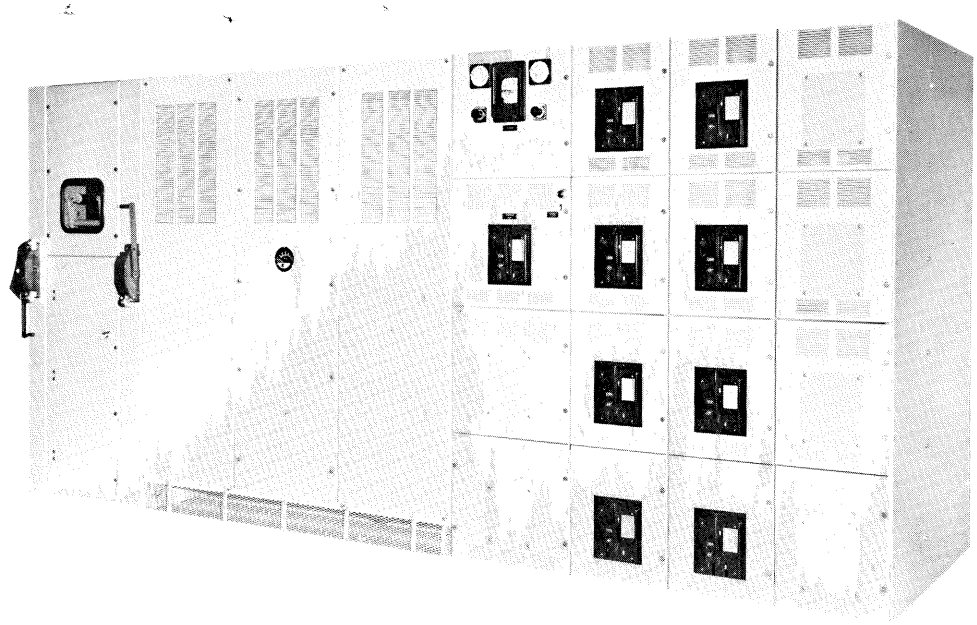
ABB Power T&D Company Inc. Distribution Systems Division

ABB Secondary Unit Substations Low Voltage K-LINE® Switchgear with Drawout Power Circuit Breakers

Technical Bulletin 3.1.2-1B



500 kVA – 2,500 kVA
Primary Voltage: 2.4 kV – 13.8 kV
Secondary Voltage: 208/120 – 600 V
Indoor or Outdoor Sheltered-Aisle, Walk-In

ABB

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 1,000 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 silicone-filled and dry-type transformers permits 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 ABB Secondary Unit Substations

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

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

Quality Assurance

The ABB Power Distribution organization Quality Assurance Program has been continuously improved. It currently employs the Total Quality approach to providing reliable equipment and satisfying customer needs. The program conforms to the requirements of: ISO 9001, MIL-Q-9858, MIL-I-45208, ANSI N45.2, 10CFR50 Appendix B, and ANSI/ASME NQA-1 and NQA-2, as applicable.

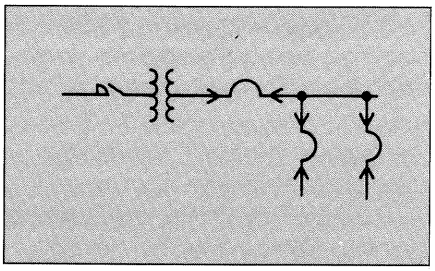
Seismic Capability

Substation equipment, including primary switches, termination compartments, transformers and low voltage distribution equipment, is designed and has been tested to withstand high levels of seismic vibration without service interruption. Equipment for nuclear plants, qualified per IEEE 344-1975 and 1987, is available with full documentation.

Environmental Qualification

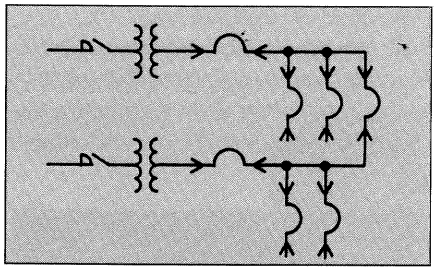
Secondary unit substation equipment has been evaluated by comprehensive analyses and testing for maintainability and life expectancy. Documentation in accordance with IEEE 323-1974 and 1983 is available for Class 1E Nuclear applications.

Select the System



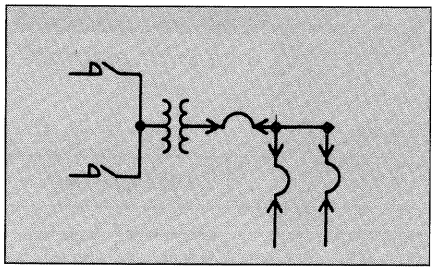
Radial

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



Secondary-Selective

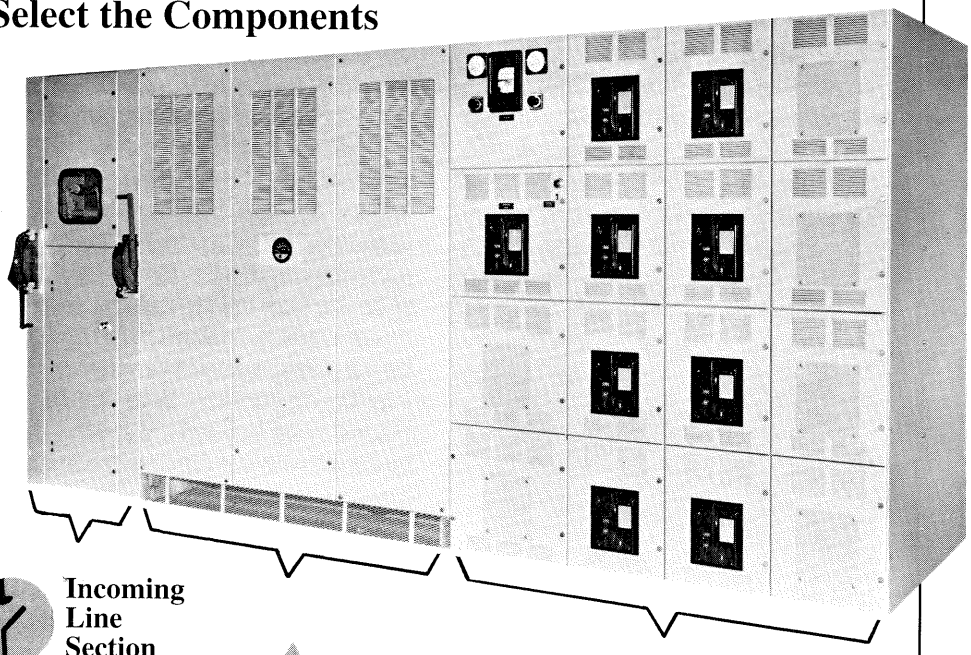
This system generally has two incoming primary devices and two stepdown transformers. The outgoing side of each transformer is connected to a separate bus through a power circuit breaker. The two sections of bus are connected by a normally open power circuit breaker. Each bus has one or more outgoing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



Primary-Selective

This system contains two incoming primary devices connected to a single stepdown transformer and an outgoing section for the connection of one or more outgoing 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

Metal-Clad Switchgear

Transformer Section

Ventilated Dry

Totally Enclosed Non-Ventilated Dry

Sealed Dry, Gas-Filled

Liquid-Immersed
- Silicone
- Oil

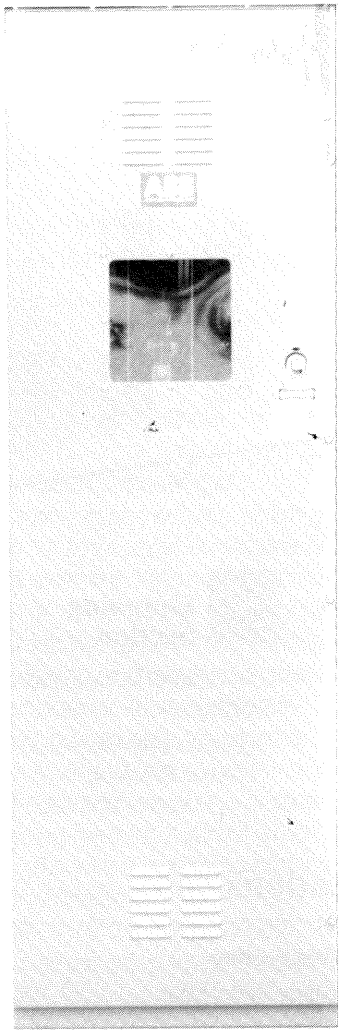
Outgoing Section

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

Index — Secondary Unit Substations

Air Interrupter Switch — Single or Duplex

The ABB Type PK Primary Entrance Unit utilizes the ABB Versa Switch.



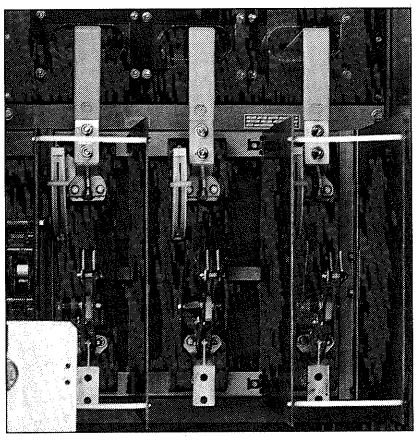
Single Switch Arrangement (Front View)

Completely redesigned, the Versa Switch is a stationary-mounted three-pole two-position (on-off) gang-operated device which utilizes a snap-action, quick-make, quick-break blade. The switch carries the continuous current through the main blades. Interruption is performed by the spring-biased interrupter blades. As the main blades separate from the jaw casting, the interrupter blade is retained in the arc chute by the spring-loaded internal restraining interrupting contacts. When the main blades move beyond arc striking distance with the jaw casting, the spring-biased interrupter blade snaps through the internal interrupting contacts and the arc chute, quickly extinguishing the arc. The Versa Switch insulation system consists of molded reinforced polyester glass. Optional porcelain insulators can be provided when specified.

Visual check of the blade position is made through the lexan safety window. Fused switches (optional) are mechanically interlocked to prevent the opening of the compartment door while the switch is in the closed position. Current limiting or expulsion-type fuses can be provided as specified and the switch compartment can be designed for top or bottom entrance. Either cable lugs or potheads can be furnished. Lightning arrestors can also be supplied when specified. (Lightning arrestors are required for use with ventilated dry-type transformers having less than 95 kV BIL rating.)

Totally redesigned, the ABB Type PK Primary Entrance Unit combines the flexible Versa Switch with a greatly simplified state-of-the-art direct drive mechanism. The new direct drive mechanism requires no field adjustments and eliminates the potentially dangerous chain drive mechanism.

The ABB Type PK Primary Entrance Unit is available in two arrangements. The Single Switch consists of the load break Versa Switch (and optional fuses) in the front of the compartment. The Duplex Switch consists of two switches in adjacent compartments, hard bussed together before feeding to the transformer. If the Duplex Switch is provided with optional fuses, the switches are bussed together before feeding through a single set of fuses to the transformer. Both switch arrangements are available in indoor or outdoor construction.



Three-Phase Versa Switch Assembly

Table 1 — Air Interrupter Switch Ratings

System Rating kV Nominal	Voltage			Current						Life Expectancy[2]	
	Rated Max. Voltage (kV)	Rated Dielectric BIL Impulse (kV)	Low Frequency Withstand (kV)	Rated Cont. Current (Amperes)	Load Interrupting Capacity (Amperes)[3]	Rated Max. Cur. Asym. RMS (kA)	Fault Closing Cur. Asym. RMS (kA)	3-Second Short-time Current Sym. RMS (kA)	Switch Fused	Mechanical Endurance w/o Maint. (No. Opr.)	Load Cur. Endurance w/o Maint. (No. Opr.)
2.4 – 4.16	5.5[1]	60	19	600	600	40	40	25	Fuse Interrupting Rating See Table __	500	50
6.9 – 13.8	15.0	95	36	600	600	40	40	25		500	30

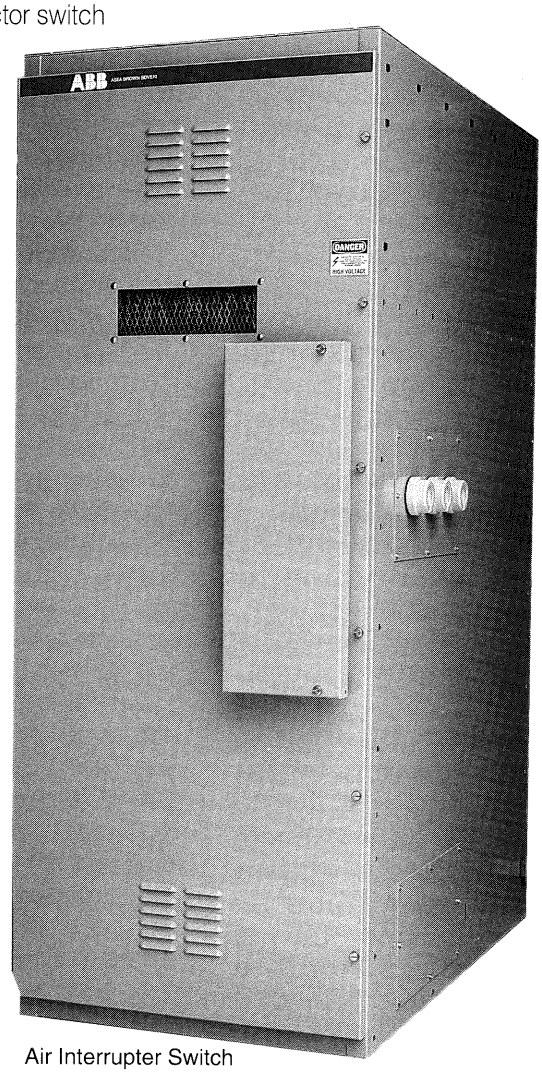
1. Current ANSI C37 standard for this class is 4.16 kV.
2. These values are based on the requirements of ANSI STD C37.58.1 and represent actual design tests. These numbers are intended to give the user guidance for inspection and maintenance.
3. For ratings above 600 A continuous or 40 kA, consult factory.

Air Interrupter Switch and Selector Switch

To reduce equipment floor plan area when two incoming lines are required, ABB offers the air interrupter and selector switch. This arrangements utilizes a single compartment and consists of a stationary rear-mounted three-pole two-position (Line 1 and Line 2) no-load break switch in series with a three-pole two-position (on-off) Versa Switch. Visual indication on the front-mounted operating handle indicates Line 1 or Line 2.

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

Options described under the single and duplex switch section are also available with the selector switch arrangement.



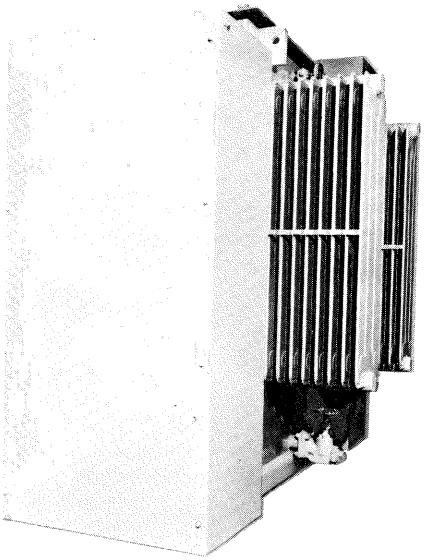
Air Interrupter Switch

Metal-Clad Switchgear

For the ultimate in primary protection and personnel safety, specify ABB metal-clad switchgear with stored-energy drawout power circuit breakers. ABB metal-clad switchgear is available for system ratings of 2.4 through 27 kV up to 1,000 MVA. For additional information on ABB metal-clad switchgear, see product bulletin 3.2.4-1D.

Air Terminal Chamber

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



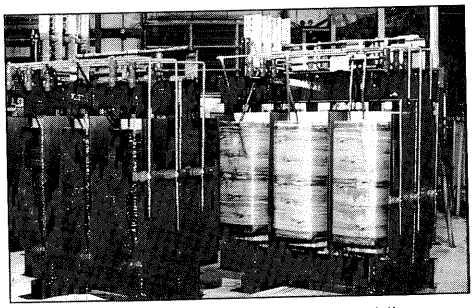
Ventilated Dry-Type Transformers

VPI Transformers

ABB's VPI ventilated dry-type transformers are generally suitable for use indoors anywhere people can work and breathe. Standard designs are suitable for installations ranging from libraries and hospitals to steel mills, paper mills and chemical production plants.

Cooling ducts provide an efficient and economical way of cooling transformers and allow them to operate in most ambient conditions.

ABB's 220°C winding insulation materials are used on all designs, regardless of temperature rating. This gives the 80°/150°C transformer a reserve capacity of approximately 35% above the 80°C ambient air (AA) nameplate rating.



VPE and VPI Core and Coil Assemblies

Silicone VPE Transformers

The Silicone VPE transformer was introduced as an option to our standard ventilated dry-type designs with the intent of virtual elimination of the moisture storage problem which plagues the standard dry-type units in areas of high humidity.

Silicone VPE is a process utilizing standard dry-type designs, offering optional conductors, BIL levels and temperature rises with a 220°C Class Nomex insulation, yielding the ultimate in overload capability. A special VPE sealant process makes the core and coil assembly virtually impermeable to moisture, dust, dirt, salt air and most industrial contaminants.

The special VPE sealant process was developed for the U.S. Navy as a protective shield on shipboard transformers. To date, the VPE Transformer is the only acceptable transformer approved for this specific application. This exceptional design is now being made available to utility, industrial and commercial end users.

The VPE process gets its sealant protective qualities and strength by utilizing a silicone varnish in lieu of epoxy or polyester varnishes. The silicone varnish is a true 220°C insulating material tested to 250°C plus. It offers excellent dielectric strength and remains pliable even after severe thermal aging, thereby eliminating cracking. It does not require adjustments to operate at low temperatures or to allow for degradation at hot spots on the coils.

In addition to these outstanding features, its resistance to moisture and moisture retention puts the Silicone VPE transformer in a category all its own. The nominal coating of silicone varnish received through the Silicone VPE process provides excellent dielectric strength. The varnish has been tested, after immersion in water for 24 hours, and still maintained a dielectric strength of 1,500 volts per mil. Many other transformer manufacturers use varnish to achieve their insulation level. However, the Silicone VPE process, even though it provides additional dielectric strength, is used only as a sealant for your protection, meaning all of the BIL levels required by your specification will be met in each unit's standard design.

When cured the silicone varnish meets, or exceeds, UL 94 VO flammability tests and has a rating of 39 when coated over Nomex Aramid paper.

Coils

In order to provide the most reliable and efficient units to meet specified requirements, ABB manufactures all types of windings currently available for dry-type applications. Unless there is a customer preference, selection of winding design is made on the basis of engineering considerations, and need not be specified.

The windings may be either rectangular or circular construction, depending on the kVA. Wherever possible, rectangular construction is used with sheet-wound aluminum secondary windings and with a wire-wound aluminum primary winding. (Copper conductors are optional.) The use of sheet conductors in the standard secondary windings virtually eliminates the axial forces associated with short circuits. The primary coil is wound over the secondary coil, the two separated by an insulating barrier.

Core

Each unit can utilize a core with cruciform or rectangular cross sections in both legs and yokes. The core is designed and built to provide the lowest possible losses from the effects of magnetic hysteresis and eddy currents. All possible steps are taken to prevent local circulating currents and to avoid construction bending stresses. ABB design objectives are optimum performance with a long reliable life.

