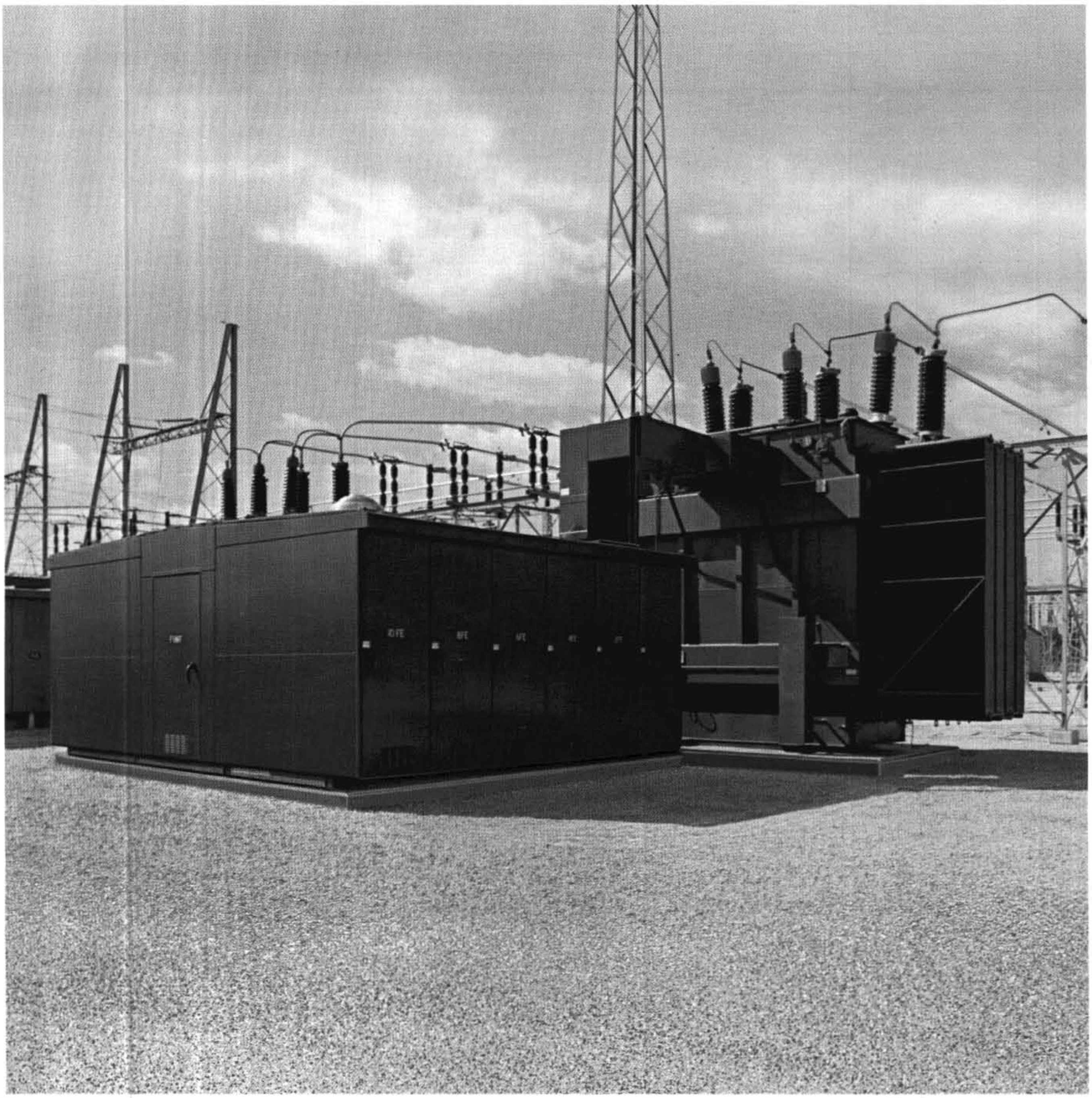
BBC
BROWN BOVERI

I-T-E Type HK
Metal-Clad Switchgear

4.16 kV 75 thru 350 MVA
7.2 and 13.8 kV 500 thru 1000 MVA
1200 thru 3000 Amperes

Bulletin 3.2.1-1B

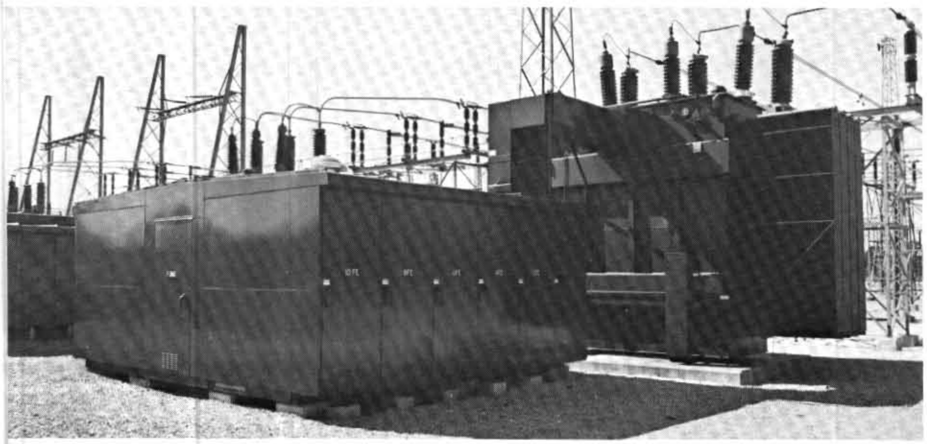


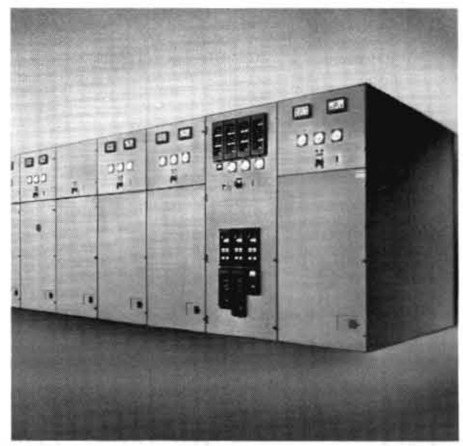
Brown Boveri Electric

I-T-E Air-Magnetic Metal-Clad Switchgear designed for safety and reliability

- Stored-energy closing
- Closed-door horizontal drawout
- Safe, positive interlocking
- Coordinated insulation system for each voltage class
- Simplified maintenance
- Most compact Switchgear in many ratings
- All parts easily accessible

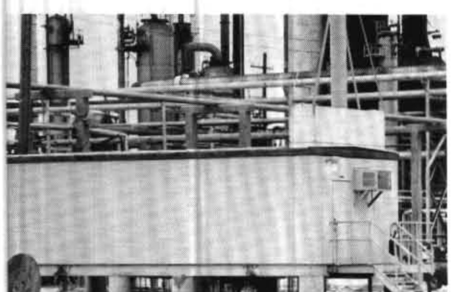
Full symmetrical interrupting ratings throughout the line





With I-T-E Metal-clad switchgear you get full nameplate symmetrical MVA interrupting capability on every circuit breaker. Our program of design, qualification and quality control testing is the most complete in the industry. See pages 42 to 44 for complete rating information.

I-T-E Power Distribution Centers



I-T-E Metal-clad switchgear is available in completely integrated, pre-packaged climatized distribution centers. Power Distribution Centers are pre-wired and pre-tested in self-contained enclosures permitting fast installation and reducing construction costs.

Index

Two basic voltage classes of HK Switchgear

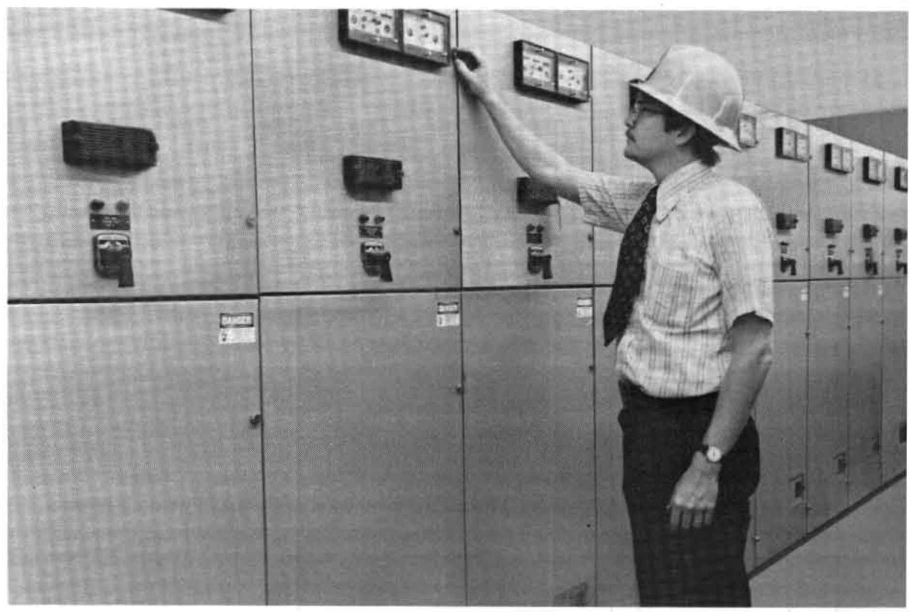
4.16 kV and 13.8 kV, available in both indoor and outdoor construction.

