determining the value of short-circuit currents and the corresponding power factor for various sizes of transformers and various voltages, in combination with different sizes and lengths of cable. In Table 70 is given the multiplying factor to use in obtaining the asymmetrical values of current at different power factors.

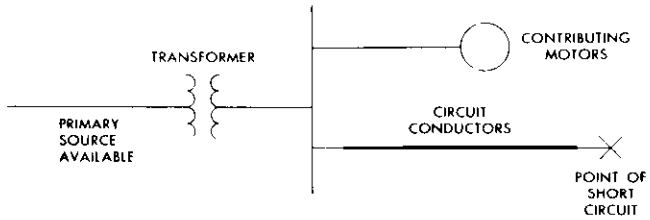


Figure 18

In the study diagrammed above, these basic characteristics are assumed:

1. Primary source available is 500 MVA at the primary of the transformer, with a source circuit X/R ratio of 25.
2. Transformer kVA covers a range of six standard sizes; 500, 750, 1000, 1500, 2000, 2500.
3. Distribution voltages of 208, 240, 480, and 600 v are assumed; 3-phase, 60 Hertz.
4. Minimum transformer impedances are 5.0% up through 500 kVA and 5.75% for 750 kVA and higher, less the standard allowable tolerance of -7½%. X/R ratios are selected from typical data furnished by several transformer manufacturers from which the characteristics in Table 68 (following) are calculated. The data is based on liquid-immersed, self-cooled transformers. Dry-type transformers generally have higher resistance, and the results of this study should be conservative for systems in which they are used.
5. Motor impedance is based on an equivalent reactance of 25 and an X/R ratio of 6.
6. Feeder conductors chosen are at least 115% of the size normally required for the standard frame sizes of low-voltage, air-magnetic power circuit breakers. Calculations in this study are based on 3-phase conductors, of minimum insulation thickness, in magnetic ducts. Table 69 gives the conductor sizes and alternate arrangements for which this study can be used.
7. Short-circuit duty can be read direct from the set of 32 curves. The short-circuit current available, in symmetrical amperes, and the corresponding short-circuit power factor are shown for any distance, in circuit feet, from the terminals of the transformer up to 5000 ft. These values include the current contributed by the connected motors.
8. Asymmetrical short-circuit currents, if desired, can be found from the symmetrical values above by using a multiplying factor read from Figure 19 and corresponding to the short-circuit power factor at the point of fault. Use the multiplying factor from Curve M_A to find the average 3-phase asymmetrical amperes and Curve M_M to find the maximum asymmetrical amperes in one phase with the greatest possible offset. For accurate values of M_A and M_M, use the values in Table 70.

TABLE 68 — TRANSFORMER CHARACTERISTICS

Transformer Rating kVA	X/R	R (%)	X (%)	Z (%) *
500	3.4	1.3	4.4	4.6
750	3.9	1.3	5.1	5.3
1000	4.2	1.2	5.1	5.3
1500	5.2	1.0	5.2	5.3
2000	6.1	.85	5.2	5.3
2500	6.5	.80	5.2	5.3

* Minimum value takes impedance tolerance into account.

TABLE 69 — CIRCUIT CONDUCTORS

Circuit Rating Amperes	Conductor Size	Conductor Insulation	Alternate Conductor Sizes
50	# 4 AWG	Type R	—
100	# 0 AWG	Type R	—
225	250 MCM	Type RH	—
400	2-250 MCM	Type RH	—
600	2-500 MCM	Type RH	3-# 4/0 AWG
600	2-500 MCM	Type RH	4-# 2/0 AWG
1600	4-750 MCM	Type RH	3-2000 MCM
1600	4-750 MCM	Type RH	5-400 MCM
1600	4-750 MCM	Type RH	6-300 MCM