To achieve these objectives, ABB starts with non-aging high-permeability cold-rolled grain-oriented silicon steel and constructs the cure with step-lap mitered joints which reduce sound levels and losses in the finished product. The steel is precision cut at the factory to assure that it will be smooth and burr-free.

For rigidity and support, the upper and lower yokes are solidly clamped with steel channels. Tie plates within the low-voltage cylinders connect the top and bottom clamps and provide a rigid structure for lifting. All laminations are stacked on special fixtures so that the core stays flat and stress-free when it is completed.

Special Design Options

- Seismic qualifications
- Nuclear 1E applications
- Low X/R ratios
- Special altitude requirements
- Higher overload capacity
- Retrofit designs
- High efficiency requirements
- Special ambient conditions
- Outdoor
- Rectifier transformer designs
- Special sound requirements

User Benefits

- Reliability
- Low installation cost
- Low operation cost
- Low maintenance
- UL listing (when requested)
- Flame retardant
- No toxic substances
- Compliance with applicable ANSI, NEMA and IEEE standards

Cast Coil Transformers

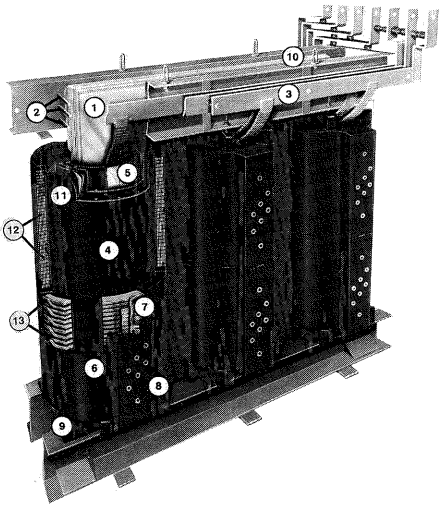
The ABB Cast Coil Transformer is a dry-type unit with coils cast in epoxy. This process produces the strongest coils of any transformer today, while totally isolating them from the atmosphere surrounding the installation. Epoxy is the best insulation against corrosive fumes, moisture and flyings and is ideal protection in modern industrial and commercial applications. ABB casting technology was developed in the United States in the 1960s (not a foreign license). Its proven performance has made for acceptance in all commercial and industrial applications. There are now over 8,000 ABB cast coil transformers in service in the U.S. today. The advantages of this modern technology include low losses, virtually no maintenance and complete design flexibility.

Coils

High- and low-voltage coils are each separately cast in epoxy. Both are vacuum cast, in a mold, providing a heavy outer coating of epoxy on all sides and ends for maximum electrical and mechanical strength. A non-vacuum cast secondary winding is optional. High-conductivity aluminum and copper conductor are available. Completed cast coils are mounted on the core, blocked radially against the core and each other by epoxy spacers and silicone rubber. The coils are also clamped axially, top and bottom, by epoxy blocks and silicone rubber pads. The silicone rubber provides firm but flexible support to permit thermal expansion of the coils under varying loads while holding them in place.

High-voltage coils are disc-wound using an exclusive "upset" winding technique to eliminate drop-downs between discs. This process, usually found only in large, expensive power transformers, combined with the higher-than-air dielectric of epoxy, permits optimum disc spacing for higher capacitance. This in turn helps reduce voltage surges (from lightning or switching) before they reach their maximum, often destructive, peaks. In the ABB high-voltage coil, rectangular copper or high-conductivity aluminum conductors are insulated using 220°C rated material, rather than merely wrapped in glass cloth as done by other manufacturers. The insulated ABB coil is then placed in a mold, thoroughly dried by heating and vacuum, and filled with epoxy while still under vacuum. This vacuum casting insures the absence of voids. A precise curing process in time-temperature controlled ovens insures the full, maximum strength of the heavy epoxy casting which surrounds and protects every ABB cast coil.

Low-voltage coils are of full-width sheet or heavy foil conductor for maximum strength and to allow the high current to distribute freely in the conductor, essentially eliminating the axial forces developed in other types of windings under power surges. Combined with heavy epoxy casting, sheet conductors have the great strength needed to resist the crushing forces of short circuits. Leads of each winding are solidly welded to the sheet conductor over the total coil width. The optional DyNiCast low-voltage coil consists of sheet conductor wound interleaved with Nomex insulation that has been impregnated with uncured epoxy and polyester-glass sheets inside and out and on each side of each cooling duct. Epoxy-filled margins complete the process to seal out the environment.



① Core	⑧ High-Voltage Taps
② Framing Bolts	⑨ Support Blocks with Resilient Pads
③ Low-Voltage Bus	⑩ Lifting Lugs
④ Low-Voltage Coil	⑪ Air Ducts
⑤ Sheet Conductor	⑫ Disc Winding Section
⑥ High-Voltage Coil	⑬ Upset Crossover Connections
⑦ Fiber Glass Blankets	

Epoxy Resin

ABB cast coil transformers are cast with a special formulation designed to withhold moisture and other contaminants from the windings, while easily conducting the heat which forms during operation and resisting the forces of ambient temperature fluctuations down to –40°C. The ABB epoxy will not ignite

if subjected to electric arc of nominal duration and, if ignited, will self-extinguish when the flame is removed. The filled epoxy resin system has been proven to resist cracking under extreme temperature fluctuations when subjected to cyclic tests. Samples were heated in an oven, then quenched in extremely cold baths of acetone, over many cycles.

ABB units have coils vacuum cast in "filled" epoxy — a material far superior to the "pure" epoxy poured into castings by other manufacturers. In other units, the epoxy thickness must be controlled to conform to the dimension of glass-cloth-wrapped wire where the epoxy can be supported by the cloth. The pure or unfilled epoxy would otherwise be subject to a lack of the desirable characteristics supplied by the ABB filler. Filled epoxy has improved heat conduction, better adhesion to the wire, better arc resistance and other advantages over pure or unfilled resins.

Taps

The transformer high-voltage taps can be reached by removing the panels which also protect against tampering with the taps. The taps are rigidly supported by being cast into the epoxy along the central face of each high-voltage coil. Taps are changed by moving the flexible bolted links from one connecting point to the other. Tap terminals are clearly numbered and referenced on the transformer nameplate.

Core

ABB cores use grain-oriented, non-aging silicone electrical steel to ensure low losses and sound levels, cut to precise dimensions on a numerically-controlled core cutter. Mitered corners permit the flux to travel with the grain at all times, reducing magnetizing current. Cruciform sections of steel obtained by using several different widths of steel strip produce a core cross-section closest to the inside of the coil, conserving steel and further reducing losses. Clamping the core with through- and end-bolts, using heavy reinforced steel channel and angle formed to match each core size, uniformly clamps the sheets into a solid structure that resists noise generation.

Vibration-Dampening Units

The core-and-coil assembly rests on vibration-dampening pads, to prevent transmitting core vibrations into the enclosure, foundation and any conduit or bus duct connected to the case. To be most effective, this requires the removal, after siting, of certain hardware items which were installed for shipping purposes.

Case

The case has removable panels for gaining access to the taps and for inspection of bus connections, wiring and the core-and-coil. The complete case structure can be removed and knocked down to reduce size and weight for passage through tight openings, down hallways, into elevators and rigging into tight locations. The case is constructed of heavy gauge steel and painted ANSI #61 light gray. Key panels can be interlocked to limit access. Special hinged panels and smaller tap-access doors are available options.

Accessories

The ABB Cast Coil Transformer offers optional temperature indicators and forced-air cooling fan control packages, or merely provisions for future fan cooling. Analog units have dial-type indicators for monitoring temperature with a single coil sensing element, which can be equipped with fan control relays, indicator lights, alarm and trip contacts. Digital units have an LCD display of the highest coil temperature; power, fan and alarm lights with contacts plus trip contacts; and thermocouples in all three phases. A fan exerciser circuit runs briefly every six days to forestall motor lubrication dryout. Fan systems offer up to 133% (standard) of nameplate rating, and up to 150% on special order.

Special Design Options

- Seismic qualifications
- Low X/R ratios
- Special altitude requirements
- Higher overload capacity
- Retrofit designs
- High efficiency requirements
- Special ambient conditions
- Outdoor
- Rectifier transformer designs
- Special sound requirements

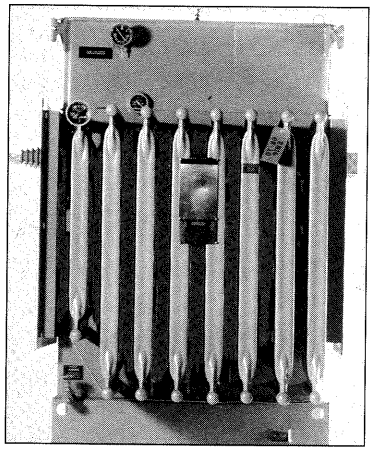
User Benefits

- Reliability
- Low installation cost
- Low operation cost
- Low maintenance
- No toxic substances
- Compliance with applicable ANSI, NEMA, and IEEE standards

Liquid-Immersed Transformers

ABB liquid-filled transformers are one of the most efficient designs available for secondary unit substations. A reliable solution for either indoor or outdoor installation, ABB liquid-filled transformers are designed to withstand electrical, mechanical and thermal stresses that occur during service. ABB designs have been proven through actual short-circuit testing to assure reliable performance.

ABB liquid-filled transformers are easily coordinated with high-voltage and low-voltage switchgear. They are three-phase small power transformers available in ratings up through 2,500 kVA, 15 kV, 95 kV BIL. All ratings are available with 55°C or 65°C rise.



Liquid-Filled Transformer

Fluids

ABB liquid-filled transformers are available with a choice of three insulating fluids:

WEMCO® C Insulating Oil is a standard in the industry and is an excellent choice for outdoor applications. It is used as an insulating and heat-transfer medium providing a natural and efficient method of transferring the heat from the electrical elements to the tank walls, radiators or other heat exchanger.

Silicone transformer fluid is a clear, low-viscosity liquid with heat stability, compatibility with other design materials, low flammability, and low toxicity. It is the best choice for those concerned about fire safety. An ABB silicone-filled transformer with a 12 psig tank, pressure-relief device and current-limiting fusing, allows the customer to meet NEC 450-23 according to Underwriters Laboratories (UL) guidelines. No special installation is required except for a liquid containment area if installed in a non-combustible building.

WEMCO NF is a non-flammable fluid which is formed by combining transformer-grade mineral oil with a perchloroethylene additive.

WEMCO NF needs NEC 450-24 and has been approved by Factory Mutual as a non-flammable transformer fluid.

Core

ABB liquid-filled transformers feature a stacked core design. Grain-oriented electrical steel is used to build the core with a series of laminations. The step-lap joining of core legs to the top and bottom yokes establishes a superior flux path which results in better performance, reduced exciting current, lower sound levels and improved iron losses.

The core is rigidly supported to prevent shifting of laminations and to maintain joint integrity. The core supports are calculated to provide the required beam strength to minimize movement.

Coils

ABB liquid-filled transformers feature tightly wound coils that won't shift during operation or under short-circuit stresses. The low-voltage winding is an aluminum sheet conductor that extends the full height of the coil. Insuldur layer insulation is coated with a diamond pattern of B-stage epoxy adhesive which cures during processing to form a high-strength bond. The high-to-low insulation and spacers are placed over the low-voltage winding and the aluminum strap-wound high voltage is wound directly over the low voltage to form a rigid high-strength coil assembly. Accurately located taps and a large winding cross-section keep unbalanced ampere turns to a minimum. This reduces the vertical forces that pull the high-voltage and low-voltage windings apart during short circuit.

Insulation

Insuldur® layer insulation is treated with special chemical stabilizers that thermally upgrade the insulation. Transformers with Insuldur layer insulation can operate at 12% higher load.

DuraBIL® turn insulation is a single layer of epoxy powder deposited electrostatically on strap conductor. The coated strap is cured in a controlled environment and monitored to insure a continuous uniform coating. It is tough, flexible and inert, and won't degrade and contaminate the transformer fluid with moisture.

Tank and Finish

The transformer tank is designed to withstand a pressure 25% greater than the maximum operating pressure. Carbon-steel plate is reinforced with external side-wall braces as required. Tank seams are continuously welded using an automatic seam welder.

Each cooler assembly is individually welded and receives a pressurized check for leaks prior to assembly on the tank. After the coolers are attached to the tank, the completed tank assembly is leak tested.

After making sure there are no leaks, the entire tank is shot-blasted to prepare the surface for painting. Primer and intermediate coats of paint are applied by a flo-coat method to insure complete coverage. The finish is cured in an oven before the final coat is applied.

After the transformer has been assembled, a final 6-hour leak test is performed before shipment to insure a leak-free transformer.

Testing

Each ABB liquid-filled transformer is tested before it leaves the factory to make sure it meets the customer specifications and the latest revision of the ANSI Standard Test Code C57.12.90. Testing is performed in ABB's world-class, state-of-the-art facility, which has been calibrated according to the guidelines of NBS 1204. Certification by the National Institute of Standards and Technology (NIST) and the National Research Council (NRC) means that all test results are traceable to an industry-accepted standard.

After each transformer is tested, a Certified Test Report is issued which becomes part of the transformer's permanent documentation. It lists the results of all the tests that were performed.

Standard tests include:

- Resistance measurement of all windings on the rated voltage connection 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 and excitation current at rated voltage and frequency on the rated voltage connection.
- Impedance and load loss at rated current and frequency on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on an order.
- Induced potential tests.
- Mechanical leak test on tank and coolers.

Design tests are made on a sufficient number of transformers and ratings to demonstrate compliance with standards for sound level, temperature rise, impulse and tank pressure test.

Table 2 — Transformer Accessories

Description	Liquid Immersed	Ventilated Dry	Cast Coil
No-load tap changer, externally operated	S	NA	NA
No-load taps, internally connected	NA	S	S
Combination drain and filter valve (sampling device optional)	S	NA	NA
1-inch filling plug and filter press connection in cover	S	NA	NA
Thermometer (dial type, without alarm contacts)	S	NA	NA
Liquid level gauge (without low-level alarm contacts)	S	NA	NA
Provision for lifting	S	S	S
Provision for jacking	S	S	S
Pressure-relief device	O*	NA	NA
Ground pad	S	S	S
Instruction nameplate	S	S	S
Pressure-vacuum gauge (without alarm contacts)	S	NA	NA
Sealed tank	S	NA	NA
Winding temperature equipment	O	O	O
Tap changer interlocks	O	NA	NA
Thermometer with alarm contacts	O	NA	NA
Liquid level gauges with alarm contacts	O	NA	NA
Pressure relief device with alarm contacts	O	NA	NA
Sudden pressure relay	O	NA	NA

O — Optional S — Standard NA — Not Applicable *Standard with WEMCO® NF-Filled Transformers

Low-voltage metal-enclosed bus duct is available in continuous current ratings of 600 A through 4,000 A at 600 V. Standard construction includes silver-plated copper or aluminum bus mounted on polyester-glass bus supports. Outdoor bus duct is weatherproof and is provided with heaters to reduce condensation.

Standard features and options include the following:

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

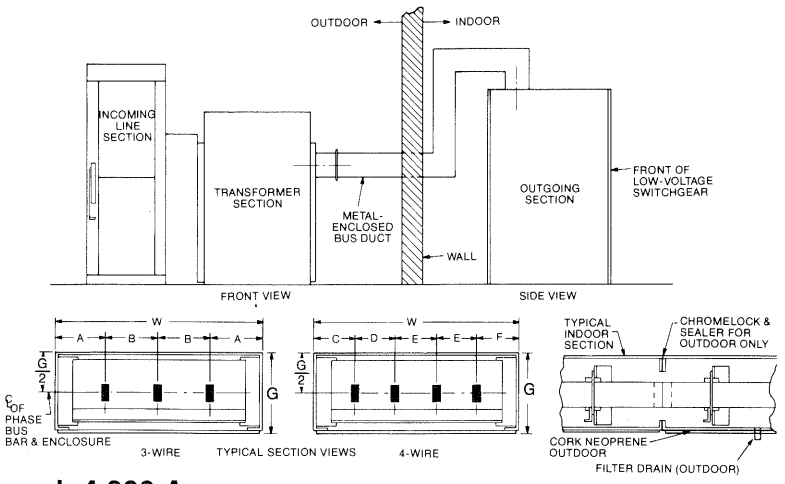


Table 3 — Indoor/Outdoor — 600 through 4,000 Amperes

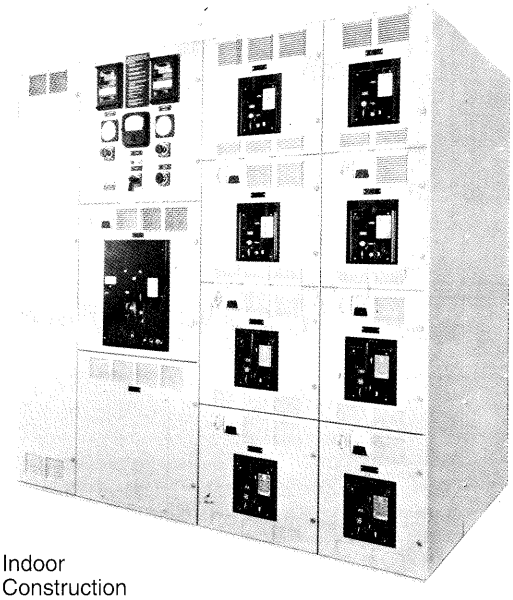
Type	Dimensions W	A	B	C	D	E	F	G	Current Rating, A	Housing Material	Removable Cover
3-Wire	22	6	5	—	—	—	—	16	600 – 2,500 3,000*	12 Ga. Steel	600 – 1,600 A 12 Ga. Steel 2,000 – 4,000 A ⅛" Aluminum
4-Wire 50% – 100% Neutral	27	—	—	6	5	5	6	16	600 – 2,500 3,000*	12 Ga. Steel	
4-Wire Split Phase 50% Neutral	39	—	—	6	7	9	8	16	3,000 3,200*	11 Ga. Steel	
	49	—	—	7.5	10	12	7.5	22	4,000*	⅛" Aluminum	
4-Wire Split Phase 100% Neutral, 3-Wire Split Phase	43	—	—	8	9	9	8	16	3,000 3,200*	11 Ga. Steel	⅛" Aluminum
	49	—	—	7.5	10	12	7.5	22	4,000*	⅛" Aluminum	
	34	8	9	—	—	—	—	16	3,000	11 Ga. Steel	
	39	7.5	12	—	—	—	—	22	3,200* 4,000*	⅛" Aluminum	

*Copper only.