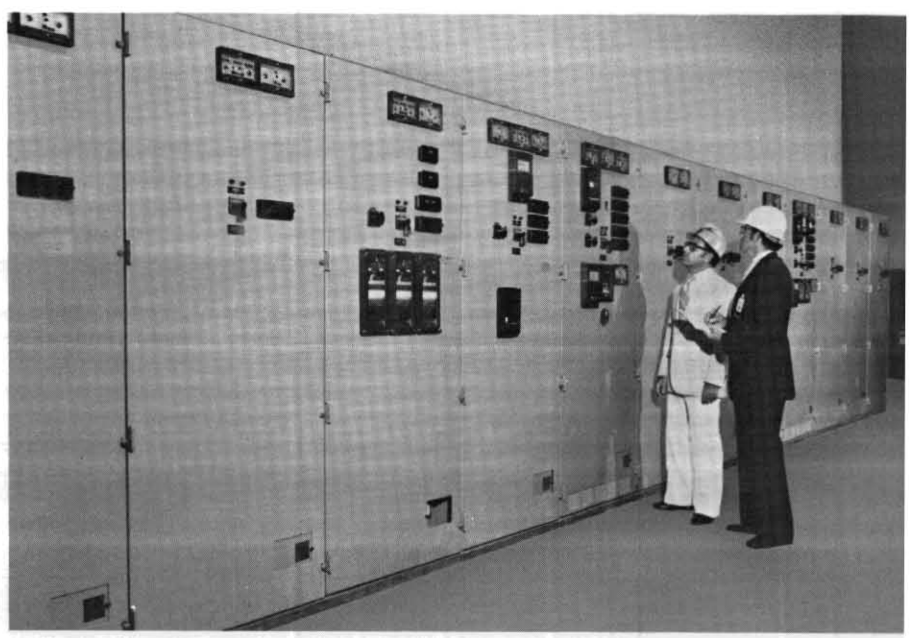
Space-saving compactness

Space-saving compactness is the first thing you notice in this I-T-E Metal-Clad Switchgear. One standard cubicle size in each class saves space and simplifies layout. It also permits complete allocation of space for future frame additions. You may even substitute some higher-rated breakers in existing cubicles.

I-T-E switchgear makes it possible to save space in every installation. Standard frames are designed to house auxiliary equipment—potential transformers—lightning arresters—and bus tie transitions. Information on pag27 and 31 show preferred location of auxiliary equipment.

You can install this equipment in many locations where other switchgear won't fit.





Additional features of Metal-Clad Switchgear

Economy and Convenience:

- Completely engineered product.
- Standardized construction.
- Ease of match and line-up.
- Arc extinction in air (vacuum optional for 15kV).
- Standardized ratings.
- Complete line of solid state relays.
- Integrally-mounted ground sensors.

Safety and Ease of Maintenance:

- Segregated compartmentation.
- Drawout potential transformers or stationary control power transformers with drawout primary fuses.
- Main bus accessible from either front or rear of switchgear
- Bus sectionalizing through a tie breaker.
- Safe manual closing of stored energy breaker.

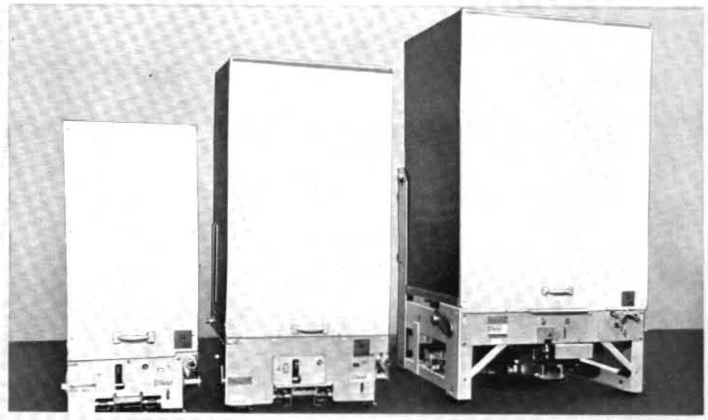
Service Continuity:

- Re-usable interrupting device.
- Self-contained operating mechanism.
- Multiple-shot reclosing.
- Automatic transfers for multiple-source systems.
- Limiting of damage to a single compartment.
- Bus differential protection minimizes bus fault downtime.
- Stored-energy breakers permit faster transfer of banks of feeders.
- Three-phase interruption—no single phasing.
- Speed and positive action for bringing a synchronized generator on the system.

Complete line of high-voltage air-magnetic power circuit breakers

Compact breaker design

The compact design of I-T-E HK air-magnetic power circuit breaker makes optimum use of space. Because of the use of modern materials throughout, you get a breaker with superior interrupting and dielectric performance in a compact size.



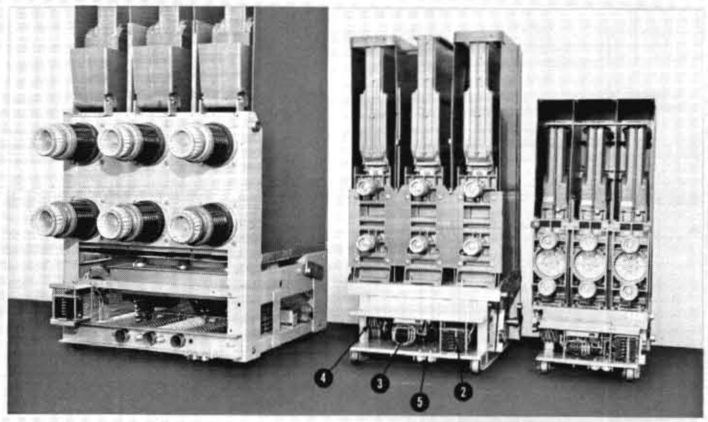
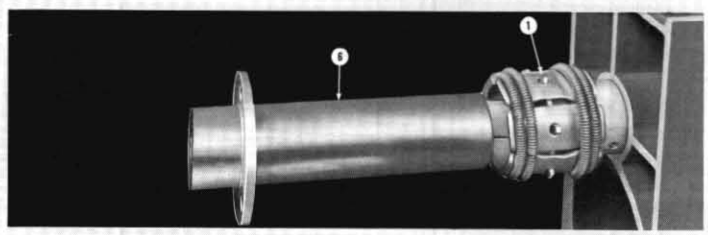


Table 1

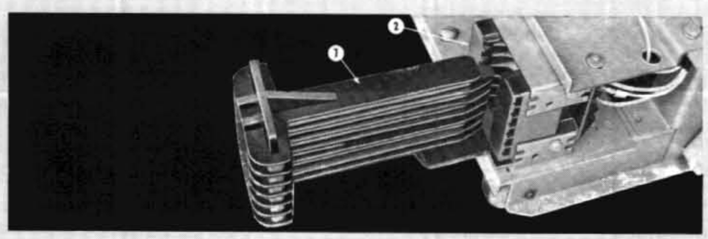
Type	Continuous Current, A	Interrupting Capacity
5 HK 75	1200	75 MVA
5 HK 250	1200 2000	250 MVA
5 HK 350	1200 2000 3000	350 MVA
7.5 HK 500	1200 2000	500 MVA
15 HK 500	1200 2000	500 MVA
15 HK 750	1200 2000	750 MVA
15 HK 1000	1200 2000 3000	1000 MVA

Primary contacts

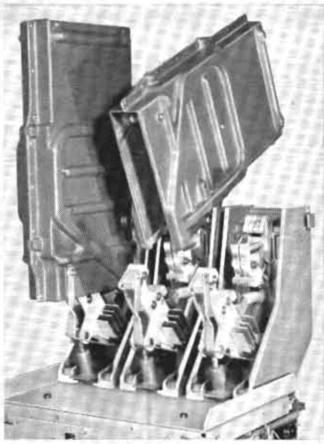


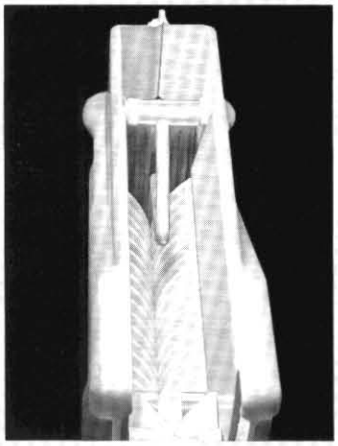
The self-aligning disconnects (1) are located on the circuit breaker for complete accessibility. Conservatively designed lock-wound, stainless steel multiple springs insure good high-pressure contact with the stationary primary disconnects (6) located in the switchgear.