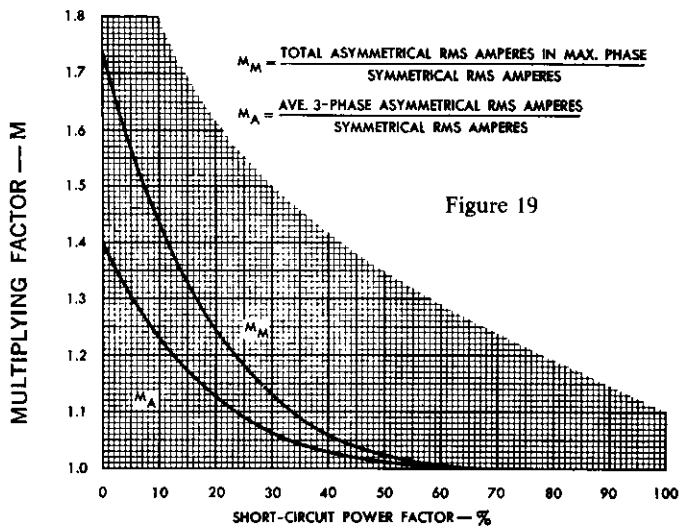


Figure 19

Multiplying Factors to obtain short-circuit asymmetrical current from symmetrical values, at an instant ½ cycle (60 cycle basis) after initiation of a fault.

TABLE 70 — SHORT-CIRCUIT MULTIPLYING FACTORS

Short-Circuit Power Factor Per Cent	Short Circuit X/R Ratio	Multiplying Factor		Short-Circuit Power Factor Per Cent	Short Circuit X/R Ratio	Multiplying Factor	
		Maximum 1-Phase RMS Amperes at ½ Cycle (Curve M_M)	Average 3-Phase RMS Amperes at ½ Cycle (Curve M_A)			Maximum 1-Phase RMS Amperes at ½ Cycle (Curve M_M)	Average 3-Phase RMS Amperes at ½ Cycle (Curve M_A)
0	∞	1.732	1.394	29	3.3001	1.139	1.070
1	100.00	1.696	1.374	30	3.1798	1.130	1.066
2	49.993	1.665	1.355	31	3.0669	1.121	1.062
3	33.322	1.630	1.336	32	2.9608	1.113	1.057
4	24.979	1.598	1.318	33	2.8606	1.105	1.053
5	19.974	1.568	1.301	34	2.7660	1.098	1.049
6	16.623	1.540	1.285	35	2.6764	1.091	1.046
7	14.251	1.511	1.270	36	2.5916	1.084	1.043
8	12.460	1.485	1.256	37	2.5109	1.078	1.039
8.5	11.723	1.473	1.248	38	2.4341	1.073	1.036
9	11.066	1.460	1.241	39	2.3611	1.068	1.033
10	9.9501	1.436	1.229	40	2.2913	1.062	1.031
11	9.0354	1.413	1.216	41	2.2246	1.057	1.028
12	8.2733	1.391	1.204	42	2.1608	1.053	1.026
13	7.6271	1.372	1.193	43	2.0996	1.049	1.024
14	7.0721	1.350	1.182	44	2.0409	1.045	1.022
15	6.5912	1.330	1.171	45	1.9845	1.041	1.020
16	6.1695	1.312	1.161	46	1.9303	1.038	1.019
17	5.7967	1.294	1.152	47	1.8780	1.034	1.017
18	5.4649	1.277	1.143	48	1.8277	1.031	1.016
19	5.1672	1.262	1.135	49	1.7791	1.029	1.014
20	4.8990	1.247	1.127	50	1.7321	1.026	1.013
21	4.6557	1.232	1.119	55	1.5185	1.015	1.008
22	4.4341	1.218	1.112	60	1.3333	1.009	1.004
23	4.2313	1.205	1.105	65	1.1691	1.004	1.002
24	4.0450	1.192	1.099	70	1.0202	1.002	1.001
25	3.8730	1.181	1.093	75	0.8819	1.0008	1.0004
26	3.7138	1.170	1.087	80	0.7500	1.0002	1.00005
27	3.5661	1.159	1.081	85	0.6198	1.00004	1.00002
28	3.4286	1.149	1.075	100	0.0000	1.00000	1.00000

GUIDE SPECIFICATIONS FOR SECONDARY UNIT SUBSTATIONS

NOTE: Gray color and italics denotes information to be supplied by purchaser regarding either:
- Choice of alternates
- Addition of optional features
- Specific information

SCOPE

These specifications cover a complete (indoor) (outdoor) secondary unit substation from the incoming line terminals to the outgoing feeder terminals.