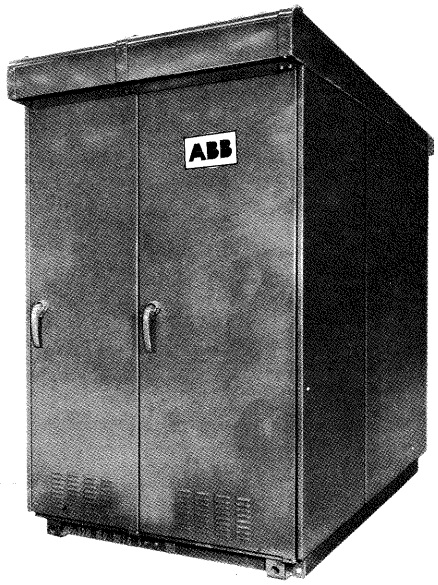
Table 4 — Weights

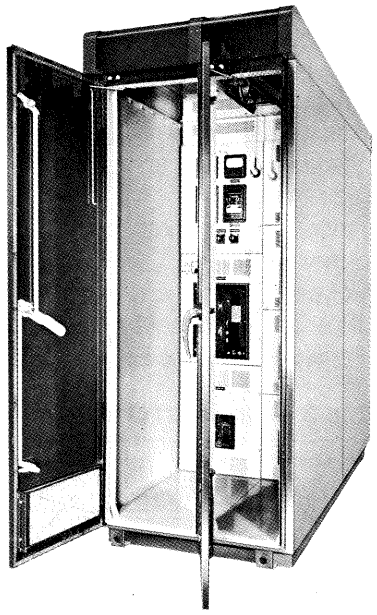
Capacity (Amps)	Weights (lbs. /3 Phase Ft)					
	Aluminum Bus			Copper Bus		
	3-Wire	4-Wire 50% Neutral	4-Wire 100% Neutral	3-Wire	4-Wire 50% Neutral	4-Wire 100% Neutral
600	40	45	45	44	50	50
800	41	46	46	48	54	55
1,000	41	46	47	46	53	54
1,200	41	46	48	49	56	58
1,600	46	51	53	55	63	66
2,000	42	46	48	62	69	76
2,500	50	56	59	70	78	86
3,000	63	69	77	85	95	107
3,200	—	—	—	96	107	120
4,000	—	—	—	126	141	158

Low-Voltage Switchgear



Indoor Construction





Weatherproof Walk-In Construction

Compact ABB 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. 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 push-button 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. A large working area is provided in the rear compartments for pulling and connecting cables.

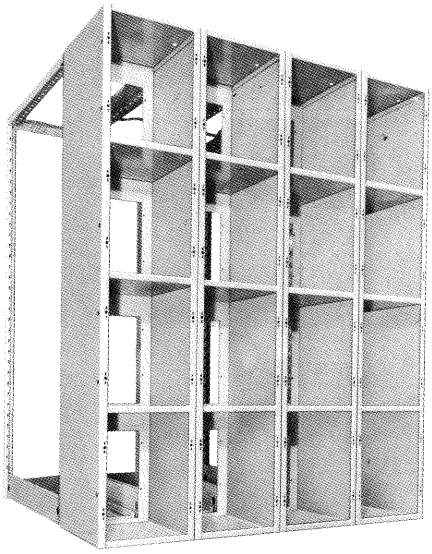
Standard outdoor construction provides:

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

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

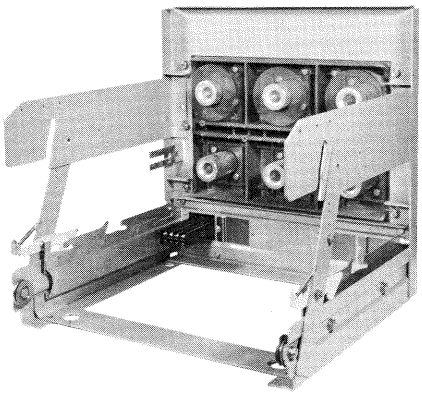
Table 5 — Switchgear Ratings

Switchboard Construction	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	4,000	2.2	65	105
Outdoor	K-DON	600	600	1,600	2.2	65	105



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

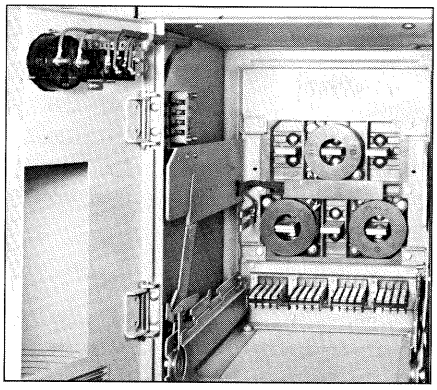
A cradle comprises main and secondary separable contacts, current transformers (if required) and all other drawout mechanisms in a complete jig-welded rigid assembly. There is no dependence upon the switchboard frame for any critical alignment. Any size cradle can be installed into any compartment of 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

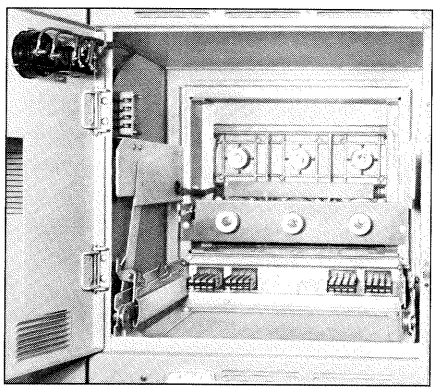
All individual circuit breaker compartments are isolated from each other and from the bus area. Front door louvered grilles are scientifically designed to allow full air circulation. Hinged doors are flanged for greater rigidity. Hinges are completely concealed by being mounted inside the enclosure, 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 makes maintenance far easier. Notice also that the control contacts are located at the bottom where they are safe. They are front-removable to make replacement or modification easily accomplished from within the circuit breaker compartment.

Fully insulated high-dielectric toroidal current transformers are located on the stationary primary leads within the circuit breaker compartment. Convenient location and accessibility make changing a minor maintenance procedure. Standard low-voltage current transformers have metering accuracies in conformance with ANSI C37.20. Current transformer short-circuiting block has safe, convenient location. It is placed at front of circuit-breaker compartment and can be easily reached with circuit breaker still in compartment.



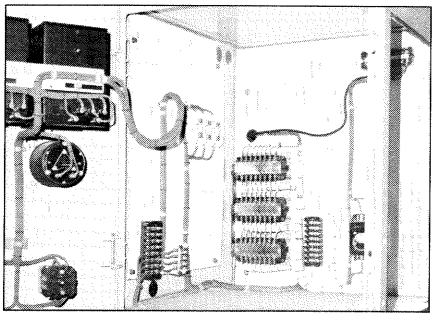
K-800 Compartment



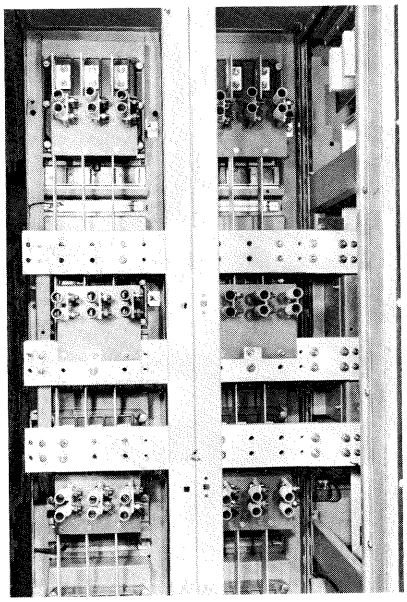
K-DON-1600 Compartment

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 switchgear.
⑤ Stationary primary leads mate with movable primary leads mounted on circuit breaker.
⑥ Secondary disconnects are removable from the front for ease of accessibility.
⑦ Complete compartment isolation is provided between each K-LINE® or K-DON® circuit breaker and main bus compartment.

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

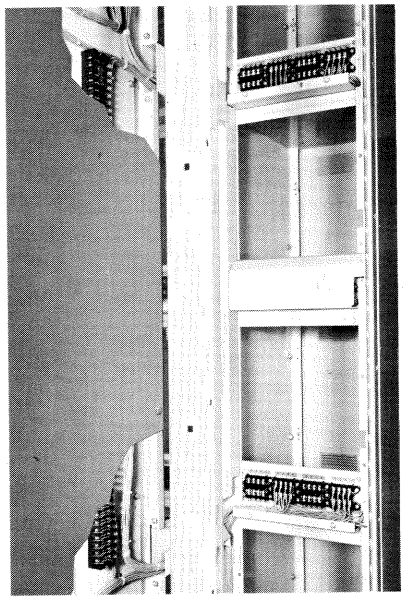


Bus and Cable Compartment



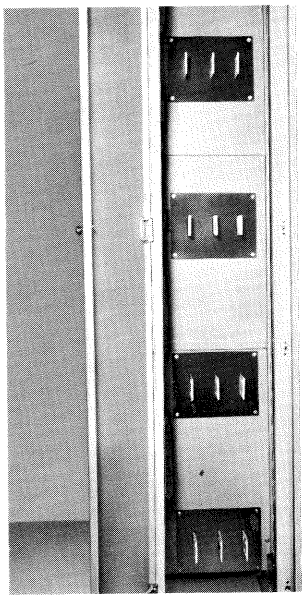
Polyester-Glass Insulation System

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.



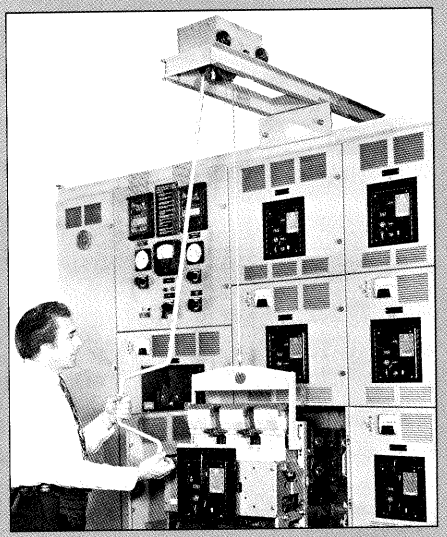
Rear Barriers (optional)

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.

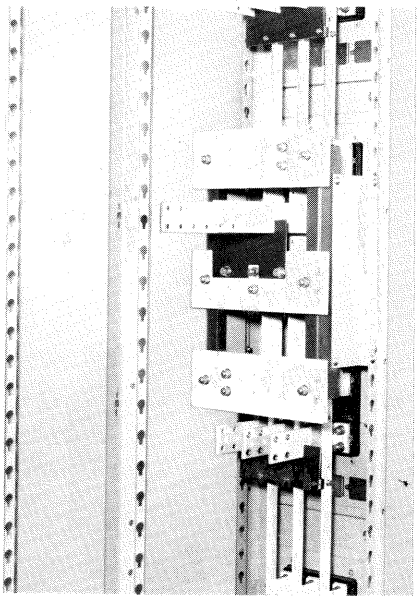
Accessories

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 a 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.

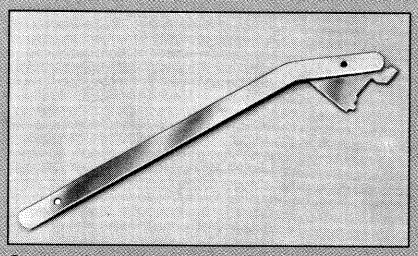
Standard Paint Finish

All ABB switchgear frames and related parts are painted utilizing a modern electrostatic powder painting system. The parts are conveyed through the 5-stage iron phosphate wash house prior to drying and paint process. The wash house chemically cleans and applies an iron phosphate coating to allow excellent adhesion of the powder paint. After the surface preparation of the parts is complete they travel through a gas-fired dry-off oven for removal of all remaining liquids prior to the painting process. In the powder paint booth a high-quality ANSI #61 polyester powder paint is applied manually at a thickness of 1.5–2.0 mils. This paint process provides a durable semi-gloss finish for all frames and piece parts. After application of the powder paint, parts are conveyed to the cure oven for proper curing. The curing process requires ten minutes at a metal temperature of 400°F during which the powder turns to liquid and bonds to the iron phosphate coating previously applied. This process achieves a smooth, uniform paint finish that conforms to UL requirements. Both interior and exterior switchgear is painted with this high-quality process.

Cured parts also conform to the following:

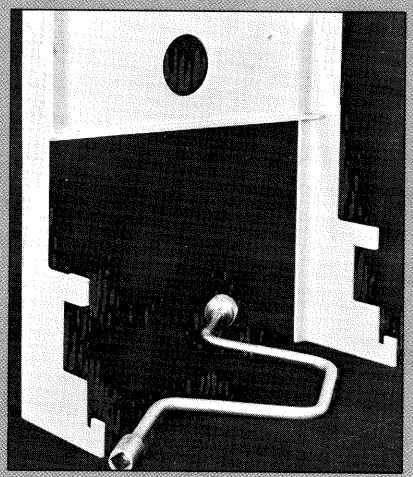
- Steel physical and mechanical properties for paint testing — ASTMD-609
- Humidity resistance (rust creepage) — ASTMD-2247
- Salt spray resistance — ASTMB-117 — over 200 hours

Accessories



Spring-Charge Maintenance Handle

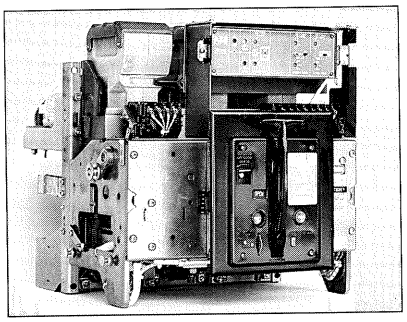
Each factory-assembled switchgear is shipped with circuit breaker racking crank and lifting yoke as standard accessories. A maintenance handle for manual spring charging is included on electrically operated breakers only.



Circuit Breaker Racking Crank and Lifting Yoke

Power Circuit Breakers

The low-voltage section of the secondary unit substation is equipped with our K-LINE® metal-enclosed switchgear. Originally designed in 1957 and continuously updated, the K-LINE switchgear is the longest-running design concept in the industry with over 100,000 breakers in service. The K-LINE switchgear meets the stringent 10 CFR 50, Appendix B standards and is seismically and environmentally qualified for Nuclear 1E applications. Over half of the nation's 1E switchgear installed in the U.S. is ABB design. With its rugged welded-frame construction, the K-LINE switchgear is a design you can count on for many decades of service.



Manually Operated K-1600M

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 on page 36.

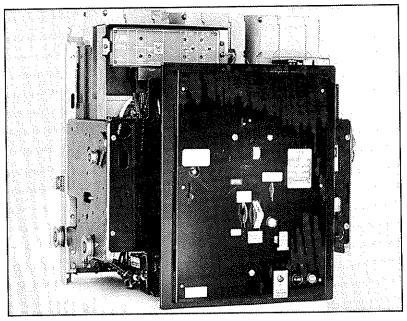
This modern line of low-voltage, air-magnetic, drawout power circuit breakers offers a selection of either manually or electrically (motor-charged) operated spring-closing mechanisms, which provide positive quick-make operation. K-LINE circuit breakers are provided with the MPS-C electronic overcurrent trip device. Breakers with the original, OD direct-acting, electro-mechanical trip device remain available as well as the type SS, POWER-SHIELD, solid-state overcurrent trip device. Consult factory whenever the OD or SS overcurrent device is desired.

K-DON®

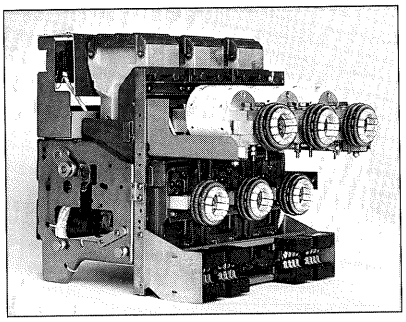
The K-DON circuit breaker is a compact, versatile protective device which incorporates all of the features of the K-LINE circuit breaker and the current-limiting characteristics of the Amp-Trap* fuse. The current-limiting fuses are integrally mounted on, and physically connected in series with, the breaker. 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.

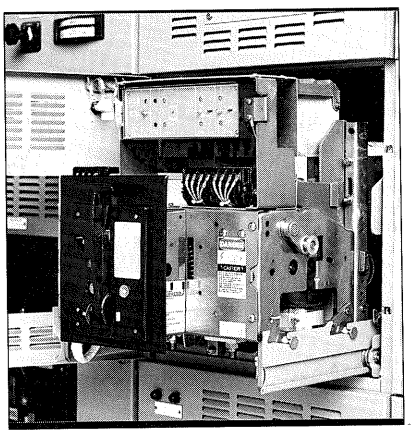
*Registered Trademark — Gould-Shawmut



Electrically Operated K-4000M



Rear View
Manually Operated K-DON® 1600M



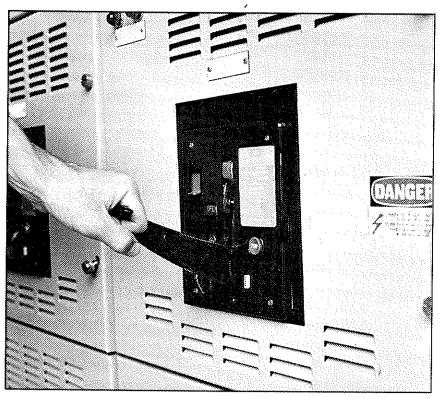
Manually Operated K-1600M
in Fully Withdrawn Cradle Position

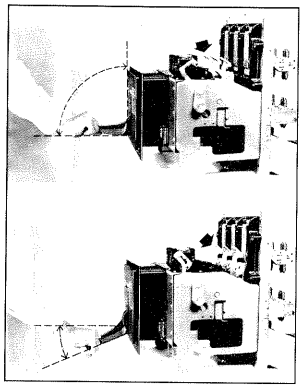
Table 6 — K-DON® Power Circuit Breaker Ratings[1]

Circuit Breaker Type	Maximum Continuous Current Rating, Amps	Interrupting Capacity, Symmetrical RMS Amperes 240, 480, and 600 Volts
K-DON-800M	800	200,000
K-DON-1600M	1,600	200,000

1. Fused circuit breakers with 2,000 A, 3,000 A and 4,000 A continuous current ratings are available with separately mounted, drawout, current-limiting fuses.

Manual Stored-Energy Breakers Give Quick-Make, Quick-Break Operation





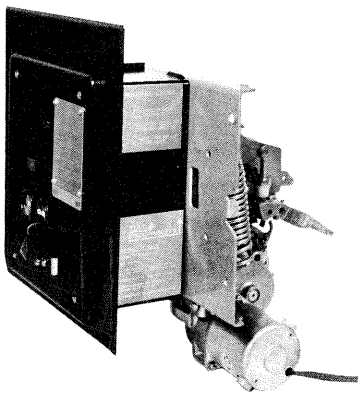
Less Upkeep, Longer Contact Life

A manually charged stored-energy breaker offers 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 800 through 2,000 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

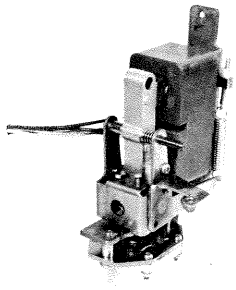
All K-LINE® circuit breakers are also available with motor-charged, stored-energy closing mechanisms to be used when remote control or local electrical control is required. The normal control power required by this mechanism is only a fraction of the power requirement for a solenoid closing mechanism.

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.

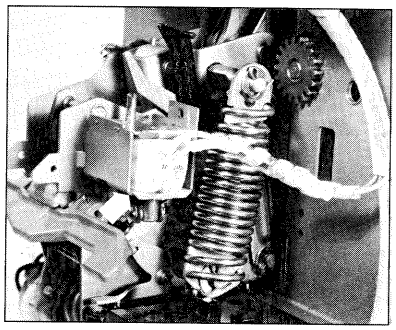


Electrically Operated Mechanism

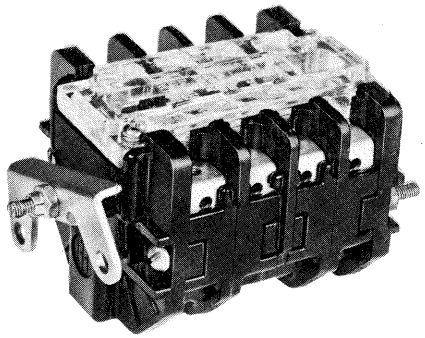
Breaker Components



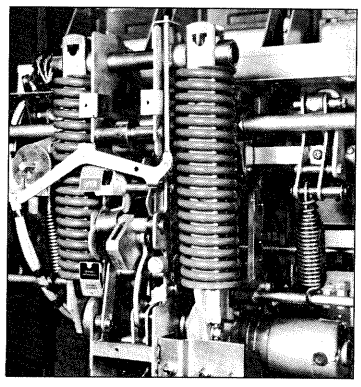
Undervoltage Trip Device



Shunt Trip Device



Auxiliary Switch

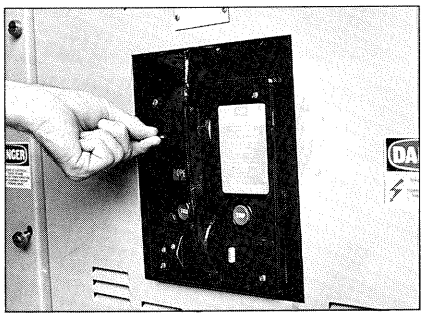


K-3000 Motor-Charged Stored-Energy Operating Mechanism

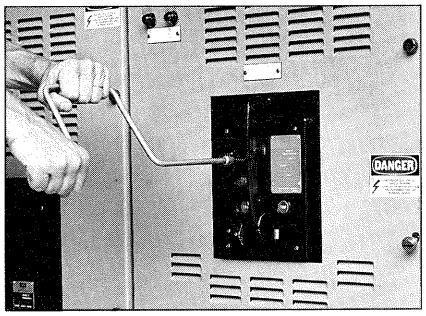
Safe, Efficient, Closed-Door Drawout

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 ABB 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 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.