Secondary contacts



The self-aligning, secondary contacts (2) automatically mate with contacts (7) in the circuit-breaker compartment while in test and connected positions. Note that the secondary contacts automatically disconnect when the circuit breaker is withdrawn to the disconnect position. The control relay (3) and four-stage auxiliary switch (4) are mounted on the readily-accessible rear

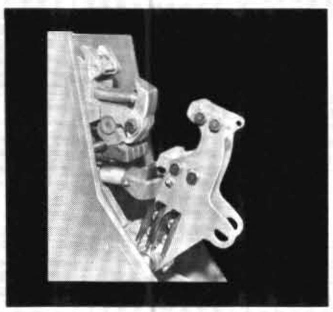


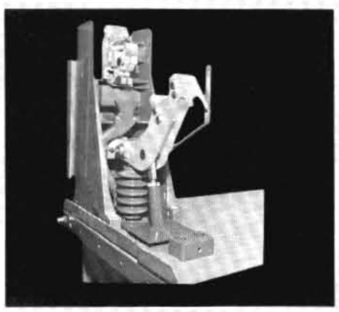


Tilting arc chutes

Contact and arc chute inspection on most HK breakers is simplified with light weight, easily titled, removable arc chutes. The three separate arc chute shells and primary lead supports are made of high-impulse strength, flame-retardant, polyester-glass moldings. Also, note the polyester-glass "chair" moldings for individual pole pieces which are supplied on HK breakers through 750 MVA.

Superior arc interruption





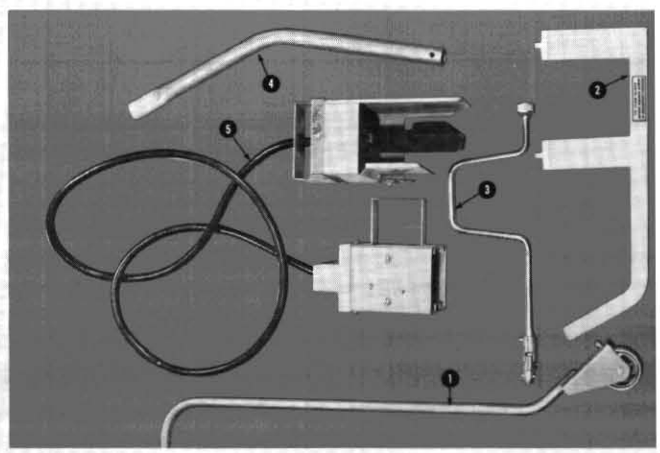
Full interrupting time of any HK breaker is uniformly less than 5 cycles. The jump gap immediately transfers the current into face-wound blowout coils that provide a high-density magnetic field. This magnetic field forces the arc up into arc plates of special ceramic material with high-mechanical and heat-shock characteristics. The action is quick and uniform, speeding arc extinction, while extending arc chute life. Low-current arcs are driven up into the chute by long life, high-capacity puffers, that also cushion contact opening and prevent contact bounce.

Special high-refractory, low-resistance silver-alloy contact surfaces coupled with 5-cycle interrupting time and high speed stored-energy closing guarantees minimum deterioration from arcing. Abundant wiping action keeps all contact surfaces clean. Simple contact and wipe adjustment is made by a screw in the pushrod.

Easy handling

No special lift devices are required to remove the breaker. The low center of gravity HK circuit breaker rolls quickly and ea The handy fifth wheel steering bar permits maneuvering even in tight quarters. Entrance of the breaker into the compartment, ev from an angle, is facilitated by full length guide rails. For extra operator safety, there is a grounded barrier on the front of the breaker for protection even when the compartment door is open.

Standard breaker accessories



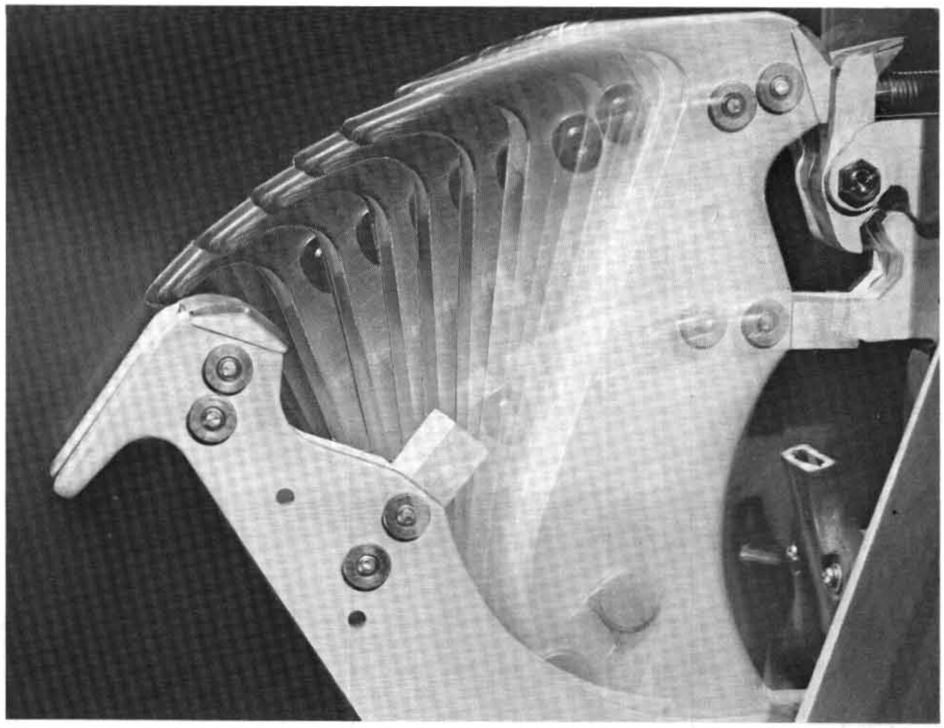
The following accessories are supplied as standard for all bre except as noted:

Fifth wheel (1)
Slow-close bar (2)
Racking crank assembly (3)
Manual charging handl
Test jack and plug (5)
Breaker lifting yoke

Arc chute tilting support (7.5 and 15HK breakers)
Arc chute lifting plates (5HK 350, 7.5 and 15HK breakers)
Ramps for outdoor, non walk-in switchgear

Stored-Energy Closing

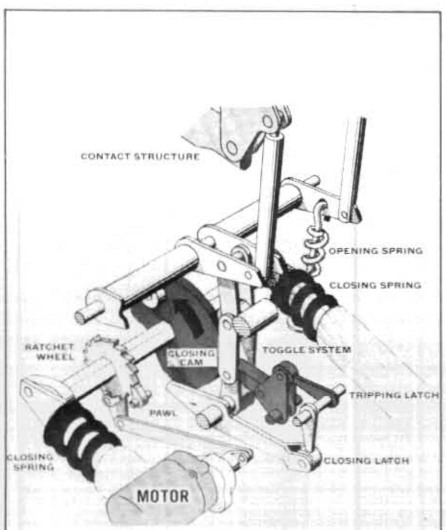
I-T-E air-magnetic circuit breakers and metal-clad switchgear were the first to offer spring-powered stored-energy closing as an integral design



Stored-energy closing insures operator safety and greatly increases contact life. Regardless of the external power source, it provides faster, uniform closing every time even against full momentary rating. Powerful compression springs store the closing energy until needed.

You can even store energy in the springs manually to close the breaker when control power is not present. This means extra dependability of control over your circuits.