SECTIONS

The substation will have the following sections:
1. Incoming line section with ( ) incoming primary circuit(s).
2. Transforming section consisting of ( ) transformer(s).
3. Outgoing section which will provide for ( ) outgoing feeders provided with low-voltage power circuit breaker(s).

GENERAL ARRANGEMENT

The accompanying sketch No. _____ indicates orientation of equipment only, not construction details.

RATINGS

The ratings of the substation will be:

Self-Cooled rating ..... _____ kVA
Fan-Cooled rating ..... _____ kVA
Frequency ..... 60 Hertz
Number of Phases 3
( ) incoming (3) (4)-wire circuit(s) .... _____ kV
( ) outgoing (3) (4)-wire circuit(s) .... _____ volts

INCOMING LINE SECTION

(2-POSITION, ON-OFF) (3-POSITION, LINE 1-OFF-LINE 2) (FUSED) (UNFUSED) AIR INTERRUPTER SWITCH(ES)

This section shall consist of a floor-mounted, formed welded metal enclosure close-coupled to the transformer section and equipped with:

( )—3-pole, 2-position, gang-operated, load-interrupter switch, type HPL-C, rated 600 amperes, _____ kV, interrupting capacity 600 amperes.

( )—*3-pole, 2-position selector switch, interlocked and in series with the air interrupter switch.*

( )—*Power fuses, current-limiting type CL-14 _____ kV, _____ amperes continuous, to be located between the switch and the transformer. The fuse door to be interlocked with the switch handle to prevent opening while the switch is in the closed position.*

( )—*Lightning arresters rated (3) (6) (9) (12) (15) kV.*

_____ size cable to enter from (above) (below) and terminate in _____ *clamp-type lugs per phase or* (1-3/C) (2-3/C) (3-1/C) (6-1/C) *pothead*(s). *Pothead*(s) *to be provided with* _____ *fitting for cables with the following specifications:* _____ *kV size,* _____ *insulation,* _____ *O.D. over insulation,* _____ *O.D. conductor,* _____ *O.D. overall.*

LIQUID (INTERRUPTER) (DISCONNECT) SWITCH(ES)

This section shall consist of non-fused, oil-insulated, load-interrupter switch, mounted on transformer tank. This switch to be 3-pole (2) (3)-position device rated _____ amperes continuous at _____ kV.

This section shall consist of non-fused, askarel-insulated, disconnecting switch, mounted on transformer tank. The switch shall be capable of breaking transformer magnetizing current and the askarel shall be of the type designed for this operation. This switch to be 3-pole (2) (3)-position device rated _____ amperes continuous at _____ kV.

_____ size cable to enter from (above) (below) and terminate in (1-3/C) (2-3/C) (3-1/C) (6-1/C) pothead(s). Pothead(s) to be provided with _____ fitting cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

OIL FUSE CUTOUTS

This section shall consist of 3-gang-operated oil fuse cutouts, mounted in an air-filled terminal chamber directly connected to the transformer tank wall. Cut-outs are to be 2-position and rated _____ amperes continuous at _____ kV.

OIL FUSE CUTOUTS (CONTINUED)

_____ size cable to enter from (above) (below) and terminate in _____ *clamp-type lugs per phase or* (1-3/C) (2-3/C) (3-1/C) (6-1/C) *pothead*(s), *Pothead*(s) *to be provided with* _____ *fitting for cables with following specifications:* _____ kV *size,* _____ *insulation,* _____ *O.D. over insulation,* _____ *O.D. conductor,* _____ *O.D. overall.*

AIR TERMINAL CHAMBER

This section shall consist of a full-height air terminal chamber directly connected to the high-voltage side of the transformer. It shall be rated _____ kV. _____ size cable to enter from (above) (below) and terminate in _____ *clamp-type lugs per phase or* (1-3/C) (2-3/C) (3-1/C) (6-1/C) *pothead*(s). *Pothead*(s) *to be provided with* _____ *fitting for cables with the following* specifications: _____ kV size, _____ insulation, _____ *O.D. over insulation,* _____ *O.D. conductor,* _____ *O.D. overall.*

METAL-CLAD SWITCHGEAR

( )—Metal-clad switchgear unit.

( )—(4.16) (7.2) (13.8) kV air circuit breaker, _____ amp, 3-pole, electrically-operated, stored-energy.
State Control Voltage Requirements.