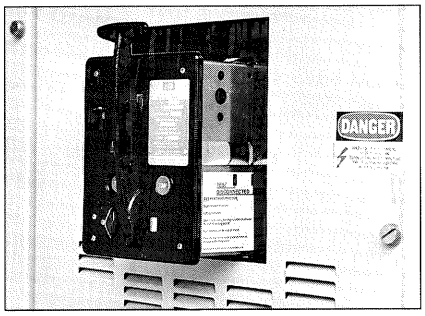
The extendable escutcheon mounted on the circuit breaker slides through an opening into the compartment door while the spring-loaded cover plate surrounding the escutcheon is held in place by the door. Visual indication on the side of the breaker denotes all three positions. Compartment doors may be 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.

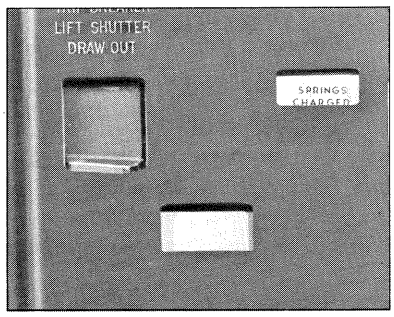


Insert crank to move breaker between positions. Crank cannot be inserted without raising lift shutter.

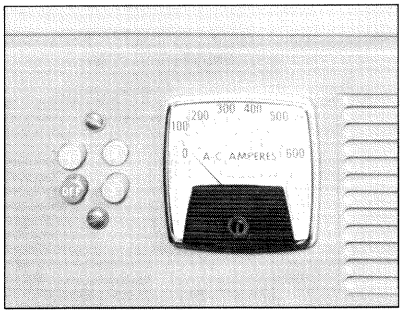


Read breaker position from target on the right side of escutcheon. When breaker is in disconnected, test or connected positions, lift shutter will close. Breaker contacts cannot be closed until lift shutter is closed.

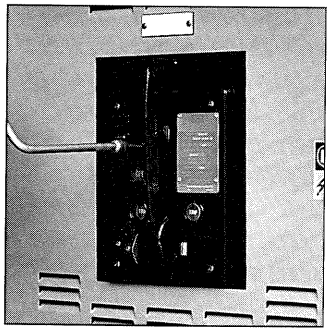
Manual closing lever. All electrically operated breakers can be closed manually with the compartment door closed, if control power is lost, by simply pulling the closing lever. Closing springs can also be charged manually with a hand lever.



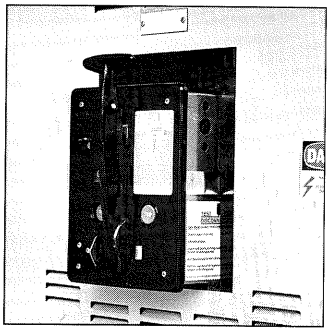
Spring-charged indicator shows condition of stored-energy springs on electrically operated breakers. Open-closed indicator visually shows position of breaker contacts directly on front of escutcheon.



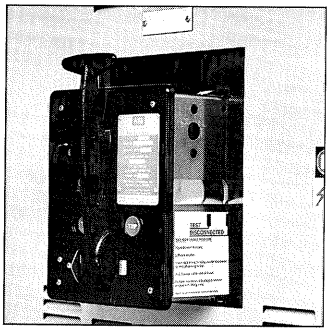
Feeder ammeter. Each feeder compartment can be equipped with a door-mounted ammeter and push-button switch for easy, convenient reading and space saving.



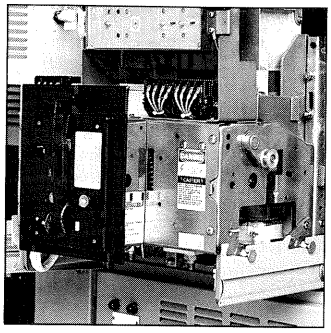
Connected



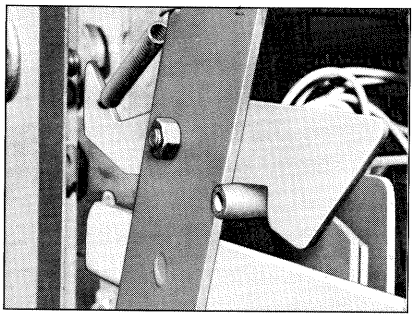
Test



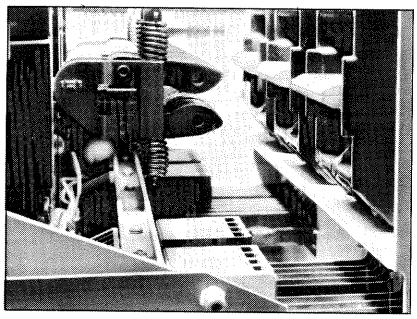
Disconnected



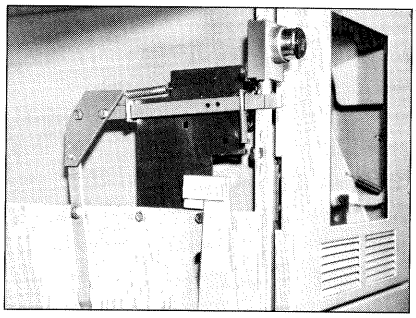
Fully Withdrawn



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

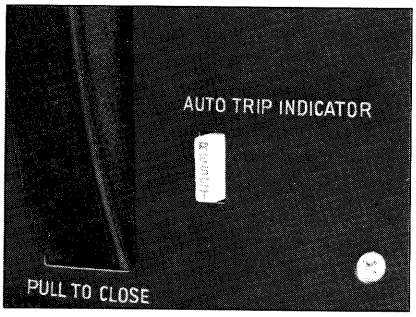


Primary, secondary and ground contacts on the circuit breaker mate sequentially in a straight-line motion with counterparts within the switchgear. This insures proper breaker operation at each position.

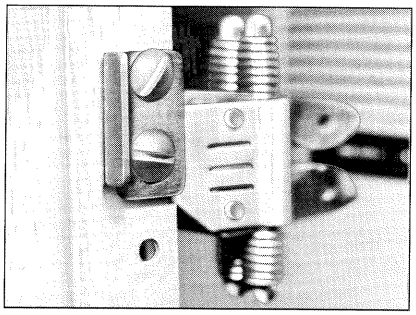


Kirk™ key interlocks offer an unlimited number of interlocking arrangements between all components of the switchgear. They are particularly adaptable to sequential operations or prevention of unauthorized operation.

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. Alarm contacts and/or mechanical lockout features are options.



Interference key on the breaker mates with slot on cradle allowing only the properly rated breaker to be inserted into the compartment. It is virtually impossible to insert a lower rating into any compartment.

MICRO Power Shield is a state-of-the-art electronic over-current protection system. The system consists of three components: the MICRO Power Shield with communication (MPS-C) microprocessor-based trip unit, a magnetic latch, and current sensors specially designed as an integral component of the entire K-LINE® family of low-voltage power circuit breakers.

Solid-state trip systems have been supplied on ABB low-voltage power circuit breakers since 1968. These years of experience, as well as modern microprocessor technology, have been incorporated into the design and manufacture of the MICRO Power Shield tripping system featured on all K-LINE circuit breakers to better protect power systems in the event of overloads or faults.

The MICRO Power Shield protection system is completely self-powered. It takes the tripping energy from the primary current flowing through the circuit breaker, eliminating the need for an external power supply.

Current sensors are integrally mounted on each phase of the circuit breaker and supply the current signal to the MPS-C trip device. This current has a value directly proportional to the current flowing in the primary circuit. If the current value flowing through the primary exceeds the programmed settings for a given time interval, the trip unit sends a signal to the magnetic latch which trips the circuit breaker.

The MPS-C trip device is available in six basic configurations (See Table 7). The protective functions available are long-time, short-time, and ground fault, each with a variable time-delay setting, and an instantaneous trip function. Selection is based on the protective and coordination requirements of the particular system.

RMS Digital Sensing

The MPS-C trip device provides accurate overload protection by performing RMS calculations on the three-phase overload currents to provide tripping in response to the true heating value of those currents.

This is accomplished with unique microprocessor digital sampling techniques to provide the most accurate protection for systems that include drivers, rectifiers, and other loads that impose potentially damaging harmonics on the system.

Ampere Ratings and Settings

The MPS-C trip device provides a full range of settings for precise protection and coordination. All settings are visible through a transparent cover with a sealable feature that inhibits tampering by unauthorized personnel. The settings are adjusted on the front of the trip device with positive detent selector switches. The settings for the long-time, short-time, and instantaneous functions are multiples of the ampere rating selected for the trip device. The available settings are shown in Table 8.

Three functions are provided with individually adjustable time-delay settings. The long-time, short-time, and ground functions are provided with minimum, intermediate, and maximum time-delay settings, adjustable on the front of the MPS-C. The actual time delays are shown in Table 9.

When provided, the short-time function is furnished with an I^2t "IN/OUT" selector switch. This provies for shaping the time-current characteristic curve in the short-time delay area from a sharp knee (I^2t "OUT") to a ramp function (I^2t "IN").

Like the short-time function, the optional ground fault function is also provided with an I^2t "IN/OUT" selector switch. This provides time-current characteristic curve shaping in the ground fault delay area. The circuitry of the ground fault function also responds to low-level arcing faults by summing the erratic currents associated with arcing.

A portable test set is available for field testing. A function switch is provided on the front of the MPS-C to facilitate testings. The "Test Function" switch defeats all trip elements except the one selected for test purposes.

Each MPS-C trip device is completely tested before shipment. There are no adjustments that must be made after shipment. Only the required settings need to be selected prior to placing the unit in service.

Ampere Selector Switch

The ampere selector switch is located on the front of the MPS-C. This exclusive feature increases the available number of pick-up settings for the three basic protective functions: long-time, short-time, and instantaneous. While providing this broader range of protection, the ampere selector switch reduces the number of different current sensors required. Only eight sensor ratings are required for long-time settings ranging from 50 to 4,000 amperes.

Narrow Pick-Up Tolerance

All K-LINE low-voltage circuit breakers utilize type MPS-C trip devices. Unlike other trip devices, greater than unity or greater than margin settings, such as 110%, are not required to assure that the MB circuit breaker will carry 100% of its sensor rating continuously. This is accomplished by the microprocessor beginning the time delay and trip functions only after 100% of the threshold value has been exceeded (–0 to +10% bandwidth tolerance). This exclusive feature of the microprocessor assures users full utilization of their investment for its intended purpose, while eliminating nuisance trips resulting from negative deviation.

Built-In Coordination

Coordination with downstream devices is also made easy with the MPS-C. Unlike some competitive trip devices, the MPS-C trip device allows the K-LINE circuit breakers to coordinate with downstream devices without the need for external override circuitry.

Table 7 — Available Trip Units

Type MPS-C	Trip Functions				Time-Current Curves (Overcurrent, Ground, and I^2t)
	Long-Time Delay	Short-Time Delay	Inst. Setting	Ground Delay	
MPS-C-3	X	—	X	—	TD-9650
MPS-C-3G	X	—	X	X	TD-9650 & 9652
MPS-C-4	X	X	—	—	TD-9651 & 9653
MPS-C-4G	X	X	—	X	TD-9651, 9652, 9653
MPS-C-5	X	X	X	—	TD-9651 & 9653
MPS-C-5G	X	X	X	X	TD-9651, 9652, 9653

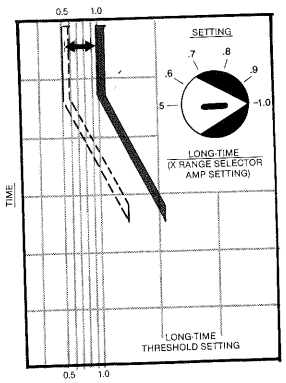
Table 8 — Sensor Ampere Ratings and Settings

Sensor Rating	Ampere Selector	Long-Time	Short-Time	Inst.	Ground Amps	Circuit Breaker
200 800	100, 200 400, 800	0.5 0.6 0.7 0.8 0.9 1.0	2 3 4 6 8 10	3 4 5 7 10 12	100 200 300 600 900 1200	K-800M KE-800M K-DON-800M
1600 2000	800, 1600 1000, 2000	0.5 0.6 0.7 0.8 0.9 1.0	2 3 4 6 8 10	3 4 5 7 10 12	300 400 600 800 1000 1200	K-1600M KE-1600M K-DON-1600M K-2000M
3000 3200 4000	1500, 3000 1600, 3200 2000, 4000	0.5 0.6 0.7 0.8 0.9 1.0	2 3 4 6 8 10	3 4 5 7 10 12	500 600 800 900 1000 1200	K-3000M K-3200M K-4000M

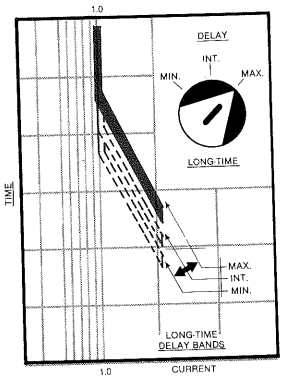
Table 9 — Time Delay Settings

Type MPS-C	Trip Function	Time Delay Band	Time Delay
MPS-C-3 & 3G[3] MPS-C-4 & 4G MPS-C-5 & 5G[3]	Long-Time	Maximum Intermediate Minimum	15.0 Seconds[1] 5.0 Seconds[1] 2.0 Seconds[1]
MPS-C-4 & 4G MPS-C-5 & 5G[3]	Short-Time	Maximum Intermediate Minimum	0.35 Seconds[2] 0.20 Seconds[2] 0.08 Seconds[2]
MPS-C-3G[3] MPS-C-4G MPS-C-5G[3]	Ground	Maximum Intermediate Minimum	0.35 Seconds[2] 0.20 Seconds[2] 0.05 Seconds[2]

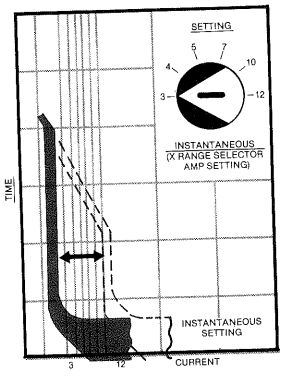
1. Measured at six times range selector ampere setting at the lower limit of the time delay band.
2. Measured at the lower limit of the maximum, intermediate, minimum short-time and ground time delay bands at any point above threshold.
3. Includes adjustable threshold instantaneous trip function.



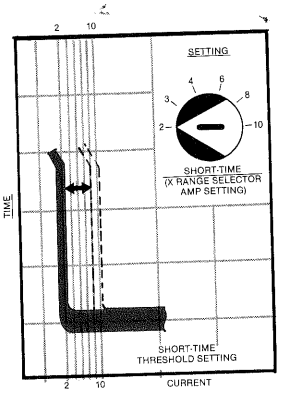
Long-Time Setting (Standard)
Six-position long-time setting selector switch provides long-time settings at any of six multiples of the (100% or 50%) range selector ampere setting. (TD-9650 and TD-9651)



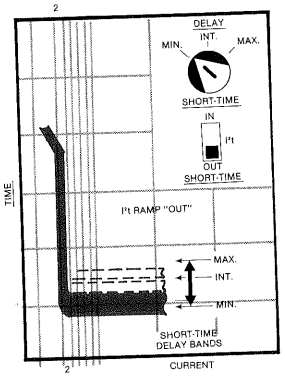
Long-Time Delay (Standard)
Three-position long-time delay selector switch varies the long-time delay band setting. Minimum, intermediate and maximum delay bands are provided. (TD-9650 and TD-9651)



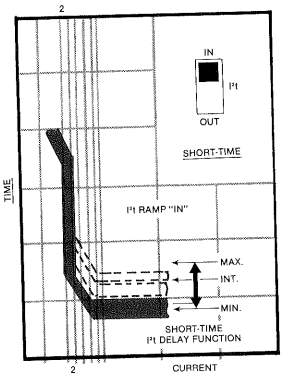
Instantaneous Setting (Optional)
Instantaneous threshold setting determines the current level at which the circuit breaker will trip without intentional time delay. (TD-9650 and TD-9651)



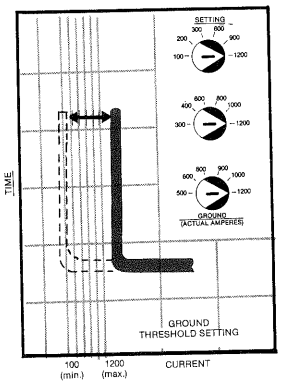
Short-Time Setting (Optional)
Six-position short-time setting selector switch provides short-time settings at any of six multiples of the (100% or 50%) range selector ampere settings. (TD-9651 and TD-9653)



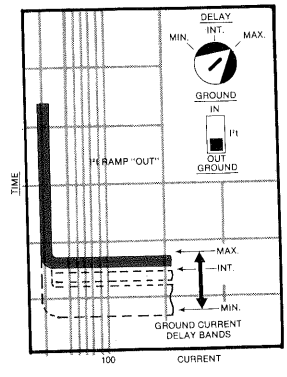
Short-Time Delay
(Standard with Short-Time Option)
Three-position short-time delay selector switch varies the short-time delay band setting. Minimum intermediate and maximum delay bands are provided. (TD-9651 and TD-9653)



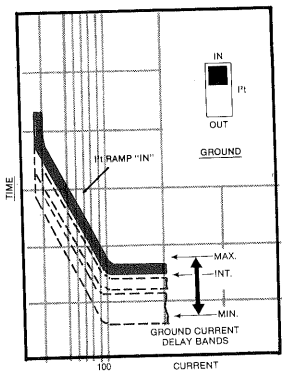
Short-Time I²t Selector
(Standard with Short-Time Option)
Short-time I²t switch provides for an I²t ramp function at the knee of the short-time characteristic curves. (TD-9651 and TD-9653)