There's an economy advantage in stored-energy closing too. The spring charging motor draws only about one-tenth the current of solenoids. So you can get along with a proportionately smaller battery, control power transformer or use an ordinary lighting circuit.



Main and arcing contacts

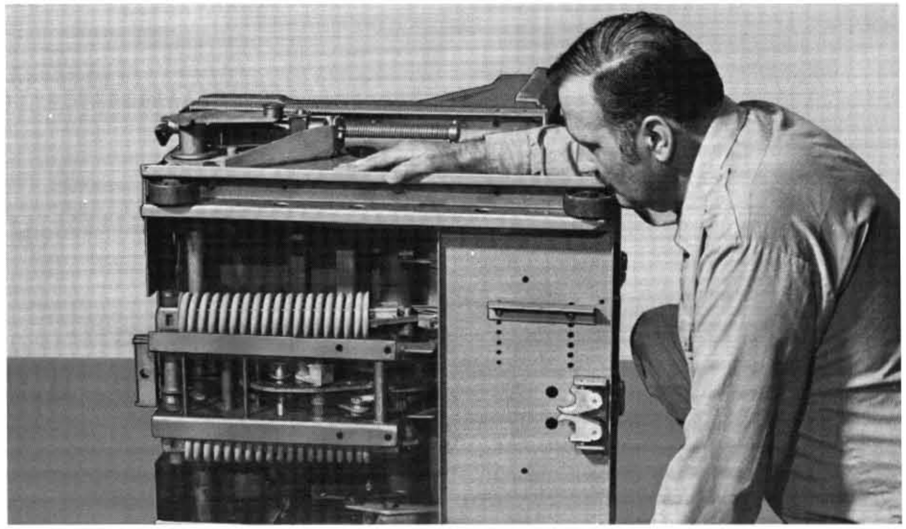
Made to be as nearly maintenance free as possible, arcing contact surfaces are made from a high refractory silver alloy having minimum deterioration during arcing. The main contacts are a silver alloy having excellent electrical conductivity. All contacts have abundant wiping action to insure good contact.

Adjustment for contact and wipe is provided by a screw on the pushrod. The arcing contacts are offset for better absorption of mechanical energy when the circuit breaker is closed.

Simplified drawing of stored energy primary mechanism assembly

Stored-energy closing

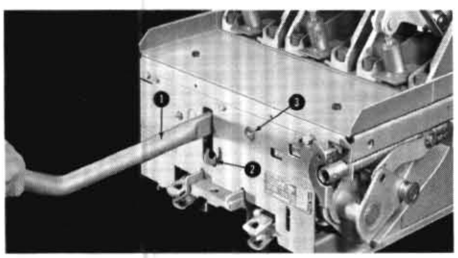
Means long contact life, little maintenance and fast, uniform closing every time regardless of control voltage. The simplified drawing shows primary mechanism elements: motor, closing cam and closing springs, and ratchet & pawl with skip tooth that eliminates need for clutch or brake. Need for unnecessary adjustments is eliminated by the absence of high pressure wear points.



The underside breaker view shows the stored-energy mechanism. Its fractional horsepower universal motor charges the springs through a unique ratchet and pawl system. A missing tooth on the ratchet wheel allows the motor to coast to a stop at the end of charging. There is no need for a brake or clutch which would require periodic maintenance. Closing springs are charged in compression and conservately designed for long life.

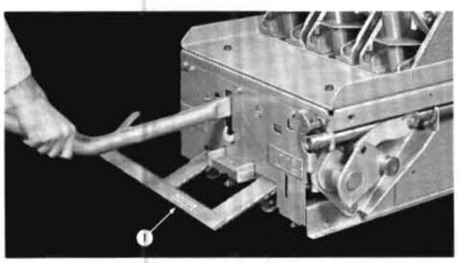
All bearings, cams and latches have been engineered without high-pressure wear points to insure long life and minimum adjustment. They are assembled in precision fixtures and lubricated for life to assure faultless operation.

Note the dual heavy duty closing sprin —these afford an extra measure of circuit breaker reliability. Only one closing sprin is required for emergency closing of the breaker. (Limited duty)



Manual operation

The convenient manual charging handle (1) fits easily over the charging lever on the front of the breaker escutcheon. A few strokes of the handle manually charges the closing springs. This arrangement provides for emergency charging without control power, with the circuit breaker in or out of the compartmer Breaker may be closed manually by simp pulling the manual closing lever (2); trippe with manual button (3). Use of a rope is recommended, when manually closing th breaker within the compartment.



Manual slow close — outside of compartment

The mechanism design allows you to close the contacts slowly, by hand, for routine inspection or maintenance. With this slow-close attachment (1) contacts may be worked forward, free of spring pressure, and held at each stroke of the manual-charging lever by the ratchet. This allows complete check of contact sequence, alignment, and pressure—an it's a simple one-man job.

Ease of Maintenance

Look how easy this 13.8 kV, 500 MVA circuit breaker is for maintenance

Removing the front shield.

Merely loosen two screws and

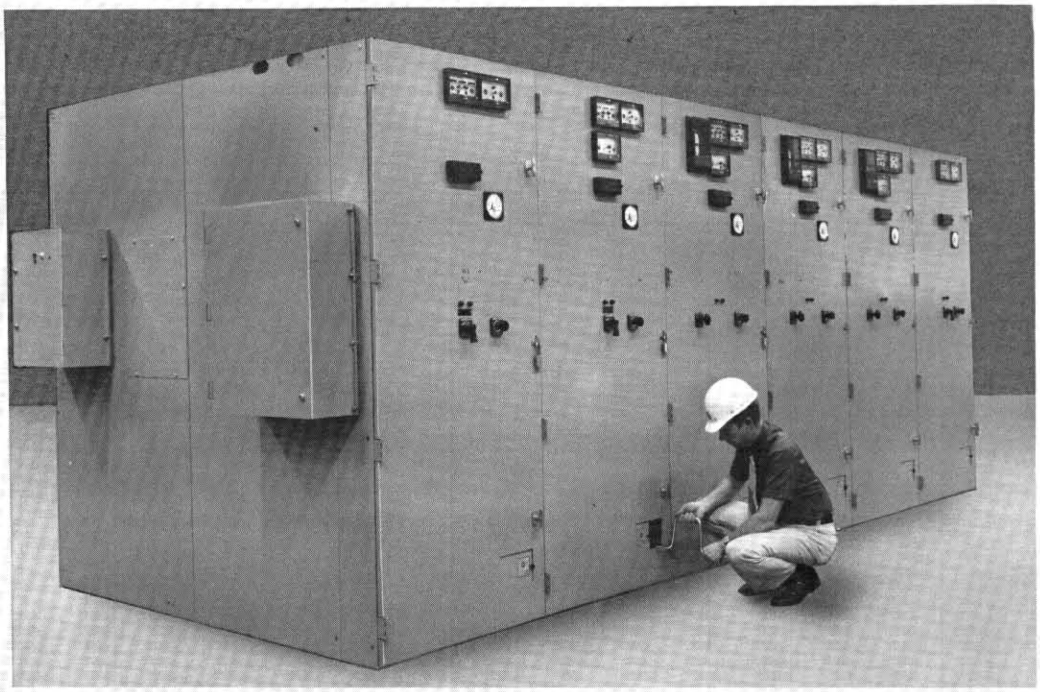
Removing the interphase barriers.

Tilting the arc chutes.

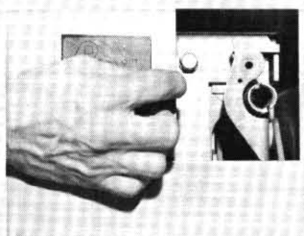
Closed-door safety

In addition to the breaker's metal shield, you get the extra safety of a second solid steel barrier at ground potential during the drawout operation. You NEVER have to open the front door until after the breaker is fully disconnected. For added safety, the breaker cannot be moved unless it has been intentionally tripped and is open.

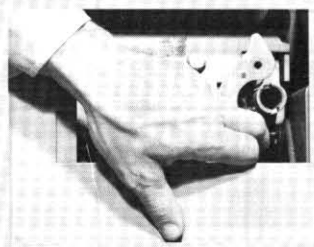
A fully separate test position is automatic in the drawout operation. The movable secondary contacts on the circuit breaker mate with the stationary contacts in the switchgear. Positive stops on the drawout mechanism assure perfect position in the connected, test and disconnected positions. In addition, the closed door disconnect feature of I-T-E switchgear means no cluttered aisles from open doors and no risk of foreign matter getting into the breaker compartment.