( )—Set of insulated main bus, _____ amp.

( )—Current transformers, _____/5, ratio.

( )—Overcurrent relays, instantaneous and time.

( )—Breaker control switch with red and green indicating lights.

( )—Ammeter, 0- _____ scale.

( )—Ammeter transfer switch.

( )—Voltmeter.

( )—Voltmeter transfer switch.

( )—Drawout potential transformers, _____ -120 volt ratio.

_____ size cable to enter from (above) (below) and terminate in _____ clamp-type lugs per phase or (1-3/C) (2-3/C) (3-1/C) (6-1/C) *pothead*(s). *Pothead*(s) to be provided with _____ fitting for cables with the following specifications: _____ kV size, _____ insulation, _____ O.D. over insulation, _____ O.D. conductor, _____ O.D. overall.

TRANSFORMER SECTION

LIQUID-IMMERSED TYPES (OIL) (SILICONE)—(OA) (OA/FA)

Transformer shall be (Oil) (Silicone)-insulated, 3-phase, 60 Hertz, (self-cooled) (forced-air cooled) with a temperature rating not to exceed a 65°C rise above 30°C average ambient.

Rated _____ kVA, with delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally-operated, deenergized tap changer. Tap changer handle to be capable of being locked in any tap position.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA Standards. All NEMA standard accessories are to be provided.

VENTILATED-DRY TYPE—(AA) (AA/FA)

Transformer shall be a ventilated-dry type, indoor construction, 3-phase, 60 Hertz, (self-cooled) (forced-air cooled) with a temperature rating not to exceed a 150°C rise above 30°C average ambient.

Rated _____ kVA, with delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally-operated, deenergized tap changer. Tap changer handle to be capable of being locked in any tap position.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA Standards. All NEMA standard accessories are to be provided.

Necessary winding-temperature equipment for control of fans.
Shall have provision for future fan cooling.

TOTALLY-ENCLOSED NON-VENTILATED DRY TYPE—(AA) (AA/FA)

Transformer shall be a totally enclosed non-ventilated dry type, gasketed weather-resistant construction for installation indoors or outdoors, 3-phase, 60 Hertz, (self-cooled) (forced-air cooled) with a temperature rating not to exceed a (150°C) (115°C) (80°C) rise above 30°C average 40°C maximum ambient.

Rated _____ kVA with a primary of _____ kV (Delta) (Wye) _____ kV Bil and a secondary of _____ volts (Delta) (Wye) _____ kV BIL Provide four (4) approximately 2½% full capacity taps in the high-voltage winding—two above and two below rated voltage—brought out through studs, complete with bolted flexible links for deenergized tap changing, made accessible through removable panels on the transformer enclosure.

Transformer to have a standard impedance per NEMA 210 (or special impedance of _____ %).

Transformer base to be designed and fabricated to permit using rollers, or skidding in any direction.

Suitable lifting eyes shall be provided at appropriate points for handling by overhead crane.

Transformer to be factory tested as prescribed by ANSI and NEMA standards. In addition, every transformer shall receive a quality control impulse test at 75% of the full BIL rating. All NEMA standard accessories are to be provided.

(Necessary winding-temperature equipment for control of fans shall be provided) or (Provision for future fan cooling shall be provided).

SEALED-DRY, GAS-FILLED—TYPE AA

Transformer shall be sealed-dry type, gas-filled, 3-phase, 60 Hertz, self-cooled, with a temperature rating not to exceed a 150°C rise above a 30°C average ambient.

Rated _____ kVA, with a delta primary of _____ kV and a secondary of _____ volts (Delta) (Wye). Provide four (4) approximately 2½% full capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally-operated, deenergized tap changer. Tap changer cover to be capable of being bolted in any tap position.

Transformer base construction to be of the fabricated type and suitable for using rollers or skidding in any direction.

Transformer to be factory tested as prescribed by ANSI and NEMA Standards. All NEMA standard accessories are to be provided.

OUTGOING SECTION

This section shall consist of one metal-enclosed (indoor) (outdoor) switchgear assembly, drawout type, rated 600 V a-c and arranged for _____ volt service on a _____ volt 3-phase (3) (4)-wire (grounded) (ungrounded) system. It shall be designed, factory assembled and tested in accordance with the latest applicable IEEE, NEMA, and ANSI requirements.