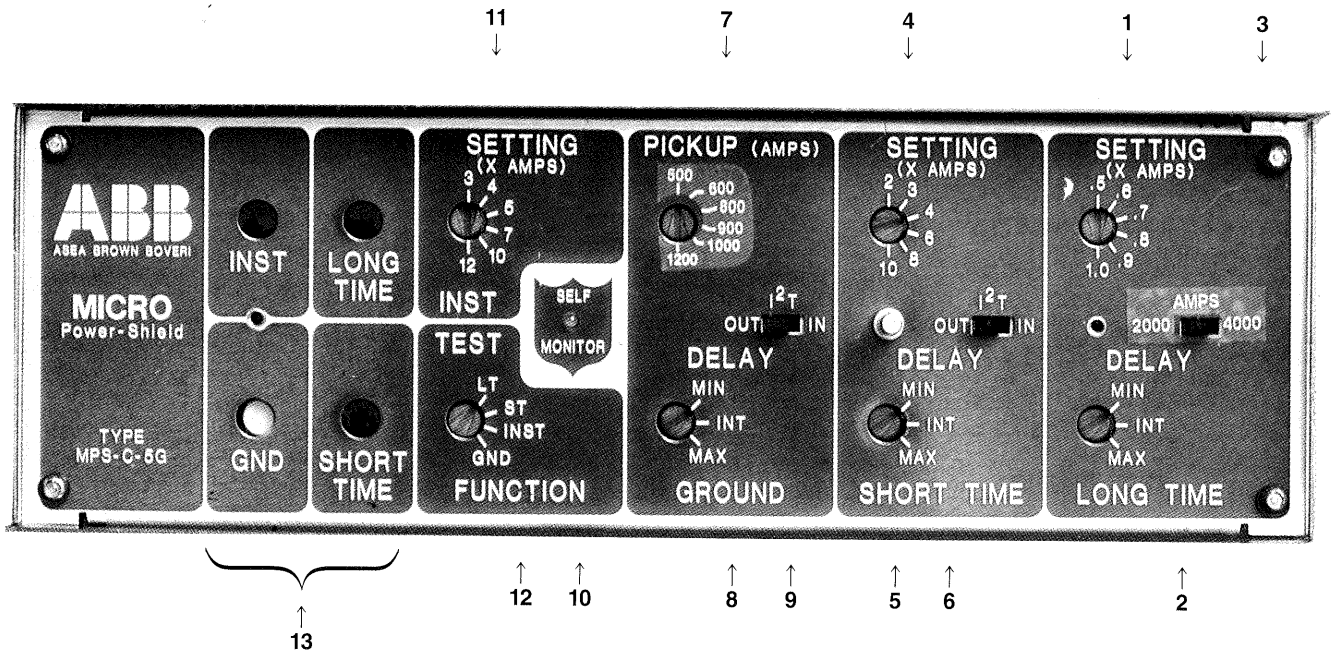
Ground Current Setting (Optional)
Ground current threshold settings are given in actual ampere values with three ranges available. The six-position ground setting selector switch provides for ground settings from 100 to 1,200 A, 300 to 1,200 A or 500 to 1,200 A. (Refer to Table 2.) (TD-9652)



Ground Delay
(Standard with Ground Option)
Three-position ground delay selector switch varies the minimum, intermediate and maximum delay bands settings. (TD-9652)



Ground I²t Selector
(Standard with Ground Option)
Ground I²t switch provides for an I²t ramp function at the knee of the ground characteristic curves. (TD-9652)



① Long-Time Pickup Setting — Standard
② Long-Time Delay — Standard
③ Ampere Selector Switch — Standard
④ Short-Time Pick-Up — Optional
⑤ Short-Time Delay — Optional
⑥ Short-Time I^2t Selector Switch — Optional
⑦ Ground Fault Pickup — Optional
⑧ Ground Fault Delay — Optional
⑨ Ground Fault I^2t Selector Switch — Optional
⑩ Self Monitor/Long-Time Pickup LED — Standard
⑪ Instantaneous Pickup — Standard
⑫ Test Function Switch — Standard
⑬ Target Annunication — Standard

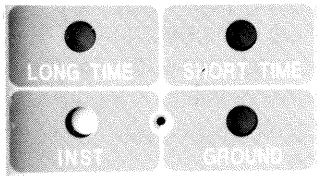
The MPS-C trip device is provided with the following list of standard features:

- Advanced sampling techniques with RMS current calculations
- State-of-the-art microprocessor control
- Range selector switch which doubles the available trip settings
- Independently adjustable, six-position selector switches for all trip element settings
- Three-position time delay bands for long-time, short-time, and ground
- Positive detents in all selector switches for precise adjustment
- True 100% current-carrying capability on long-time with a –0 to +10% tolerance band
- Switchable I^2t on short-time and ground
- Self-monitor light emitting diode which indicates trip system condition
- Long-time pick-up indication by fast pulsing of self-monitor light
- Standard mechanical trip targets, easily seen even in poorly lit areas, which require no power to maintain their indication
- Automatic reset of the trip targets by the MPS-C microprocessor
- Special ground fault circuitry which sums intermittent grounds over time to provide tripping in response to arcing grounds
- Unique test selector switch which disables all but the selected trip element when testing with the 606 secondary current injection test set
- Transparent, sealable front cover to prevent unauthorized tampering
- Outputs to optional alarm devices

Table 10 — Available Features

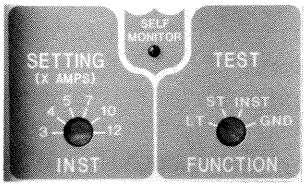
Feature	MPS-C-3	MPS-C-3G	MPS-C-4	MPS-C-4G	MPS-C-5	MPS-C-5G
2-Position Ampere Range Selector	S	S	S	S	S	S
6 Adjustable Long-Time Settings	S	S	S	S	S	S
3 Adjustable Long-Time Delay Bands	S	S	S	S	S	S
6 Adjustable Short-Time Settings	NA	NA	S	S	S	S
3 Adjustable Short-Time Delay Bands	NA	NA	S	S	S	S
6 Adjustable Ground Settings	NA	S	NA	S	NA	S
3 Adjustable Ground Delay Bands	NA	S	NA	S	NA	S
6 Adjustable Instantaneous Settings	S	S	NA	NA	S	S
Target Indication for Each Element	S	S	S	S	S	S
Automatic Target Reset	S	S	S	S	S	S
Test Function Switch for Each Element	S	S	S	S	S	S
Test Set Provisions (Type 606)	O	O	O	O	O	O
Load Alarm Contact*	O	O	O	O	O	O
Ground Alarm Contact*	NA	O	NA	O	NA	O
Ground Current Summing	NA	S	NA	S	NA	S
Short-Time I^2t (In/Out)	NA	NA	S	S	S	S
Ground I^2t (In/Out)	NA	S	NA	S	NA	S
Self-Monitor LED	S	S	S	S	S	S

* — Requires an External Source of Control Power NA — Not Available S — Standard Feature O — Optional



Trip Target Indicator

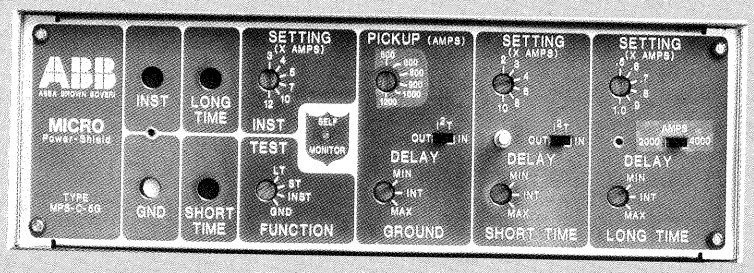
Target indicators are provided with each trip element as a standard feature. This includes long-time, short-time, instantaneous and ground. Target indication is retained and not affected by shock, vibration or loss of control power. Reset is accomplished automatically within ten seconds after reclosing the circuit breaker. If another trip is initiated target reset will occur instantaneously and a new target will display which protective element responded.



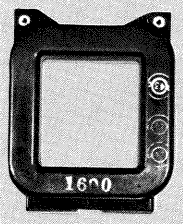
Self-Monitor LED

A self-monitoring indicating light is provided as a standard feature on all MPS-C trip units. A self-monitor function continuously checks the operating condition of the microprocessor and displays proper operation in the form of a red LED mounted on the MPS-C front panel. The red LED will blink approximately one time per second when activated by primary current flowing through the circuit breaker. The blinking red LED indicates proper operation of the microprocessor.

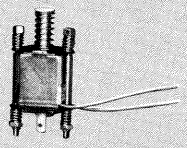
Solid-State Trip System



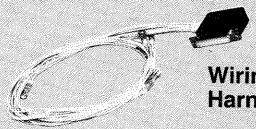
MICRO Power-Shield Trip Unit (MPS-C-5G shown)



Phase Sensor (3 required)

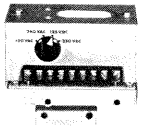


Magnetic Latch Unit



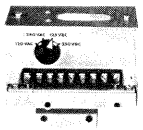
Wiring Harness

Optional Accessories



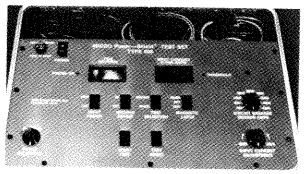
Ground Alarm Contact

This feature provides a momentary contact closure when a ground trip operation occurs. This contact is brought out to terminals where a remote alarm circuit may be connected. This contact is suitably rated for use with a remote-mounted annunciator. The contact rating at 125V_{DC} is 30 A momentary, 5 A continuous and 0.3 A inductive break.



Load Alarm Contact

A load alarm contact is available with a normally open contact that closes when the primary current exceeds the long-time threshold setting. This contact remains closed until the breaker trips. The load alarm contact is brought out to terminals where a remote alarm circuit may be connected. This contact is rated at 125 V_{DC}, 30 A momentary, 5 A continuous and 0.3 A inductive break.



Type 606 Test Set

A compact, portable test set is available to test all MICRO Power-Shield, type MPS-C trip units on site. With the K-LINE® circuit breaker drawn out to the "test" position or removed to a work table, the Type 606 test set verifies the operation of the MICRO Power-Shield trip system in accordance with the setting selected and the characteristics desired. This includes long-time threshold and delay, short-time threshold and delay, ground threshold and delay, and instantaneous threshold.

Today's power systems often require more than the four basic trip functions found on most circuit breakers. Systems that can communicate their operating parameters to the operator to provide information for load management and to alert the operator before a problem occurs are becoming a necessity rather than a luxury.

To meet this need, ABB has developed its PRICOM substation communication system. The PRICOM system is a combination of hardware and software that allows comprehensive monitoring of secondary or primary unit substations. The system provides complete current, voltage and power readings, trip and event recording, breaker setting monitoring and breaker control.

The MPS-C trip device is an integral part of the PRICOM communication network. The MPS-C communicates all power parameters to the network interface module (NIM). When the MPS-C is used as part of the PRICOM communication system, the NIM is provided with these additional standard features:

- Communication software for data exchange between PRICOM system components
- Connectors for the PRICOM Network Interface Module and Voltage Interface Module
- Non-volatile memories with battery backup
- One percent accuracy on current and voltage readings; two percent accuracy on power readings
- Tamper monitoring ability communicates the following information through the network to any PRICOM readout device: current sensor rating, range selector setting, the settings of all trip elements, plus their delay and I^2t switch positions.
- Flexibility in positioning like circuit breakers in the switchboard, since network address is maintained by the Network Interface Module, not the circuit breaker-mounted trip device
- Trip interface for the voltage and current relaying, and the Zone Protective Interlocking found in the Network Interface Module

The MPS-C trip device is provided as standard on all K-LINE® circuit breakers. If an upgrade to the PRICOM system is required, the trip devices need not be changed. For more information about the PRICOM communication system contact the nearest ABB representative.

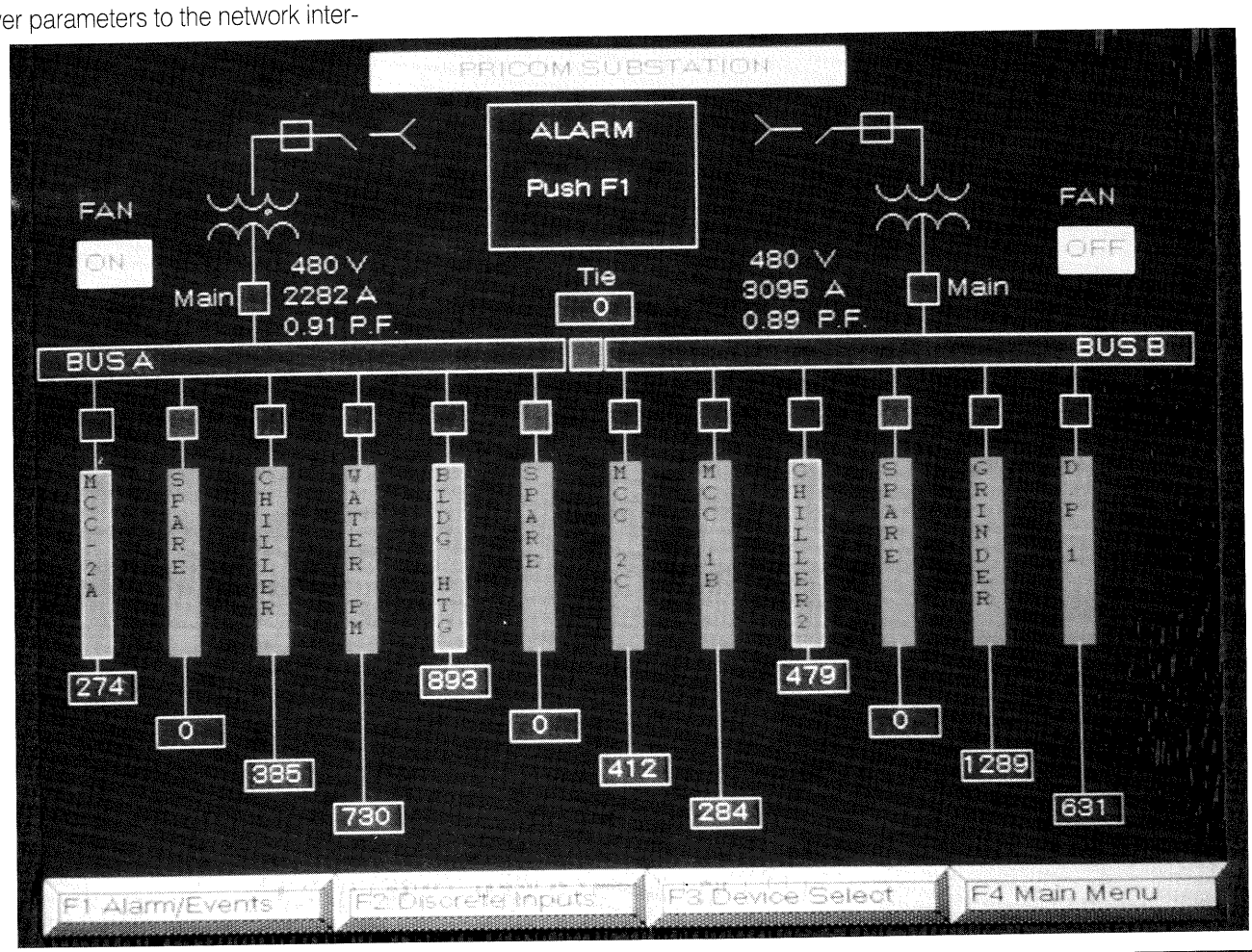


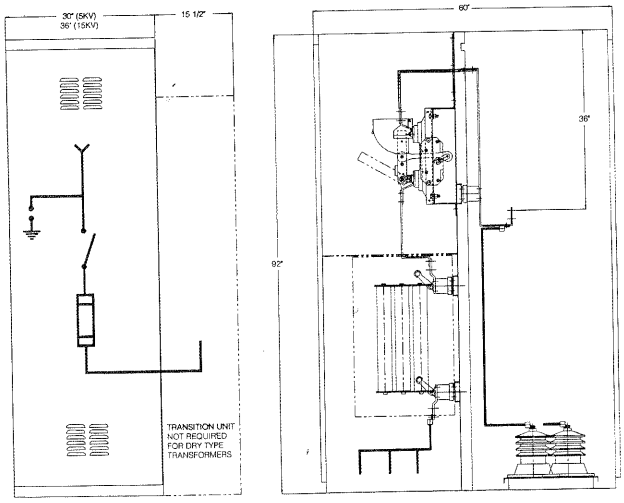
Table 11 — Features of Stored-Energy K-LINE® and K-DON® Circuit Breakers

Standard Features Include:	K-800M K-1600M K-2000M	K-3000M K-3200M K-4000M	K-DON-800M K-DON-1600M
Manually Operated			
Springs charged and breaker closed with manual handle	X	No	X
Springs charged only with manual handle	No	X	No
Manual close lever — door closed	No	X	No
Springs-charged indicator	No	X	No
Electrically Operated			
Springs charged with motor — after trip	X	X	X
Electrical closing release	X	X	X
Manual close lever — door closed	X	X	X
Shunt-trip device	X	X	X
Control relay	X	X	X
Charging motor disconnect switch	X	X	X
Springs-charged indicator	X	X	X
Secondary disconnects (operating and test position)	X	X	X
4-contact auxiliary switch	X	X	X
Provision for manual spring charge	X (door open)	X (door closed)	X (door open)
Manually or Electrically Operated			
Manual trip button	X	X	X
Breaker contact position indicator	X	X	X
Breaker racking position indicator	X	X	X
Racking interlock (Breaker must be open prior to racking.)	X	X	X
Positive racking stops	No	X	No
Padlock hasp — up to three locks (locks breaker trip-free and in position)	X	X	X
Breaker interchangeability interlock	X	X	X
Direct-acting overcurrent trip devices[1]	No	No	No
Electronic overcurrent trip device (long-time and instantaneous, MPS-C-3)	X	X	X
Automatic trip indicator (overcurrent and undervoltage trip)	X	X	X
Primary disconnects (operating position only)	X	X	X
Ground disconnect (operating and test position only)	X	X	X
Manual slow-close provision	X	X	X
Actuator to discharge springs on withdrawal from switchboard	X	X	X
Amp-trap, current-limiting fuses	No	No	X
Anti-single-phase device	No	No	X

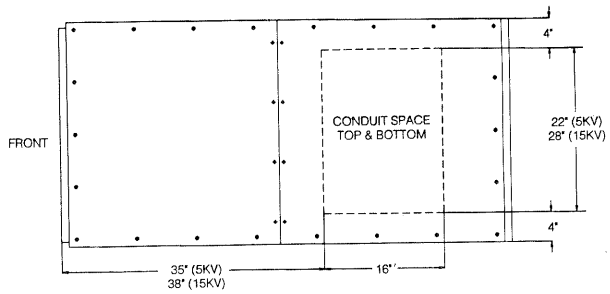
Standard Features Include:	K-800M K-1600M K-2000M	K-3000M K-3200M K-4000M	K-DON-800M K-DON-1600M
Additional Optional Features (EO or MO, except as noted)			
Local electrical trip button (on escutcheon)	X	X	X
Shunt trip with 4-contact auxiliary switch (2 spares) — MO only	X	X	X
Dual-Selective, direct-acting overcurrent trip device[1]	No	No	No
Electronic overcurrent trip device (Dual-Selective, MPS-C-4 and MPS-C-5)	X	X	X
Operation indicator (target) and load alarm for solid-state trip	X	X	X
Mechanical lockout on automatic trip (reset by indicator)			
— Overcurrent and undervoltage trip	X	X	X
— Overcurrent alone (special trip for undervoltage)	X	X	X
Alarm switch — 1 NO and 1 NC (reset by indicator)			
— Overcurrent and undervoltage trip	X	X	X
— Overcurrent alone (special trip for undervoltage)	X	X	X
Auxiliary switches — spares			
— 4 or 8 contacts — EO only	X	X	X
— 4, 8 or 12 contacts — MO only	X	X	X
Undervoltage trip device			
— Instantaneous	X	X	X
— Time delay — adjustable 0–15 sec.	X	X	X
Operation counter	X	X	X
Remote electrical-close release — MO only	No	X	No
Wiring change to charge springs when breaker closes	X	X	X
Hinged door interlock — door locked when breaker closed	X	X	X
Mechanical-transfer interlock — two breakers using flexible cable arrangement	X	X	X
Additional secondary disconnects up to 32 maximum	X	X	X
Secondary disconnects — operating and/or test position only	X	X	X
Key interlocks — switchboard mounted — 2 maximum	X	X	X
Standard Accessories			
Racking crank	X	X	X
Lifting yoke	X	X	X
Maintenance spring-charge handle — EO only	X	X	X
Slow-close bracket	No	X	No
Optional Accessories			
Transfer and lift truck	X	X	X
Overhead life device (standard outdoor)	X	X	X
Floor dolly	X	X	X
Test set for electronic trip	X	X	X

1. The direct-acting electromechanical overcurrent trip device remains available — consult factory.

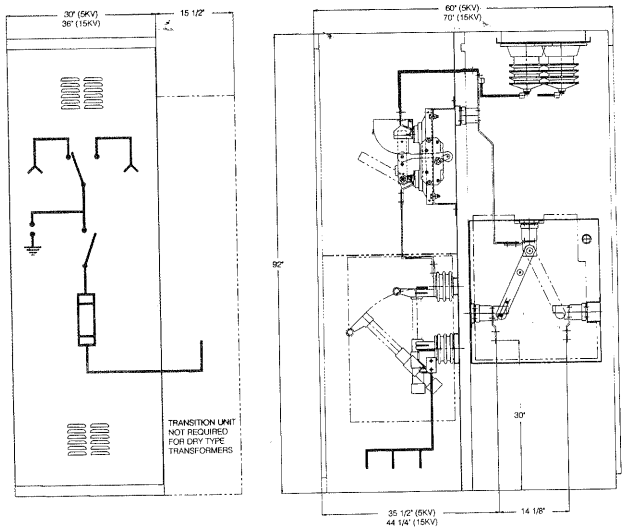
DIMENSIONS, WEIGHTS AND ARRANGEMENTS



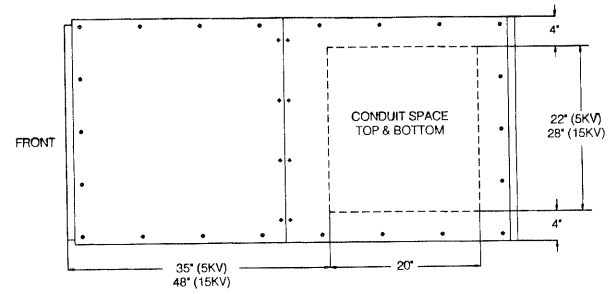
Air Interrupter Switch—Indoor[2]



Floor Plan
For duplex switch arrangement, increase width twice dimension shown.