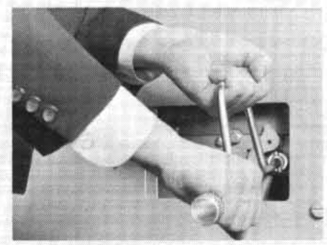
Three easy steps — fully interlocked



Slide back panel.
A plainly marked legend on the outside shows the operation of the racking release lever and the racking screw. Regardless of breaker position, these controls are always close to the opening for easy access.

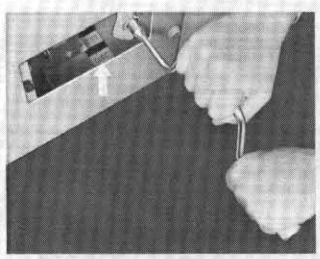


Turn racking release lever.
This unlocks the racking screw so that it is free to turn, but cannot be done unless the breaker is tripped, insuring that breaker position can be changed only when the breaker contacts are open.

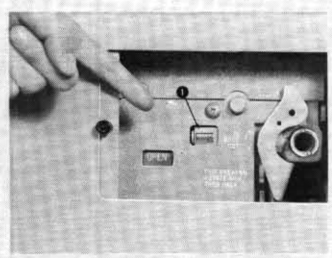


Insert crank and turn.
This easily moves the breaker from connected to disconnected positions. Locking lever provides automatic stop and lock in all positions. Breaker is trip free and cannot be operated at any point between positions.

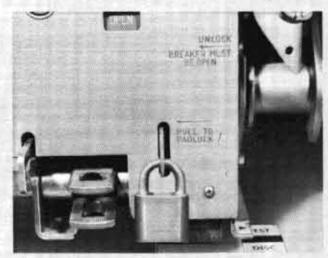
Three extra safety provisions



Breaker position indicator.
Operator can tell the position of the breaker immediately from the position indicator without opening door.



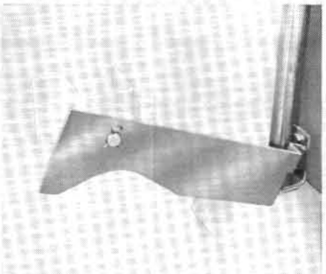
Contact position indicator.
Through sliding panel opening, operator can see indicator showing position of breaker contacts. Operations counter (1) is a standard feature on all HK breakers.



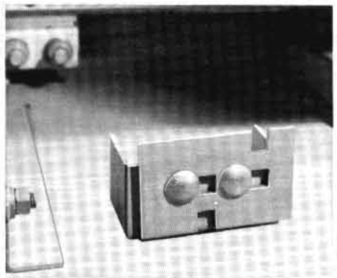
Padlocking*
Breakers may be locked in test and disconnected positions to provide safe unattended storage and prevent unauthorized removal and operation.

*Optional

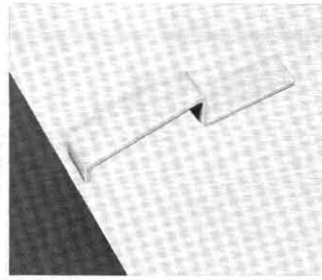
Additional safety interlocking throughout



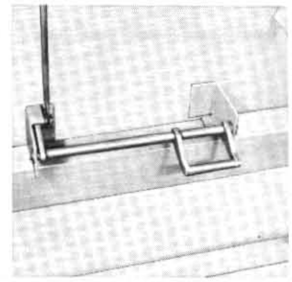
Shutter actuator.
Shutter covering primary leads is forced closed as breaker is removed from the switchgear. Breaker cannot be removed from the cubicle unless shutter is completely closed.



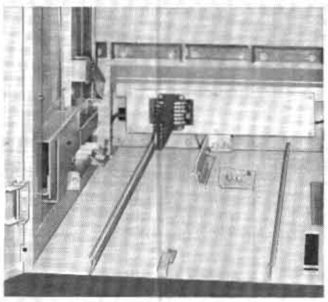
Breaker interference block.
Allows only the correct rating breaker to be inserted into the compartment. It positively prevents inserting an incorrectly rated breaker.



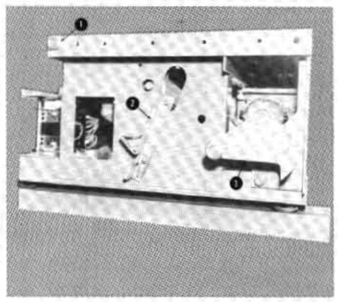
Automatic spring discharge.
Stored-energy springs automatically discharge either when breaker exits or enters compartment. Breaker is always safe to handle immediately upon removal.



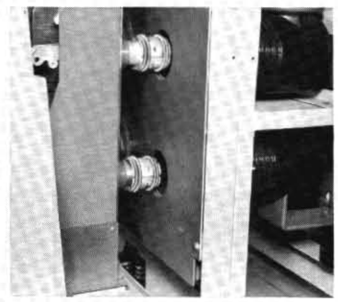
Auxiliary switch actuator.
Operates auxiliary switches ir the instrument compartment when the breaker is in the connected position. It can als be arranged for test position operation.



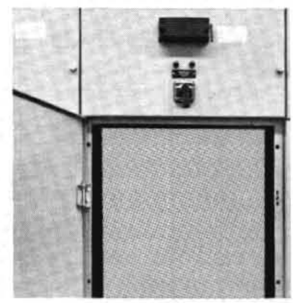
Dual breaker guide rails.
Guarantee positive alignment of the circuit breaker in its compartment, assuring proper mating of all primary, secondary and ground contacts every time.



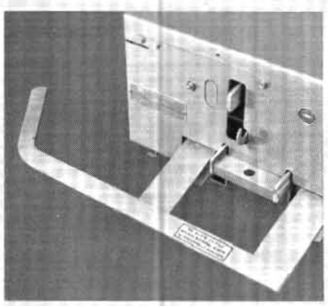
Breaker truck.
Shutter roller (1) engages actuator to move safety shutter. MOC operator (2) responds to breaker contacts to operate auxiliary switch actuator. Racking cam (3) cooperates with switchgear racking slots to move breaker.



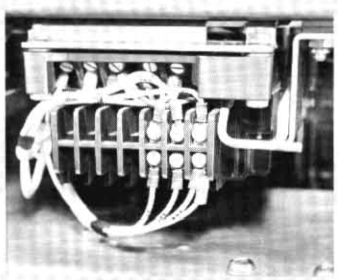
Primary, secondary, and ground contacts.
Contacts on the circuit breaker mate sequentially in a straight line motion with counterparts within the switchgear insuring proper operation at each position.



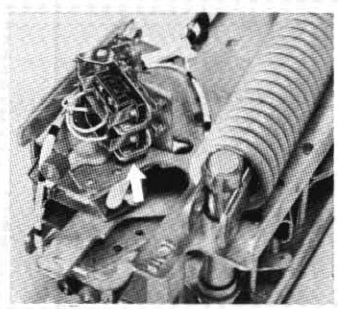
Personnel safety.
Interphase barrier assembly covering the circuit breaker current carrying parts cannot removed while the breaker is the compartment thus eliminati accidental contact with high voltage portions of the breake



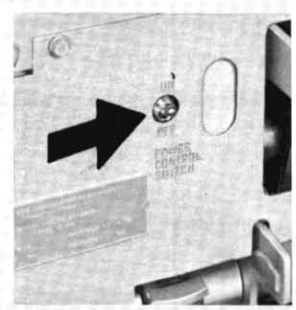
Slow close interference bar.
Prevents the slow closing operation with breaker in compartment. This prevents accidental slow contact closing of an energized breaker.



Control relay.
Linkage and limit switch prevent closing the circuit breaker unless the closing springs are fully charged. Insures powerful closing force every time.



Latch check switch*
Signals the circuit when trip latch is reset. The breaker contacts cannot be closed until the trip latch is completely and properly reset.