SWITCHGEAR (indoor) (outdoor)

Switchgear shall consist of sufficient vertical frames to house the number ot circuits specified below, with a minimum number of empty spaces remaining. Each individual frame shall be divided into a front breaker section and a rear bus section isolated by steel panels. In addition, each circuit-breaker compartment shall be completely isolated from adjacent compartment by steel panels. All surfaces shall be phosphate treated and painted with an oven baked, corrosion-resistant epoxy enamel finish. Color of finish shall be light gray, ANSI No. 61.

SWITCHGEAR (outdoor only)

Switchgear shall be of the walk-in weatherproof type with gasketing throughout. Sufficient filtered louvers and screened vents shall be provided to afford adequate ventilation. Sufficient strip heaters shall be provided. Interior lighting and convenience outlets shall be furnished in the aisle space. A manually-operated lifting device running the full length of the walk-in aisle shall be provided for easy handling of breakers. Suitable undercoating shall be applied to prevent corrosion. All exterior surfaces shall receive one additional finish coat of oven baked, corrosion-resistant acrylic enamel paint. The color of the finish coat shall be dark gray, ANSI No. 61.

BUS

A single main bus shall extend through all frames of the switchboard, with interconnections to the circuit breakers in each individual frame. All bus shall be silver-plated aluminum. The main bus shall be of the same current rating as the main circuit breaker or the power source. It shall be braced to withstand stresses resulting from the maximum short-circuit current available. Minimum bracing to be 50,000 amperes symmetrical.

DISCONNECTING DEVICES & DRAWOUT MECHANISM

The breakers shall be of the drawout type, provided with self-aligning disconnecting devices, with the disconnecting fingers mounted on the breaker for ease of maintenance. The drawout mechanism shall hold the circuit breaker rigidly in the fully-connected test and fully-disconnected positions. Interlocks shall be provided that will prevent moving the circuit breaker from the fully-connected, test or fully-disconnected positions, unless the breaker is open. Interlocks shall prevent closing the breaker between any of these positions. Provision shall be made for padlocking the breaker open and in any of the positions noted above.

CIRCUIT BREAKERS

Air circuit breakers shall be three pole, each pole equipped with a (electro-mechanical direct-acting) (solid-state) overcurrent tripping device providing adjustable long-time overcurrent and (short-time) and/or (instantaneous) short-circuit protection (with) (without) ground protection. Solid-state device shall have (load alarm) (target). All (manually) (electrically) operated breakers shall be equipped with (manual) (motor) charged stored-energy closing mechanism to provide quick-make operation.

The drawout mechanism shall be designed so that the breaker can be racked to any position without opening the door, for maximum protection to operating personnel. A hasp on the breaker escutcheon shall be provided that can receive up to three padlocks when the breaker is in the open position, positively preventing unauthorized closing or racking of the breaker. A manual trip button and external breaker position indicator shall be provided.

THE FOLLOWING EQUIPMENT SHALL BE SUPPLIED:

_____ main secondary breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ tie breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ feeder breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ feeder breaker(s), _____ amp maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ space(s) for future breaker(s), _____ maximum continuous current, _____ amp interrupting capacity at _____ V ac, (manually) (electrically) operated.

_____ control-power transformer(s) for electrically operated breaker(s).

TRANSFORMER SECONDARY METERING

_____ *voltmeter(s), with 3-phase transfer switch.*

_____ *ammeter with 3-phase transfer switch.*

_____ *watthour meter(s), (two) (three)-element, (with) (without) demand attachment.*

_____ *current transformer(s), ____/5 or suitable rating.*

_____ *potential transformer(s), suitable rating.*

FEEDER METERING

_____ *ammeter(s), with 3-phase transfer switch.*

_____ *watthour meter(s), (two) (three) element.*

_____ *current transformer(s), ____/5 or suitable rating.*

BUS DUCT—Switchgear Tie

Bus shall be non-segregated phase, metal-enclosed (indoor) (outdoor), *rated 600 Volts _____ amperes, 3-phase,* (3) (4)*-wire, 60 Hertz and shall consist of silver-plated aluminum conductors, insulated supports and housing.*