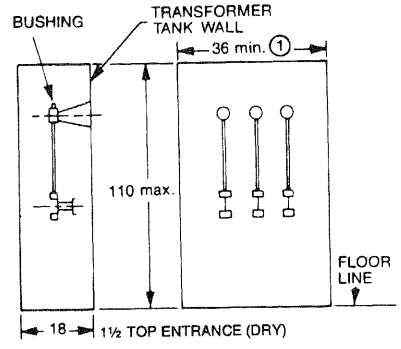


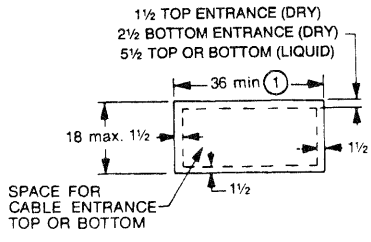
Selector Switch — Indoor[2]



Floor Plan
For top entrance add 10" to overall depth.

Typical Air Terminal Chamber Indoor/Outdoor





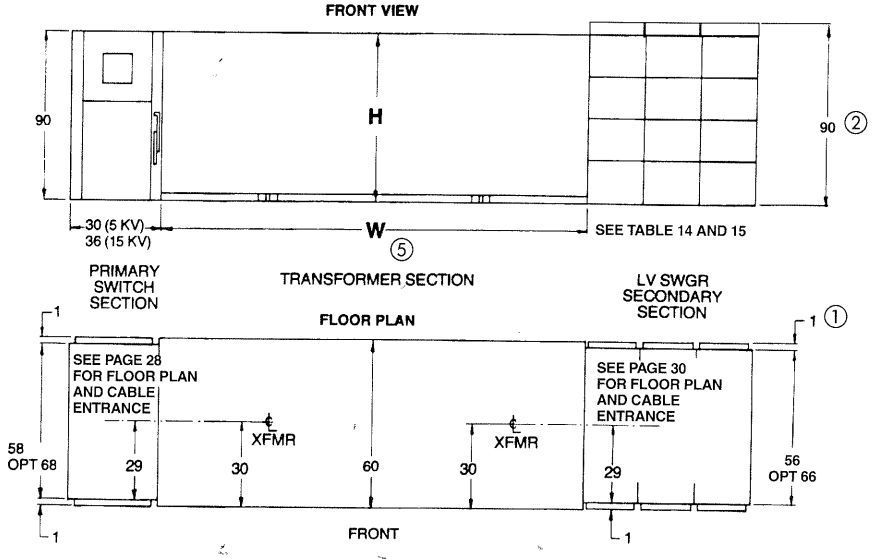
1. Not to exceed width of enclosure tank.
2. For outdoor dimensions see page 29.

Table 12
Primary Device Weights, lbs.

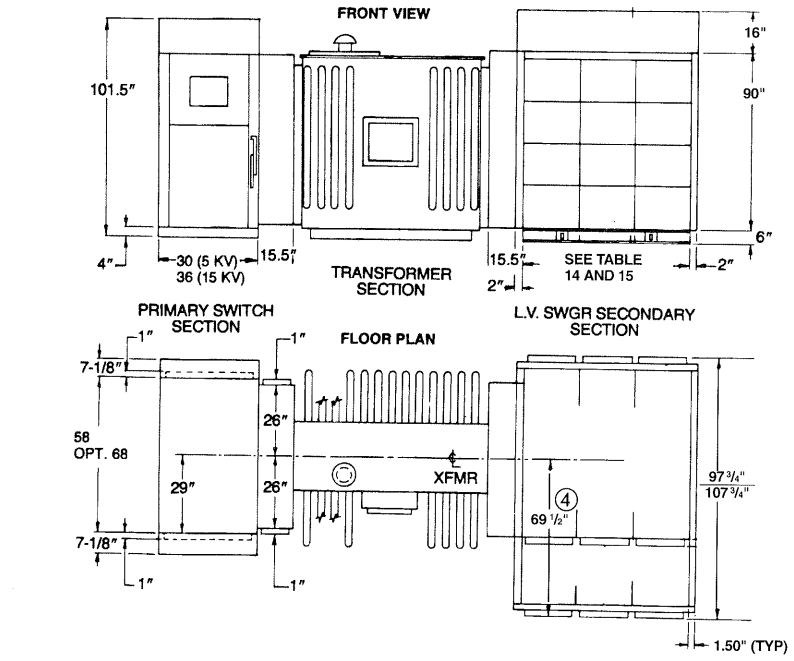
	Indoor	Outdoor
5 & 15kV Unfused Switch	1100	1200
5 & 15kV Unfused Duplex	2250	2450
5 & 15kV Unfused Selector	1300	1400
Set of Fuses (3)	200	200
Air Terminal Chamber	400	400
Transition Unit	425	475

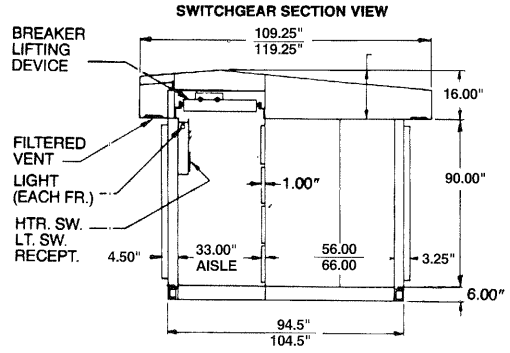
Dimensions are in inches; weights are in pounds. Both are approximate and should not be used for construction.

Dry-Type Transformer③



Liquid-Immersed Transformer③





1. Rear doors are standard.
2. Add 13½" for optional breaker lifting device.
3. Dimensions are in inches; weights are in pounds. Both are approximate and should not be used for construction.
4. 74" without main breaker and with K-DON® feeders.
5. If outdoor, add two 6" transitions.

Table 13
Transformer Section Physical Characteristics[3]

KVA	Width	Height	Weight
Ventilated Dry			
500	78	90	4000
750	78	90	5900
1000	78	90	6000
1500	90	102	8000
2000	90	102	10700
2500	112	102	13000
Cast Coil			
500	84	90	7065
750	90	90	7850
1000	96	90	8740
1500	102	102	11585
2000	108	108	13910
2500	114	114	16890
Oil-Filled –65°C Rise			
500	47	88	4000
750	47	88	4700
1000	48	88	5600
1500	54	88	8000
2000	56	88	8800
2500	60	88	11500
Silicone-Filled –65°C Rise			
500	47	88	4200
750	49	88	5200
1000	51	88	6300
1500	51	88	8700
2000	51	88	9900
2500	51	88	12000

Table 14
Main or Tie Breaker Frames

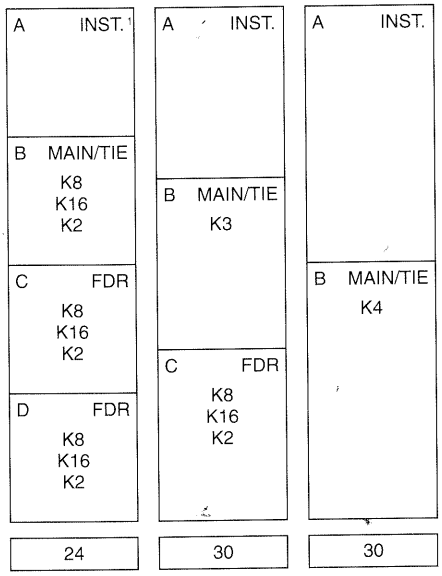


Table 15
Feeder Breaker Frames

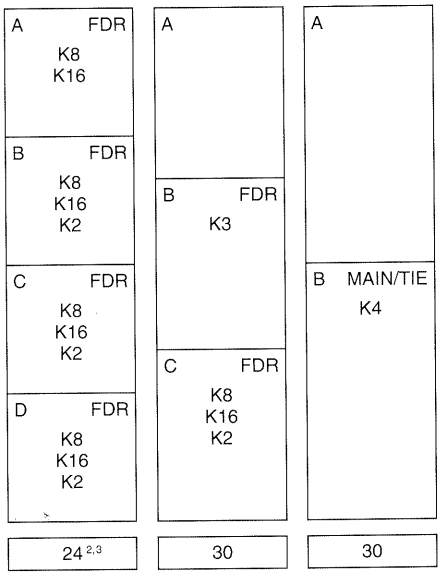


Table 16
Breaker Compartment Height

Frame	Height
4 High	22.5
3 High	30.0
2 High	45.0

Table 17
Power Cable Space

Frame Depth	Breakers	E	
		w/o MBB	w/ MBB
56	K8 to K4	21.0	NA
	K-DON	16.5	NA
66	K8 to K4	31.0	17.5
	K-DON	26.5	13.0

MBB = Main Bus Barrier

1. With tie frame, feeders may be placed in "24" "A" compartment.
2. Only one K2 per 24" wide frame or follow cumulative loading guide of ANSI C37.20.1.
3. 18" wide frame available for special applications — consult factory.

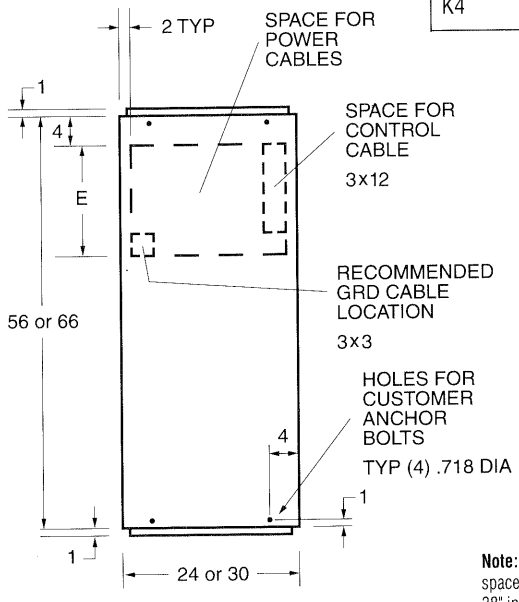
Table 19
Circuit Breaker Weights

Breaker Type	Manual Operation	Electrical Operation
K8	110	130
K16, KE8	185	205
K-DON-8	140	160
K-DON-16	265	285
K2, KE16	205	225
K3	520	550
K4	535	560

Table 18
Low Voltage Switchgear Physical Properties

Type Frame[1]	Frame Width (in.)	Switchgear Depth			
		Indoor		Outdoor	
		58	68	97¾	107¾
K8	24	800	1000	1450	1680
K-DON-8	24	950	1150	1600	1830
K16, KE8, K2, K-DON-16	24	1000	1200	1650	1880
K3	30	1550	1750	2300	2535
K4	30	1600	1800	2350	2585
Auxiliary Frame	24	800	900	1450	1580
(includes bus)	30	900	1000	1650	1785
Main Bus	24	90	90	90	90
Barrier	30	110	110	110	110
End Panel (each)	1½	—	—	500	560
Overhead Lift Device	—	100 per Switchboard			
Terminal Block Pans	—	110	110	110	110
Transition Coupling	15½	400	450	425	475

1. Switchgear only — does not include breakers.



Standard Indoor Floor Plan

Note: Minimum recommended aisle space is 48" in front of switchgear and 38" in rear of switchgear. Suggested aisle space is 54" front and rear.

All dimensions are in inches. All weights are in pounds.

Table 20
Breaker Legend

K8	K-800M
K16	K-1600M
KD8 or K-DON-8	K-DON-800M
KD16 or K-DON-16	K-DON-1600M
KE8	KE-800M (extended rating)
KE16	KE-1600M (extended rating)
K2	K-2000M
K3	K-3000M
K3.2	K-3200M
K4	K-4000M

Table 21
CL-14 Current-Limiting Fuse Ratings (50/60 Hertz) Non-Disconnect Type

		Interrupting			Max. Cont. Current		
Max. Design kV	System kV	Amps RMS Sym.	Amps Asym.	Nom. Equiv. 3-Phase MVA	Single Barrel	Double Barrel	Triple Barrel
5.5	2.4 4.16 4.76	60,000	96,000	250 430 500	10E through 400E	450E	500E and 600E
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	15E through 100E	125E	150E and 200E

Table 22 — Power Fuse Selection[1,2]

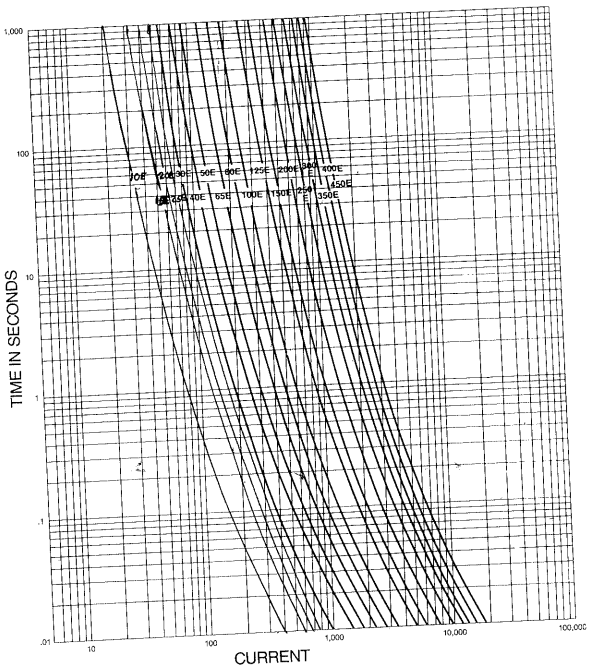
System kV, L-L		2.4		4.16		4.8		6.9		7.2	
Transformer		I	Fuse Size	I	Fuse Size	I	Fuse Size	I	Fuse Size	I	Fuse Size
kVA[3]	Impedance[4]	F.L.	Min. 133% Max.	F.L.	Min. 133% Max.	F.L.	Min. 133% Max.	F.L.	Min. 133% Max.	F.L.	Min. 133% Max.
500	**5.0**	120	150E 200E 200E	69	80E 100E 125E	60	65E 80E 100E	42	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	— — —

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
kVA[3]	Impedance[4]	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.
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 180E 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

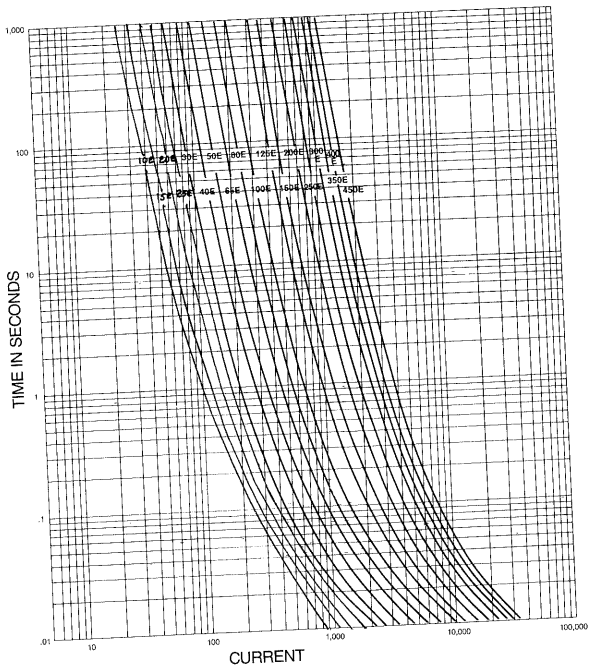
1. Recommended fuse ratings are only guidelines. Actual rating must be selected based on ANSI damage curve and inrush current of the transformer.
2. Minimum fuse size shown will clear transformer magnetizing inrush current. 133% fuse size permits overload operation of transformer up to 133% of rating. 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.
3. 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.
4. Percent impedance on self-cooled kVA base.