On-off power control switch
Enables operator to shut off power to stored-energy charg motor. Without power, the spri cannot be accidently charged

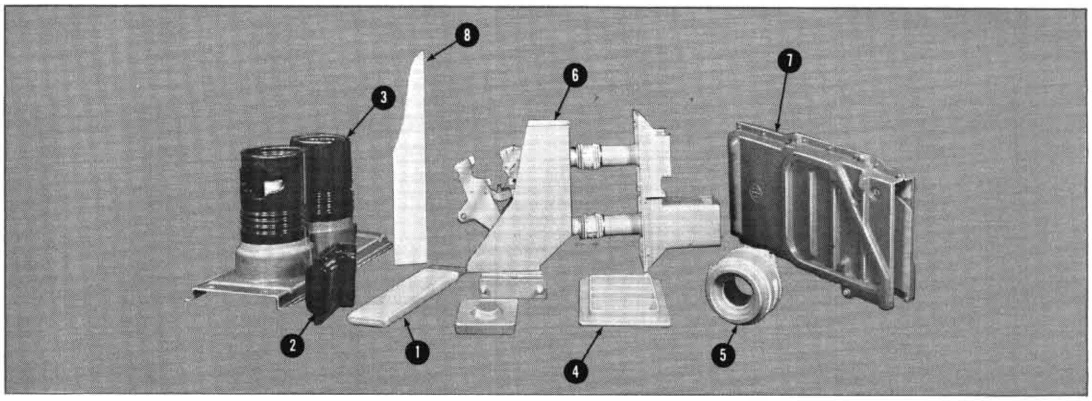
*Optional

Note: Kirk Key Interlocks which offer an unlimited number of interlocking arrangements between components of the switchgear are also available as an optional feature.

Unequaled dielectric performance from specially developed insulation materials ▲

Incorporates these latest improvements:

- **Flame retardance**
- **Track resistance**
- **Low moisture absorption**
- **High impulse strength**
- **Corona freedom**
- **Power Factor**



The finest quality insulation materials are used throughout I-T-E Metal-Clad Switchgear to ensure a well coordinated insulation system. Each specific insulation—polyester glass, epoxy, or ceramics—is designed for its own specific function and is integrated with the total insulation system.

General

Modern insulation not only must be mechanically and electrically strong, but it must remain strong under increasingly stringent conditions of size and surrounding atmosphere. It must be flame-retardant, anti-tracking, and must possess high dielectric strength and low power factor characteristics, particularly at elevated temperatures. It must be capable of withstanding more shock, vibration, corrosion, and fungus than insulation materials previously used in metal-clad switchgear. The performance and reliability of metal-clad switchgear is intimately linked with the quality of its insulation materials. To ensure integrity, insulation material is tested in conformance to applicable ASTM specifications.

Definitions

Insulation Characteristics

Track Resistance is the measure of the ability of the insulation material to resist failure by forming a carbonized path to ground under conditions of moisture and contamination.

Dielectric Strength is the measure of the ability of the insulation material to withstand voltage through its thickness.

Power Factor is the measure of losses in an insulator and indicates the likelihood of the insulating material to break down dielectrically during service.

Flame Retardancy is the relative ability of the insulating material to resist burning and to extinguish when the source of the fire is removed.

Mechanical Strength is the measure of the capability of an insulation material to withstand tensile, compressive or impact loads.

Forming Methods

Insulation materials such as polyesters, epoxies, or ceramics are formed by one of the following techniques.

Casting — A plastic composition is liquified and poured into a mold and cured. Bushings and instrument transformers are formed in this manner.

Pre-Mix Molding — This is a plastic compression molding

glass is placed in the mold and distributed and cured throughout by heat and pressure. Lead support moldings are made by this method.

Pre-Form Molding — The fiber glass sub-strate is pre-formed into the desired shape, then placed in the tool and impregnated while under heat and pressure. Arc chutes and interphase barriers are pre-form moldings.

Laminating — A process where a number of layers of re-enforcing material, most generally glass matt, are placed in a die and impregnated with resin while under heat and high pressure. Flat sheets, angles and channels are molded by this method.

Wrapped Laminates — Layers of re-enforcement and resin are formed around a mandrel and cured. Bushings are formed by this technique also.

Types of insulation materials

Polyesters

These are particularly adaptable to modern switchgear. They exhibit excellent electrical properties, are mechanically strong, easy to handle and fabricate, and are reasonable in cost. They may be formed by any of the five techniques but are predominantly used in the forms of laminates, pre-form and pre-mix.

The following table lists the range of physical and electrical properties of polyester made by various forming methods:

Characteristic	Pre-form	Pre-mix	SMC	Laminate
Flexural Strength psi	22-36,000	14-15,000	15-27,000	18-34,000
Tensile Strength psi	16,000	6- 7,000	14,000	15,000
Compressive Strength psi	20,000	23-27,000	30,000	30,000
Izod Impact ft. lbs./in. of notch	8-10	3-6	6-12	10-20
Flame Retardancy	Yes	Yes	Yes	Yes
Dielectric Strength (Short Time) vpm ⅛″ tk., 25°C	350-375	350-375	350-375	350-375
Dielectric Constant	4-6	4-7	4-6	4-6
Power Factor % 60 Hz 25°C	0.5-3	0.5-3	0.5-3	0.5-3
Power Factor % 60 Hz 105°C	3-7	2-7	2-7	3-7
Track Resistance minutes ASTM 2303	200+	300+	300+	300+

Epoxies

The epoxy resins are some of the newest and most versatile of the modern plastics. Their chief advantages are their excellent electrical and mechanical properties. They are exceedingly tough, show excellent adhesion and excellent impregnating qualities. These resins give off no by-products during cure and show very low cure shrinkage — less than 2%.

Epoxies are most generally formed by casting techniques. They are excellent for voltage and current transformers, bushings, and low volume items. They are particularly good in bonding applications. They are low enough in viscosity that they can be used to impregnate between fine wires used on transformers.

The following table compares the physical and electrical properties of epoxy systems formed by various methods:

Characteristic	Casting	Laminate	Pre-mix (Glass)
Flexural Strength, psi	17,000	40-50,000	24,000
Tensile Strength, psi	8,000	35-40,000	20,000
Comprehensive Strength, psi	22,000	60,000	32,000
Izod Impact, ft. lbs./in. of notch	.3-.5	8-30	8-15
Dielectric Strength (Short Time) vpm ⅛" tk., 25°C	450	500	350
Dielectric Constant	4	4	4
Power Factor %, 60 Hz, 25°C	1.0	1.5	1.5
Power Factor %, 60 Hz, 105°C	4.0	6.0	6.0

Ceramics

Because ceramics are relatively inert, except at exceedingly high temperatures, they are used in critical areas of I-T-E Switchgear. The proper insulation for the voltage class will always be utilized. The following table shows typical physical and electrical properties of ceramic materials.

Characteristic	Cordierite	Porcelain
Flexural Strength, psi	8-10,000	10,500
Tensile Strength, psi	4,000	6,000
Impact, ft. lbs./sq. in.	1	1.5
Specific Gravity, gms/cc	2.31	2.50
Moisture Absorption %	1-2	0
Thermal Expansion, in./in.°/F 77-1290°F	2.8×10^{-6}	5.2×10^{-6}
Thermal Shock cycles 32-2300°F	100+	1
Dielectric Strength, vpm, 25°C	100	300
Dielectric Constant	5	6.1

Switchgear insulation

Bus*

All bus, including bends and odd configurations, is fully insulated with an epoxy compound (1). Bus joints, taps, and splices are covered with a low power factor, air filled vinyl boot (2). The boots are placed over the bus joints and are secured in place. Joints are accessible with a minimum of effort. 7.5 and 15 HK bus is supported by wet process porcelain (3). The main bus is carried through the wall of the frame with porcelain bus supports imbedded in polyester glass. 5 HK bus is supported with track resistant polyester-glass angles and the main bus is carried through the wall of the frame with polyester-glass pre-mix parts (4).

Current Transformers*

A rigid epoxy case is cast and the current transformer is potted in the base and encapsulated with a flexible epoxy resin (5).

* Refer to photograph on page 10 for illustration of various insulators used in HK metal-clad switchgear.

Shutters and Primary Disconnects

The safety shutter covering the stationary primary disconnects of 5 and 15 HK switchgear through 750 MVA is made of a polyester laminate which exhibits high track resistance, high flexural strength, good dielectric strength and flame retardancy. For 15 HK 1000 switchgear, the shutter is aluminum. Directly behind the safety shutter are the stationary primary disconnect (3). 7.5 and 15 HK primary disconnects (up to 750 MVA) are porcelain housings mounted on track-resistant polyester-glass pre-forms bonded with an epoxy compound. 15 HK 1000 primary disconnect housings are mounted on aluminum. The primary conductors are mounted to the porcelain housings with an epoxy compound. The disconnect housings for 5 HK are made of polyester-glass pre-mix molding compound, except 5HK-350-3000 which utilizes epoxy.

Circuit breaker insulation

Lead Assembly*

Lead support moldings (6) are basically a polyester-glass pre-mix molding compound (through 750 MVA) which support the circuit breaker continuous current components and isolate them from ground. 15 HK 1000 MVA circuit breakers utilize epoxy bushings mounted to metal frames. Push rods are the insulating link between the breaker mechanism and the moving contact bridge. A wrapped laminate of epoxy glass cloth is used for the push rod. A gas deflector of highly track-resistant polyester is bonded to the rod to serve as a seal which prevent the possibility of ionized gases blowing into the operating mechanism.

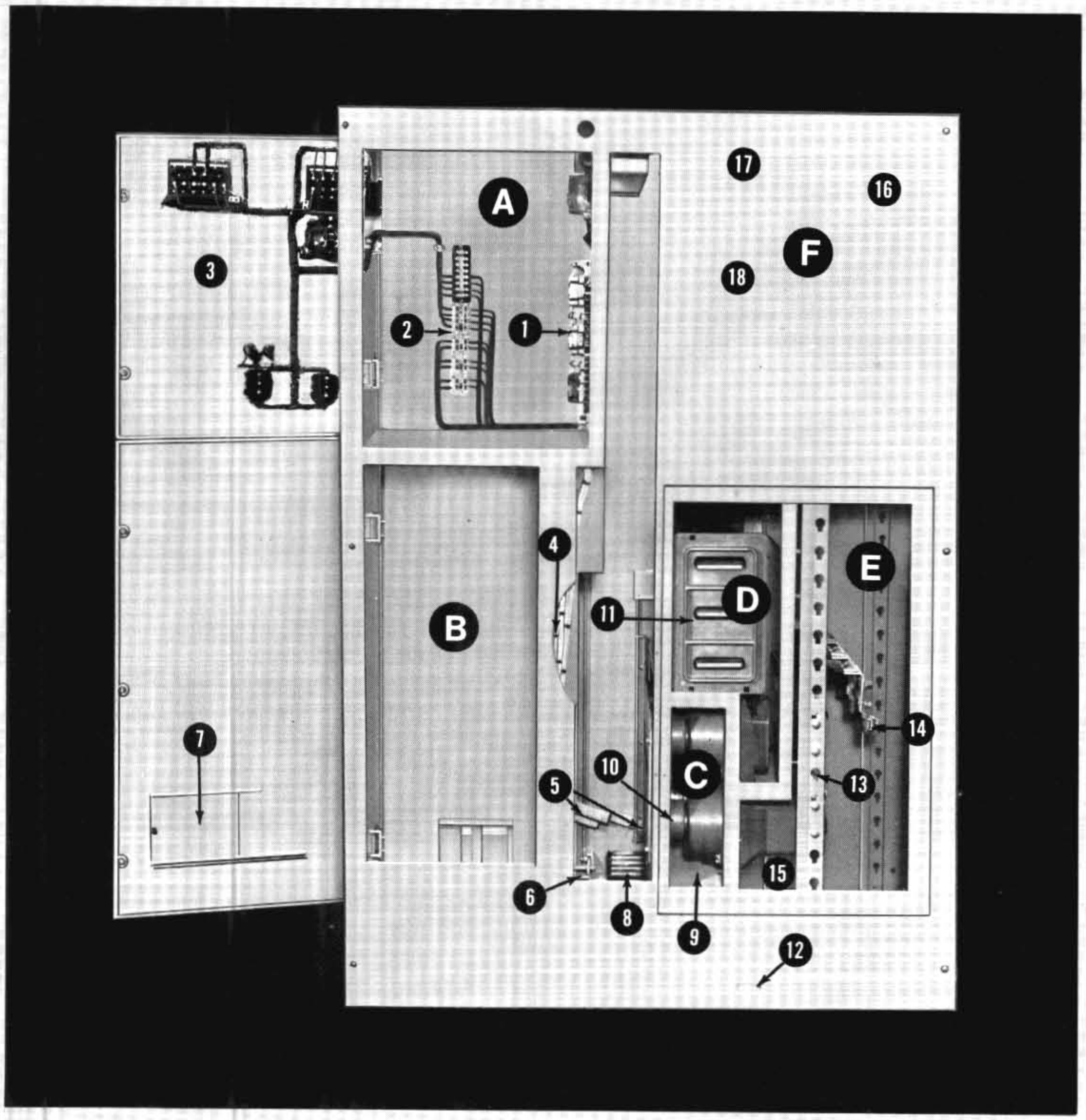
Arc Chute Assembly*

The arc chute and coil assembly (7) are made of high impact, track-resistant polyester pre-mix for 5 HK and pre-form for 7.5 and 15 HK. Arc chute halves are bonded together with epoxy and bolted, thereby preventing ionized gases from blowing through the joints. The arc chute is formed so that coils can be potted directly onto the shell and recesses are formed to receive the ceramic liners (8). The liners are cemented to the shell adjacent to the contacts. The arc plates are made of an exceptionally high heat shock material known as cordierite (see Ceramics above).

Interphase Barrier Assembly

The interphase barrier assembly has the primary function of increasing air strike distance between the phases. The front of the interphase barrier is pre-form molding polyester-glass. Polyester-glass laminates are bonded to either side of the pre-form with epoxy.

I-T-E switchgear design offers time-proven features.



Side view 5 HK 250 switchgear

Safe Compartmentation—complete accessibility of all components

Each single 5 HK switchgear frame has complete steel side sheets, shown here cut-away to illustrate compartmentation. This unit is divided into six completely segregated areas, with front formed doors with concealed hinges.

A. Instrument Compartment
Isolated from high voltage

1. Ample Auxiliary Switches, Accessible Terminal Blocks, Control Power Cutoff and Control Bus
2. CT Short-Circuiting Blocks
3. Eye-level Instruments, Relays, and Control Switches

B. Circuit Breaker Compartment

4. Cable Trough for customer control cable (bottom entrance)
5. Positive Safety Shutter and Actuator
6. Auxiliary Switch Actuator
7. Sliding Panel for closed-door drawout
8. Secondary Disconnect

C. Current Transformer Compartment

9. Front Removable Toroidal type current transformers
10. Primary Bushings — polyester glass

D. Bus Compartment
Accessible from front and rear

11. Polyester-glass, Bus Supports, Mold-on Bus Insulation, No Compound Bus Joint Covers

E. Cable Compartment

12. Ground Bus
13. Key Slotted Mounting Brackets
14. Cable Lugs (optional)
15. Bus-mounted ground fault sensor

F. Auxiliary Device Compartment
Space for:

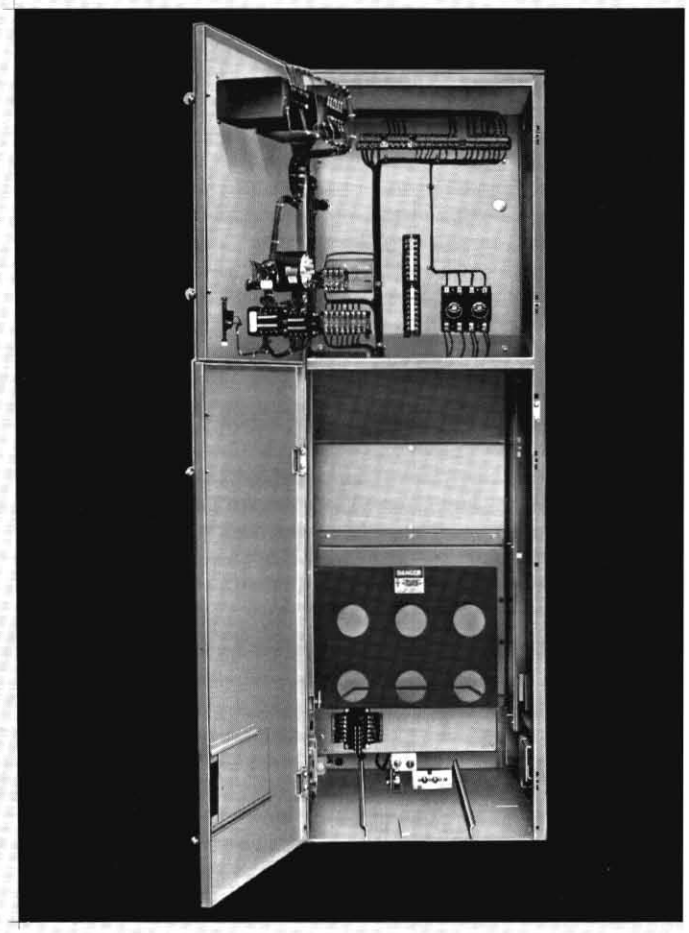
16. Trunnion Type Drawout Potential Transformers

Design flexibility with separate instrument and breaker compartments

The separate instrument compartment is completely isolated from the high voltage, and is closer to the ground for ease of accessibility. This "split" door concept allows the operator access to the instrument compartment without being exposed to the primary voltage. A wide variety of instrumentation and protective devices are available in customer-oriented configurations. All secondary wiring including terminal and CT shorting blocks, and other devices are readily accessible from the front. All secondary wiring lugs are of the looped tongue type for greater reliability. They are mounted on removable panels. Here is switchgear with ample room for construction and maintenance personnel.