CL-14 CURRENT-LIMITING FUSE CURVES

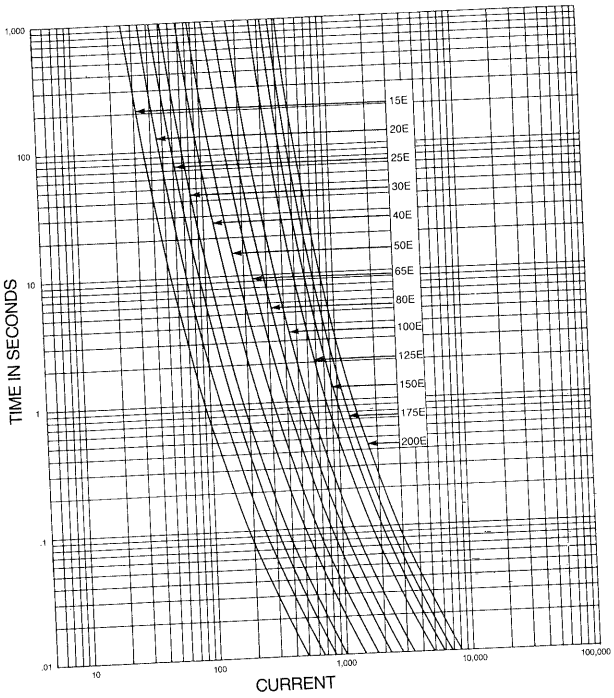
Minimum Melt Time — Current Data — 5.5kV Fused — 10E to 450E



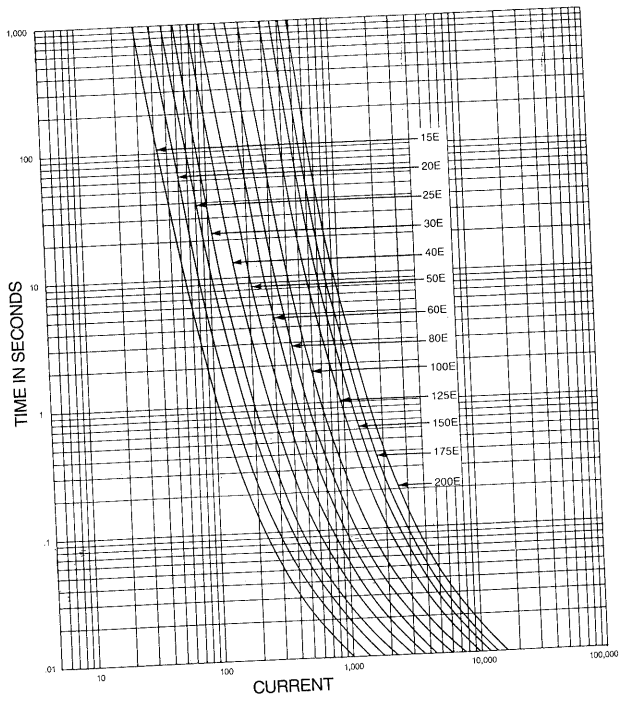
Total Clearing Time — Current Data — 5.5kV Fused — 30E to 450E



Minimum Melt Time — Current Data — 15.5kV Fused — 15E to 200E



Total Clearing Time — Current Data — 15.5kV Fused — 15E to 200E



Curves shown are for estimating only. Contact nearest ABB representative for accurate curves.

Table 23 — Standard Transformer Rating (15 kV and below)

Type	Primary Voltage Delta	kVA 3-Phase Self-Cooled	Fan-Cooled Liquid	Fan-Cooled Ventilated Dry	Fan-Cooled Weather-Resistant Ventilated	Secondary Voltage 208Y/120 240 Delta	480Y/277 480 Delta	2400 Delta 4160Y/2400 4160 Delta	Standard Impedance, Percent
Ventilated Dry 150° Rise and Cast Coil 80°C or 100°C Rise	2400								
	4260	500	—	667	667	X	X	X	5.75
	4800	750	—	1000	1000	X	X	X	5.75
	6900	1000	—	1333	1333	X	X	X	5.75
	7200	1000	—	1333	1333	X	X	X	8.0
	8320	1500	—	2000	2000	X	X	X	5.75
	12000	2000	—	2666	2666	X	X	X	5.75
	13200	2500	—	3333	3333	—			5.75
	12470								
	13800								
Liquid-Immersed 65°C Rise	2400								
	4160	500	—	—	—	X	X	X	5.0
	4800	750	862	—	—	X	X	X	5.75
	6900	1000	1150	—	—	X	X	X	5.75
	7200	1000	1630	—	—	X	X	X	8.0
	12000	1500	1725	—	—	X	X	X	5.75
	12470	2000	2300	—	—	—	X	X	5.75
	13200	2500	3125	—	—	—	X	X	5.75
	13800						X	X	

Standard impedance for units with secondary voltage above 600 V is 5.5%. Standard impedance tolerance is ±7½%.

Table 24 Temperature Guarantees

Transformer Type	Ambient[1]	Rise[2]	Hot Spot Rise
Liquid-Immersed	30°C	65°C	80°C
Ventilated-Dry	30°C	150°C	180°C
Cast Coil Dry	30°C	100°C	130°C

Altitudes must not exceed 3300 feet, otherwise derating is required.

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

Table 25 — Lightning Arresters

kV Rating or 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 2, 3		
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 26 — Dielectric and BIL Rating

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
Ventilated Dry	1.2	4 kV	10 kV	Twice Normal Voltage
	2.5	10 kV	20 kV	
	5.0	12 kV	30 kV	
	8.66	19 kV	45 kV	
	15.0	31 kV	60 kV	
Cast Coil (Standard) Ventilated (Optional)	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	
Liquid-Immersed	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	

Table 27 — Standard High-Voltage Taps (15 kV and below)

−5%	−2½%	Voltage	+2½%	+5%
2280	2340	2400	2460	2520
3950	4055	4160	4260	4360
4560	4680	4800	4920	5040
6555	6730	6900	7070	7245
6840	7020	7200	7380	7560

−5%	−2½%	Voltage	+2½%	+5%
7900	8120	8320	8520	8730
11400	11700	12000	12300	12600
11845	12160	12470	12780	13095
12540	12870	13200	13530	13860
13200	13500	13800	14100	14400

Selection of Breaker Tripping Characteristics

The degree of service continuity provided by a low-voltage distribution system depends on the degree of coordination between circuit breaker tripping characteristics and the load.

Two methods of tripping coordination are in general use. Each represents a different degree of service continuity and initial cost.

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

Non-Selective System

A non-selective system is one in which the main, the tie (if applicable), and the feeder circuit breakers have adequate interrupting capacity for the fault current available at the point of application.

Each circuit breaker is equipped with non-selective long-time delay and instantaneous overcurrent trips. On low-level faults, normally the circuit breaker nearest the fault will open. However, should the fault current exceed the breaker's instantaneous trip setting, even though a circuit breaker nearer to the fault is in the process of tripping, any breaker including the main will trip. Service continuity will be broken.

Selective System

In a selective system, the main, the tie (if applicable), and the feeder circuit breakers each have adequate interrupting capacity for the fault current available at the point of application.

All K-LINE® low-voltage power circuit breakers have a short-time rating and a delayed trip up to a maximum of 30 cycles, with full close, latch and carry capability. These characteristics offer the ultimate in selective application and continuity in modern electrical systems.

In a selective system only the breakers farthest downstream are supplied with instantaneous trip elements. All other upstream breakers are provided with overcurrent trip devices having long-time delay and short-time delay elements.

Coordinated short-time delay is selected in lieu of instantaneous tripping to allow adequate time for the circuit breaker nearest fault to trip. Maximum service continuity is maintained through all other circuit breakers.

Normally the feeder circuit 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 that case, the feeder circuit breakers are equipped with overcurrent trip devices having long-time and short-time delay. Any fault on a feeder circuit would then cause the instantaneous trip on the downstream circuit breaker to operate, while the delayed main and feeder circuit breakers would remain closed due to the selected time delay.

Depending upon application requirements, as many as three short-time delay-equipped circuit breakers could be in series for selective operation.

The selective system offers a maximum of service continuity at a slightly higher initial cost than the non-selective system. For applications where down-time must be minimized or operating costs and problems become prohibitive, the selective system is demanded. There are many factors to consider when selecting the proper low-voltage air-magnetic circuit breaker.

K-LINE Circuit Breaker Selection

After system requirements have been established, four basic factors determine circuit breaker selection.

1. System voltage and frequency
2. Continuous load currents
3. Available fault current (short-circuit, short-time, close and latch)
4. Service conditions

1. System Voltage and Frequency

All K-LINE circuit breakers are designed to operate on AC power systems at the interrupting ratings shown in Tables 30, and 32, which apply at the following maximum voltages:

Maximum Voltage Volts AC, 50/60 Hertz
254,508,635

2. Continuous Current

The rated continuous current is the designated limit in RMS amperes which the circuit breaker will carry continuously, based on an average air temperature inside the enclosure which does not exceed 40°C ambient by more than 15°C. Circuit breakers are maximum-rated devices and can never be applied to carry current in excess of their continuous current rating, including any one- or two-hour overload. Refer to Tables 30, and 32 for K-LINE current ratings.

An important consideration in circuit breaker application is the long-time overcurrent setting associated with the specific tripping device used. All K-LINE circuit breakers use the MICRO PowerShield Type MPS-C trip unit with communication. This device assures full use of the circuit breaker continuous current capability by not actuating the solid-state long-time trip pickup unless 100% of the selected ampere rating is exceeded. Accordingly, greater-than-unity or greater-than-margin settings are not required in order to assure that the circuit breaker will carry 100% of its setting continuously. Application is made simpler and more positive. This assures the users full use of their investment for its intended purpose.

3. Available Fault Current

The rated short-circuit current (interrupting raging) is the highest current in RMS symmetrical amperes at rated maximum voltage which the circuit breaker can interrupt during the operating duty of "open," wait 15 seconds and the "close-open" operation.

These values are shown in Tables 30, and 32. No circuit breaker should be applied in a circuit at any point in which the available short-circuit current is greater than the interrupting capacity of the circuit breaker. K-LINE circuit breakers, which are equipped with either instantaneous trip or short-time elements, may be safely applied up to their full respective interrupting rating. The K-LINE circuit breaker family has minimum short-circuit rating of 22,000 amperes symmetrical,

with the KE designation given to those with extended short-circuit current ratings beyond ANSI Standard ratings. Note the KE-8 and KE-16 frame sizes have a corresponding KE extended rating for broader application.

The rated short-time current of a low-voltage power circuit breaker is the RMS symmetrical current at rated maximum voltage ½ cycle after fault initiation, which the circuit breaker is required to carry for 2 periods of ½-second duration each, with a 15-second interval of zero current between those ½-second periods. See Table 30 for those ratings. The delayed trip rating may be applied. Also, K and KE circuit breakers, equipped with short-time delay, may be safely applied in selective systems where the available fault current does not exceed the delayed trip rating of the circuit breaker.

The delayed trip rating (close, latch, and carry rating) permits the circuit breaker to provide system coordination even as it closes on a fault. The delayed trip test establishes this rating as the highest current in RMS symmetrical amperes at rated maximum voltage which the circuit breaker is required to carry during the operating duty of "open," wait 15 seconds, "close-open" without instantaneous trip elements, and the short-time delay set at maximum time delay.

All K and KE circuit breakers are rated for close, latch, and carry operation and can be safely applied in selective systems where available fault current does not exceed the delayed trip rating of the circuit breaker. See Table 30

4. Service Conditions

The service conditions affecting low-voltage power circuit breaker application include:

Ambient Temperature. Low-voltage power circuit breakers are designed for use within their rating where the outside ambient temperature does not exceed 40°C (104°F).

Altitude. Low-voltage power circuit breakers are for use within their rating where the altitude does not exceed 6,600 feet. When using circuit breakers above this altitude, the dielectric, voltage and current ratings shall be multiplied by the factors in Table 29 to obtain new ratings for the altitude at which the breakers will be applied.

Unusual Service Conditions. Unusual service conditions may require unusual construction or operation, and these should be brought to the attention of those responsible for the application, manufacture and operation of the circuit breaker. Wherever possible, steps should be taken at the site of the installation to nullify the deleterious effects of unusual service conditions. Among such unusual conditions are:

Exposure to damaging fumes or vapor
Exposure to steam
Exposure to salt air
Exposure to oil vapors
Exposure to dripping moisture
Exposure to hot and humid climate
Exposure to extreme temperatures
Exposure to excessive abrasive magnetic or metallic dust
Exposure to abnormal vibration shocks or tilting
Unusual insulation requirements
Unusual configuration of enclosing rooms, causing hot air pockets, rooms not having normal ventilation, or rooms containing large amounts of magnetic material or stray magnetic fields
Unusual operating duty, frequency of operation, or difficulty of maintenance
Operation at unstable control voltages

Operating Conditions

a. Servicing consists of adjusting, cleaning, lubricating, tightening, etc., as recommended by the manufacturer. When current is interrupted, dressing of contacts may be required as well. The operations are listed on the basis of servicing at intervals of six months or less.
b. When closing and opening no-load.
c. With rated control voltage applied.
d. Frequency of operation not to exceed 20 in 10 minutes or 30 in an hour. Rectifiers or other auxiliary devices may further limit the frequency of operation.
e. Servicing at no greater intervals than shown in ANSI C37.16.
f. No functional parts should have been replaced during the listed operations.
g. The circuit breaker should be in a condition to carry its rated continuous current at rated maximum voltage and perform at least one opening operation at rated short-circuit current. After completion of this series of operations, functional part replacement and general servicing may be necessary.
h. When closing and opening current up to the continuous-current rating of the circuit breaker at voltages up to the rated maximum voltage and at 85% power factor or higher for AC circuits.
i. When closing currents up to 600% and opening currents up to 100% (80% power factor or higher) of the continuous-current rating of the circuit breaker at voltages up to the rated maximum voltage. When closing currents up to 600% and opening currents up to 600% (50% power factor or less) of the continuous-current rating of the circuit breaker at voltages up to the rated maximum voltage, the number of operations shown shall be reduced to 10% of the number listed.
j. If a fault operation occurs before the completion of the listed operations, servicing is recommended and possible functional part replacements may be necessary, depending on previous accumulated duty, fault magnitude, and expected future operations.

Table 29
Low-Voltage Power Circuit Breaker Altitude Derating Factors

Altitude (feet)	Voltage	Correction Factor Current	Dielectric
6,600	1.00	1.00	1.00
8,500	.95	.99	.95
13,000	.80	.96	.80

Note: Value for intermediate altitudes may be derived by linear interpolation.

Table 30 — K-LINE® Power Circuit Breaker Ratings

Circuit Breaker Type	Maximum Continuous Current	Symmetrical (RMS) Interrupting Current						Symmetrical Close & Latch and 30-Cycle Short-Time Rating
		240V		480V		600V		
		Instantaneous Trip*	Delayed Trip	Instantaneous Trip*	Delayed Trip	Instantaneous Trip*	Delayed Trip	
K-800M	800	42,000	25,000	42,000[2]	25,000	22,000	22,000	25,000[1]
K-1600M	1,600	65,000	50,000	50,000	50,000	42,000	42,000	50,000[3]
K-2000M	2,000	85,000	55,000	65,000	55,000	55,000	55,000	55,000
K-3000M	3,000	85,000	65,000	65,000	65,000	65,000	65,000	65,000
K-3200M	3,200	85,000	65,000	65,000	65,000	65,000	65,000	65,000
K-4000M	4,000	130,000	85,000	85,000	85,000	85,000	85,000	85,000

1. For 600V, K-800M C&L is 22,000. 2. 42,000 is for grounded wye application. For all other applications, value is 30,000. 3. ST rating for K-1600M at 600V is 42,000.

Table 32 — K-DON® Fused Power Circuit Breaker Ratings

Circuit Breaker Type[1]	Maximum Continuous Current	AC Voltage	Maximum Interrupting Symmetrical Rating RMS Amperes[2]	Amp-Trap™ Continuous Fuse Rating
K-DON-800M	800	up to 600V	200,000	300 – 1,200
K-DON-1600M	1,600	up to 600V	200,000	300 – 2,500

1. Separately mounted drawout fuse carriages are available for breakers above 1600 A with fuse sizes up to 6,000 A. 2. Ratings are instantaneous

Table 33 — 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	Recommended Control Circuit Fuse Size, A
				Anti-Pump	Release			
K-800M	120 V_{AC}	10	6.5	.15	.15	104 – 127	50 – 127	10
K-1600M	240 V_{AC}	5	1.15	.075	.75	208 – 254	208 – 254	10
K-DON-800M	48 V_{DC}	25	3.14	.11	1.33	38 – 56	28 – 56	15
K-DON-1600M	125 V_{DC}	10	1.3	.06	.7	100 – 140	70 – 140	10
K-DON-800M	250 V_{DC}	5	.65	.03	.3	200 – 280	140 – 280	10
K-DON-1600M								
K-3000M and	120 V_{AC}	10	10.0	.15	4.0	104 – 127	50 – 127	10
K-4000M	240 V_{AC}	5	1.84	.075	1.84	208 – 254	208 – 254	10
	48 V_{DC}	25	5.0	.11	5.0	38 – 56	28 – 56	15
	125 V_{DC}	10	2.0	.06	2.0	100 – 140	70 – 140	10
	250 V_{DC}	5	1.0	.03	1.0	200 – 280	140 – 280	10

Table 34 — Breaker 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	28	75
250 V_{DC}	0.10	212	75	150

Circuit Breaker Selection

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

1. Determine the system short-circuit capacity in symmetrical RMS amps.
2. Determine from Table 35, columns 3, 4 and 5, respectively, the approximate continuous current rating and the time-delay and instantaneous overcurrent trip settings.
3. Select from Table 35, columns 1, 2, 3 and 4, respectively, the frame size, trip system rating, time-delay and instantaneous settings as follows: (a) When there is a choice of breaker frame size the larger will provide maximum flexibility in case of load growth. (b) The trip system rating should be equal to or greater than the value determined in Table 35, column 3. (c) Time-delay setting should be set at a value nearest to that determined in Table 35, column 4. (d) Instantaneous setting should be set at a value nearest to that determined in Table 35, column 5. However, this value may have to be adjusted downward to coordinate with Amp-Trap to be selected in step (b).

Amp-Trap™ Selection

Table 36 is to be used for selecting the correct fuse sizes to coordinate the instantaneous and long-time settings of the electronic trip device to provide proper coordination between the circuit breaker and the fuse. It was developed to provide the greatest range of coordination possible, taking advantage of maximum fuse sizes whose let-through current can be withstood by the circuit breaker. Refer to Figure 3 for typical breaker Amp-Trap coordination curve.

Figure 1 is a second aid in the selection of the proper Amp-Trap fuse sizes. However, Figure 1 is not to be used as the only criterion if, as in this case of molded-case circuit breakers, there is an I^2t limitation in the equipment to be protected by the fuse. (See Figure 2.)

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

1. The peak let-through current must not exceed the withstand capability of the equipment to be protected by the MBD circuit breaker. (a) If the equipment protected by the circuit breaker has a peak current withstand capability at least equal to that of the circuit breaker, fuse size selection may be made by using Table 36. (b) If the equipment protected by the circuit breaker has a peak current withstand capacity less than the circuit breaker, Figure 1 must be used to determine the maximum fuse size.

Draw a vertical line on Figure 1 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-through 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.

Table 35 — K-LINE® Circuit Breaker Application

Type of Application	Purpose of Circuit Breaker	Continuous Current Rating of Circuit Breaker	Recommended Settings of Overcurrent Trip Device	
			Time Delay	Instantaneous
Service entrance (general)	• Protect source transformer windings from overheating, due to overload of fault current flow. • Protect circuit conductors from effects of overcurrent flow. • 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	700%
Service feeder (general)	• Protect circuit conductors from effects of overcurrent flow. • Protect connected electrical equipment from effects of fault current flow.	Based upon 115% of estimated load current	115% of est. load current	700%
Individual motor circuit	• Protect motor windings from overheating due to overcurrent or fault current flow. • To protect circuit conductors and other connected electrical equipment from overload or fault current flow. • 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	1200%
Group motor circuit	• Protect circuit conductors from overheating. • Protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. • 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	1200%
Combined motor and lighting	• Protect circuit conductors from overheating. • Protect circuit conductors, motor windings and other connected electrical equipment from fault current flow. • 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	1200%
Lighting circuit	• Protect circuit conductors from effects of overload or fault current flow. • 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	700%

Note: Low-voltage power circuit breakers are tested for interruption in a circuit having a power factor of 0.15. This means that the peak short circuit current will equal 2.3 times the circuit breaker RMS symmetrical short-circuit rating. Other 600 V equipment, such as a molded-case circuit breaker, is tested using a higher power factor and, therefore, is proven to withstand a peak current of less than 2.3 times its RMS symmetrical rating.

2. The second consideration is that the fuse size coordinates with the circuit breaker solid-state trip device time-current characteristic. Proper application of Table 36 and its associated notes will assure coordination and, therefore, avoid needless fuse replacements for current levels within the interrupting rating of the breaker.

For applications 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 solid-state trip device time-current curves is in multiples of the range selector amperes and pickup setting. There are so many combinations of settings as to render it completely impractical to publish general coordination curves for fuses and solid-state 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 range selector amperes and pickup 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 2 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.

When fused circuit breakers are used on high-inrush circuits such as for motor starting, for extended periods, the maximum allowable fuse size from Table 36 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 replacements should be considered if the coordination is critical.

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 Type AL. The two-times ratio is applied to fuse ratings up to 2,000 A, but for fuse ratings of 2,500 A to 6,000 A the ratio may be reduced to 1.5 times.

To illustrate the use of Figure 2, assume a fault current of 80,000 A symmetrical using a 300 A current-limiting fuse. Enter the table at 80,000 A sym. and project to the intersection of this line with the curve for the 300 A fuse, then project this point horizontally to a value of 30,000 peak let-through amps.

K-DON-1600M — 115,000 peak
K-DON-800M — 150,000 peak

Table 36 — MPS Trip Device Amp-Trap Fuses

Circuit Breaker Type	Trip System Rating Amps	Range Selector Amps	Long-Time Setting X Range Selector	Instantaneous Pickup Setting X Range Selector	Coordinating Fuse Sizes (see notes) Min Amps	Coordinating Fuse Sizes (see notes) Max Amps
1	2	3	4	5	6	7
K-DON-800M	200	100	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	3, 4, 5, 7, 12	300	1200
		200	0.5, 0.6, 0.7, 0.8, 0.9	3, 4, 5, 7	300	1200
		200	0.5, 0.6, 0.7, 0.8, 0.9	12	400	1200
		200	1.0	3, 4, 5, 7	400	1200
		200	1.0	12	600	1200
	800	400	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	3, 4, 5, 7	600	1200
		400	0.5, 0.6, 0.7, 0.8, 0.9	12	800	1200
	400	1.0	12	1000	1200	
		800	0.5, 0.6, 0.7	3, 4, 5, 7	1000	1200
		800	0.8, 0.9, 1.0	3, 4, 5, 7	1200	1200
		800	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	12	1200	1200
K-DON-1600M	800	400	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	3, 4, 5, 7	600	2500
		400	0.5, 0.6, 0.7, 0.8, 0.9	12	800	2500
		400	1.0	12	1000	2500
		800	0.5, 0.6, 0.7	3, 4, 5, 7	1000	2500
		800	0.8, 0.9, 1.0	3, 4, 5, 7	1200	2500
		800	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	12	1600	2500
	1600	800	0.5, 0.6, 0.7	3, 4, 5, 7	1000	2500
		800	0.8, 0.9, 1.0	3, 4, 5, 7	1200	2500
		800	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	12	1600	2500
		1600	0.5, 0.6, 0.7, 0.8	3, 4, 5, 7	2000	2500
		1600	0.9, 1.0	3, 4, 5, 7	2500	2500
		1600	0.5, 0.6, 0.7, 0.8, 0.9, 1.0	12	2500	2500

1. When the selected settings and indicated fuse size will not coordinate, the following applies:
   a. Determine the degree of overlap by drawing a breaker-fuse coordination curve.
   b. If the degree of overlap is not deemed critical (low-probability needless fuse blowing), accept the overlap.
   c. If the degree of overlap is deemed critical, utilize a short-time delay element in conjunction with the long-time and instantaneous elements to achieve coordination.
2. The coordinating fuse size is based on the range selector setting. If a higher setting is planned for future load growth, the maximum fuse size for the trip system range should be used to maintain proper coordination.

   The maximum fuse size in the table protects the circuit breaker with 200 kA RMS symmetrical current available.

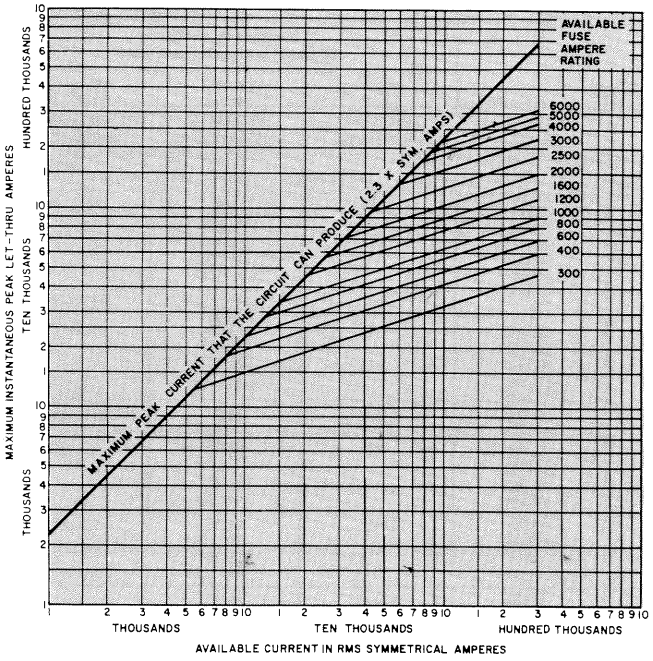


Figure 1
Amp Trap Let-Through Curves

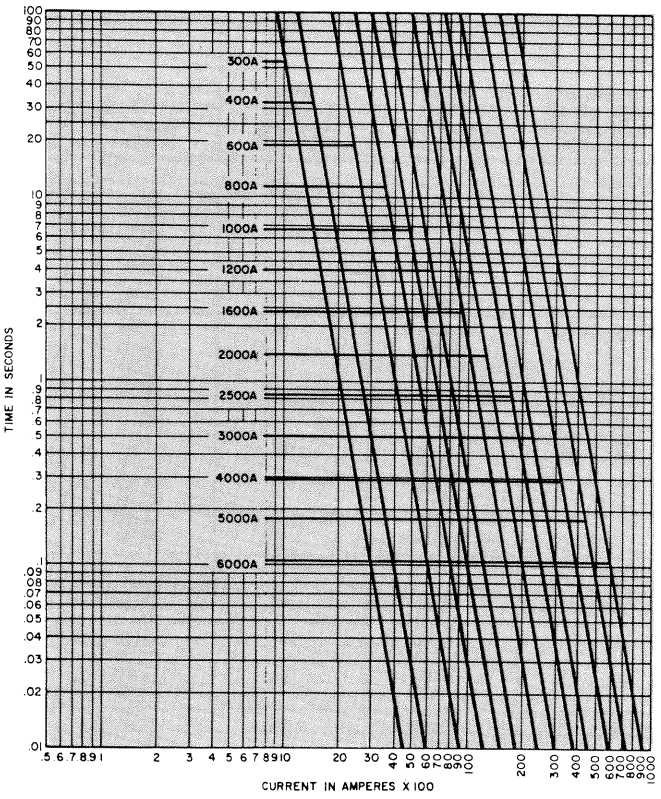


Figure 2
Melting Time-Current Characteristic Curves

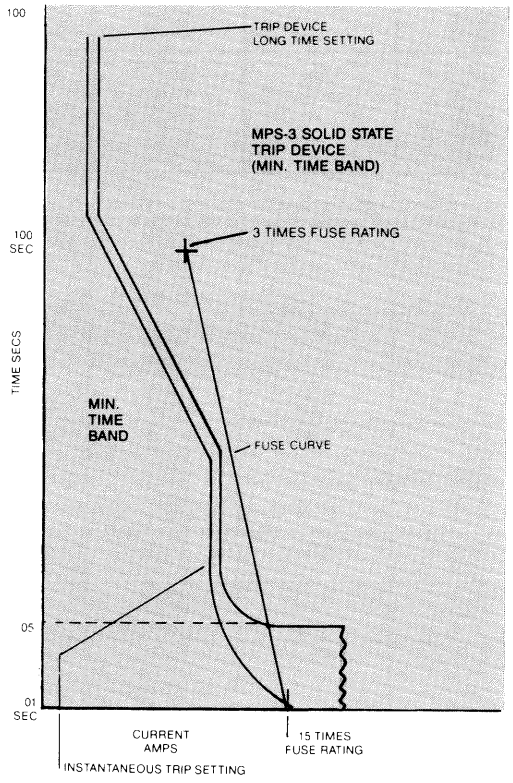


Figure 3
Typical Breaker Amp-Trap Coordination Curve

Table 37 — K-LINE® Low-Voltage Power Circuit Breaker Application

Transformer Rating 3-Phase kVA and Impedance Percent	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[1]	I	S
			Transformer Alone	Motor Load[2]	Combined	Main Breaker	Feeder with Instantaneous Trip	Feeder with Selective Trip
208 Volts								
500, 5.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,388	23,120 25,200 26,000 26,640 27,200 27,760	2,500	25,920 25,000 28,800 29,440 30,000 30,560	K16	K8	KE8 or K16
750, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2,080	28,640 32,000 33,360 34,440 35,280 36,170	4,200	32,840 36,200 37,560 38,600 39,480 40,370	K3	K8	K8 or K16
1,000, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2,780	35,840 41,120 43,360 45,200 46,720 48,350	5,800	41,440 46,720 48,960 50,300 52,320 53,950	K3	K8 K16	K16 K2
240 Volts								
500, 5.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,203	20,080 21,840 22,560 23,120 23,600 24,060	4,800	24,880 26,640 27,360 27,920 28,400 28,860	K16	K8	K16
750, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,804	24,960 27,760 28,880 29,920 30,640 31,380	7,200	32,160 34,960 36,080 37,120 37,840 38,580	K2	K8	K16
1,000, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2,406	31,120 35,680 37,520 39,120 41,360 41,840	9,600	40,720 45,280 47,120 48,720 50,960 51,443	K3	K8 or K16	K16

1. 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.
2. Motor load contribution for 208V is based on 50%. 240V application table is based on 100% motor load contribution.
3. These circuit breakers are applied at less than 25% above transformer full-load rating. If 25% is required, use the next larger size.
4. K8 applies only if circuit is grounded WYE. Otherwise use next higher rated breaker.

Table 37 (continued)

Transformer Rating 3-Phase kVA and Impedance Percent	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[1]	I	S
			Transformer Alone	Motor Load[2]	Combined	Main Breaker	Feeder with Instantaneous Trip	Feeder with Selective Trip
480 Volts								
500, 5.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	601	10,000 10,960 11,280 11,600 11,840 12,020	2,400	12,400 13,360 13,680 14,000 14,240 14,420	K8	K8	K8
750, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	902	12,400 13,840 14,480 14,960 15,360 15,690	3,600	16,000 17,440 18,080 18,560 18,980 19,290	K16	K8	K8
1,000, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,203	15,600 17,920 18,800 19,600 20,240 20,920	4,800	20,400 22,720 23,600 24,400 25,040 25,720	K16	K8	K8 KE8 or K16
1,000, 8.0%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,203	12,030 13,350 13,980 14,315 14,555 15,040	4,800	16,830 18,150 18,750 19,115 19,355 19,840	K16	K8	K8
1,500, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,804	20,640 24,960 26,800 28,480 29,840 31,370	7,200	27,840 32,160 34,000 35,680 37,040 38,570	K2[3]	K8[4]	KE8 or K16
2,000, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2,460	24,720 30,560 34,080 36,730 38,960 41,840	9,600	34,320 40,160 43,680 46,320 48,560 51,440	K3	K8[4] KE16 KE16 or K2	K16 KE16 or K2
2,500, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	3,010	27,900 36,300 40,400 44,500 48,100 52,350	12,000	39,900 48,300 52,400 56,500 62,100 64,350	K3.2[3]	K8 KE8 or K16 KE16 or K2	KE8 or K16 KE16 or K2
600 Volts								
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	1,900	9,920 10,640 10,920 11,150 11,330 11,520	K8	K8	K8
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	2,900	12,860 14,010 14,450 14,830 15,140 15,460	K8[3]	K8	K8
1,000, 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	3,800	16,210 18,050 18,780 19,440 19,970 20,530	K16	K8	K8
1,500, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,444	16,500 19,920 21,390 22,740 23,870 25,110	5,800	22,300 25,720 27,190 28,540 29,670 30,910	K16[3]	KE8 or K16	KE8 or K16
2,000, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	1,924	19,730 24,830 27,180 29,370 31,280 33,630	7,700	27,430 32,530 34,880 37,070 38,980 41,330	K2[3]	KE8 or K16	KE8 or K16
2,500, 5.75%	50,000 100,000 150,000 250,000 500,000 Unlimited	2,406	22,380 29,160 32,430 35,640 38,500 41,840	9,600	31,980 38,760 42,030 45,240 48,100 51,440	K3	KE8 or K16 KE16 or K2	KE8 or K16 KE16 or K2

Note

Red type denotes choice of alternates, or specific information to be added by the specification writer.

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 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) ..... ____ V

Primary Incoming Line Section

Air Interrupter Switch(es)

(2-position — On-Off)
(3-position — Line 1-Off-Line 2)
(Fused) (Unfused)

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

[ ] 3-pole 2-position gang-operated load-interrupter switch, Versa-Switch™ type, rated 600 A, ____ kV, interrupting capacity 600 A.
[ ] 3-pole 2-position selector switch, interlocked and in series with the air interrupter switch.
[ ] Power fuses, current-limiting type CS, ____ kV, ____ A 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) to be provided with ____ fitting for cables with the following specifications: ____ kV, size ____ OD over insulation, ____ OD conductor, ____ OD 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) to be provided with ____ fitting for cables with the following specifications: ____ kV, size ____ OD over insulation, ____ OD conductor, ____ OD overall.

Metal-Clad Switchgear

[ ] Metal-Clad switchgear unit.
[ ] (4.16) (7.2) (13.8) kV air circuit breaker, ____ A, 3-pole, electrically-operated, stored-energy. Control voltage requirements shall be ____ V.
[ ] Set of insulated main bus, ____ A.
[ ] 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, 0-____ scale.
[ ] Voltmeter transfer switch.
[ ] Drawout potential transformer, ____/120 V 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) to be provided with ____ fitting for cables with the following specifications: ____ kV, size ____ OD over insulation, ____ OD conductor, ____ OD overall.

Transformer Section

Ventilated-Dry Type (AA) (AA/FA)

Transformer shall be a (standard) ventilated-dry type (VPI) (VPE), constructed for installation in dust-free and moisture-free area, 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 a 30°C average, 40°C maximum ambient. Rated ____ kVA with a primary of ____ kV (delta) (wye), ____ kV BIL* and a secondary of ____ V. Four approximately 2½% full-capacity taps in the high-voltage winding, two above and two below normal, brought out through studs, complete with bolted flexible links for de-energized tap changing, made accessible through removable panels on the transformer enclosure. Transformer is to have standard impedance per NEMA 210 (or special impedance of ____%).

Transformer base is to be designed and fabricated to permit using rollers or skidding in any direction. Transformers to be factory tested as prescribed by ANSI and NEMA standards.

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

Cast Coil Type (AA) (AA/FA)

Transformer shall be a cast coil ventilated dry-type, three-phase, 60 Hertz (self-cooled) (forced air-cooled) with a temperature rating not to exceed a (80°C) (100°C) rise above a 30°C average, 40°C maximum ambient. Rated ____ kVA with a primary of ____ kV (delta) (wye), ____ kV BIL* and a secondary of ____ V (delta) (wye) BIL*. Four approximately 2½% full-capacity taps in the high-voltage winding, two above and two below normal, brought out through bolts, complete with bolted flexible links for de-energized tap changing, made accessible through removable panels on the transformer enclosure. Transformer is to have standard impedance per ANSI C57.12.01 (or special impedance of ____%).

Primary and secondary shall be wound as separate windings, coaxially mounted. HV windings are to be disc-wound and vacuum-cast in a mold in epoxy. LV windings shall be wound with sheet conductor

*For BIL levels of coils, refer to Table 26.

and (vacuum-cast in a mold) (cast with epoxy by DyNiCast Construction without vacuum).

Transformer enclosure shall be for (indoor) (outdoor) installation. Base to be designed and fabricated to permit using rollers or skidding in any direction. Transformers to be tested as prescribed by ANSI standards.

(Necessary winding temperature equipment for control of fans shall be provided to permit operation at ____% of AA rating.) or (Provision for future forced-air cooling shall be provided.)

Liquid-Immersed Type

(Oil) (Silicone Liquid) (WEMCO® NF) (OA) (OA/FA)

Transformer shall be (Oil) (Silicone Liquid) (WEMCO NF)-insulated 3-phase, 60 Hertz (self-cooled) (forced air-cooled) with a temperature rating not to exceed a 65°C rise above a 30°C average ambient. Rated ____kVA with delta primary of ____kV and a secondary of ____V (delta) (wye). Four approximately 2½% full-capacity taps in the high-voltage winding, two above and two below normal, brought out to an externally operated de-energized 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 any direction. Transformer to be factory tested as prescribed by ANSI and NEMA standards. All NEMA standard accessories are to be provided.

Secondary Outgoing Section

Switchgear shall consist of one metal-enclosed (indoor) (outdoor) assembly, drawout type, rated 635 VAC and arranged for ____V 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 (ANSI C37.20 for the assembly and C37.13, C37.16, C37.17 and C37.50 for the power circuit breakers).

Switchgear (Indoor) (Outdoor)

Switchgear shall consist of sufficient vertical frames to house the number of 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 conpletely isolated from adjacent compartment by steel panels. All surfaces shall be phosphate-treated and painted with an oven-baked corrosion-resistant enamel finish. Color of finish shall be light gray, ANSI No. 61.

Switchgear (Outdoor Only)

Switchgear shall be of the walk-in outdoor type with gasketing. 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. The color of the finish coat shall be light gray, ANSI No. 61.

Bus

A main bus shall extend through all frames of the switchgear, with connections to the circuit breakers in each individual compartment. All bus shall be silver-plated copper. 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 65,000 A symmetrical, minimum size main bus to be 1,600 A continuous.

Disconnecting Devices and 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.

Circuit Breakers

Air circuit breakers shall be 3-pole, equipped with a solid-state overcurrent tripping device providing adjustable long-time overcurrent and (short-time) and/or (instantaneous) short-circuit protection (with) (without) ground protection. All (manually) (electrically) operated breakers shall be equipped with (manually) (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.

The following shall be supplied:

____ main secondary breakers with
- ____ A maximum continuous current
- ____ A interrupting capacity at ___ VAC (manually) (electrically) operated

____ tie breaker(s) with
- ____ A maximum continuous current
- ____ A interrupting capacity at ___ VAC (manually) (electrically) operated

____ feeder breaker(s) with
- ____ A maximum continuous current
- ____ A interrupting capacity at ___ VAC (manually) (electrically) operated

____ feeder breaker(s) with
- ____ A maximum continuous current
- ____ A interrupting capacity at ___ VAC (manually) (electrically) operated

____ space(s) for future breaker(s) with
- ____ A maximum continuous current
- ____ A interrupting capacity at ___ VAC (manually) (electrically) operated

____ control-power transformer(s) for electrically operated breaker(s)

Transformer Secondary Metering

____ voltmeter(s), with 3-phase transfer switch
____ ammeter(s), with 3-phase transfer switch
____ watt-hour meter(s) (2) (3)-element (with) (without) demand attachment, ____/5 or suitable rating
____ potential transformer(s) of suitable ratings

Feeder Metering

____ ammeter(s), with 3-phase transfer switch
____ watt-hour meter(s) (2) (3)-element
____ current transformer(s), ____/5 or suitable rating

Bus Duct — Switchgear Tie

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

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