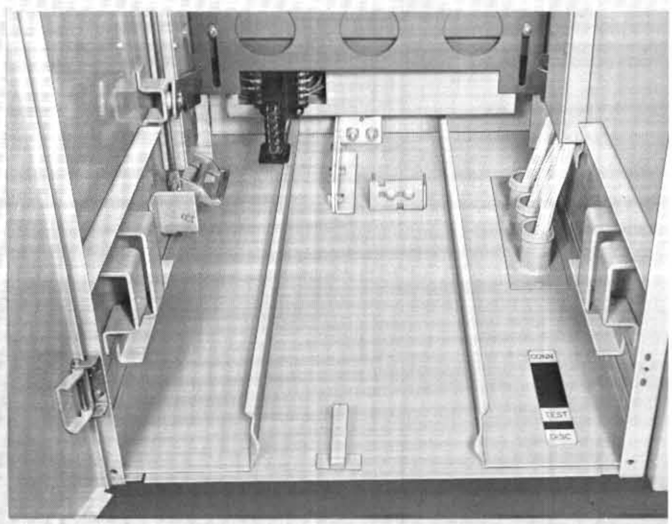
Customer's wire may enter directly from the top or through a covered cable trough from the bottom. Opening in compartment floor is provided for several large conduits. Ample room is available for 24 auxiliary contacts. When a full height instrument panel is required, an 8-inch front extension with a full height front door on each frame in the line-up will be provided. The greatly reduced panel space required by I-T-E protective relays will minimize the need for a 90" instrument panel.

A safety shutter covers all high-voltage stationary primary disconnects. It is forced downward when the breaker is removed from the switchgear, and covers the primary leads with the breaker in the test or disconnect positions. With the circuit breaker removed you can work in the circuit-breaker enclosure and be perfectly safe from contact with high voltage. On the lower left is the actuator which operates the auxiliary switches mounted in the instrument compartment. It responds to the opening and closing of the circuit breaker contacts when the breaker is in the connected position. An actuator which responds to breaker movement in and out of the switchgear can be furnished on the lower right-hand side of the circuit breaker compartment.



Safe, simple, maintenance-free drawout

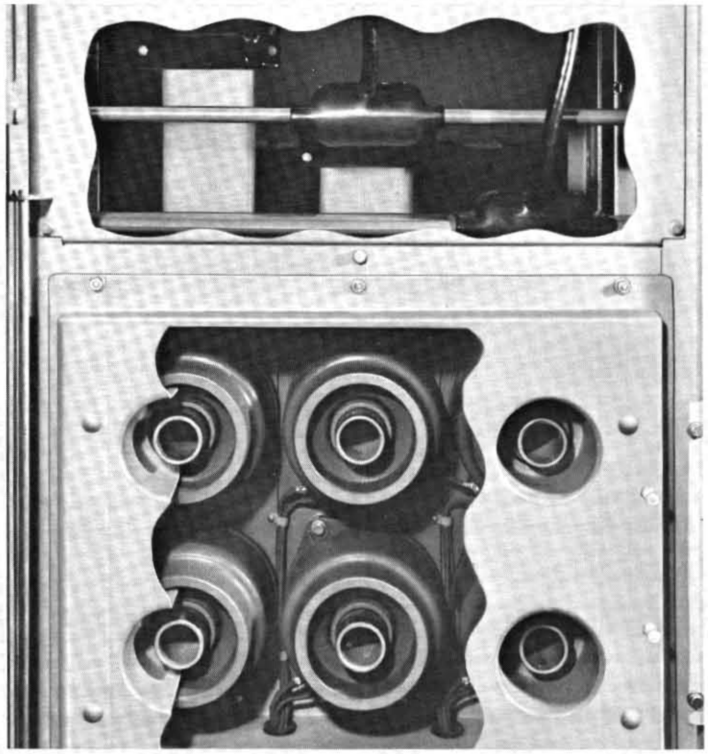
No complex drawout mechanism is necessary in the switchgear. Simple stationary racking slots and guide rails are all that is required. An interference key on the floor allows only the correct rating breaker to be inserted. For added safety, HK switchgear is designed so that the breaker closing springs are automatically discharged before the breaker enters or leaves the compartment. Stationary secondary contacts and ground bus at the rear automatically mate with circuit breaker in test and connected position.



5 HK

Convenient bus location

This is a feature that makes switchgear installation and maintenance easier than ever. Bus can be reached after de-energization of the circuit from the back through the rear panel OR FROM INSIDE THE CIRCUIT BREAKER COMPARTMENT by simply removing the isolating metal barrier. The bus itself, silver plated for high-conductivity connections,is fully insulated with flame-retardant, track-resistant epoxy resin molded insulation. Vinyl bus joint covers with corona-free high-dielectric characteristics provide sealed joints without need for compound. All problems inherent in the taping of joints have been completely eliminated. Maintenance inspections are fast and simplified.



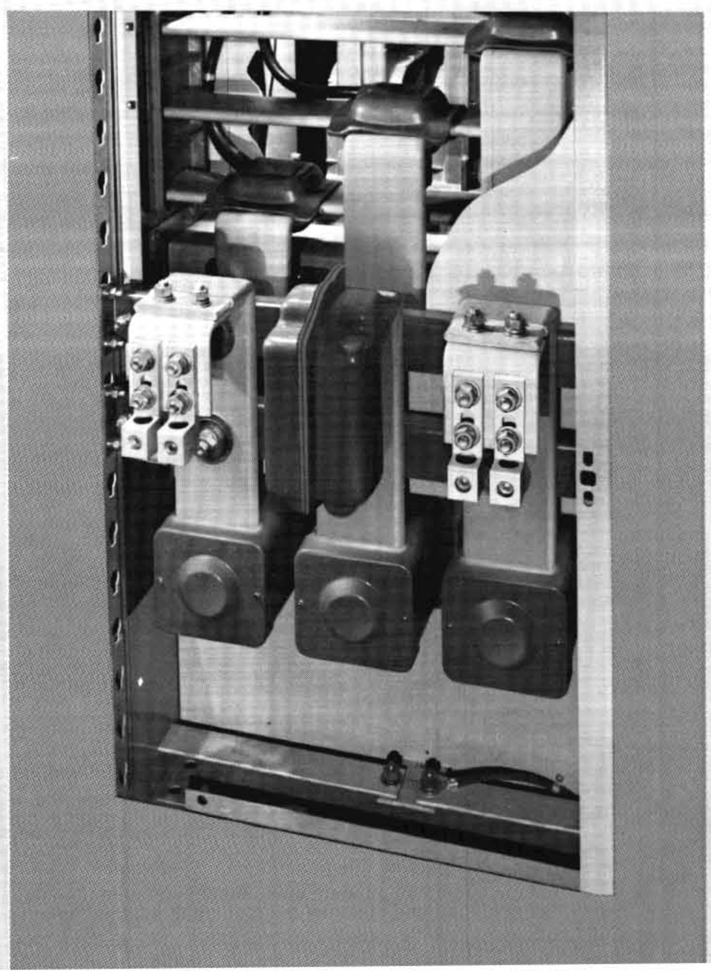
Front access to current transformers

No need to disturb the main bus to change current transformer ratings. Just remove the shutter assembly covering the primary disconnects. The toroidal-type bushing current transformers easily slip over primary studs. Their large cores allow them to be used for some relays and instrument burdens and with substantial short-circuit strength. They are insulated for full-voltage rating of the switchgear. As this cut-away view shows, you can locate them on both load and line sides of the circuit breaker. Thus, in a differential scheme the circuit breaker is included in the protected zone without the necessity for an extra frame, provided the upper current transformers are being utilized in differential protection. The primary lead support is made of a special, flame-retardant, track-resistant polyester-glass molding.

Accessibility for economical installation

No tight space when it comes to cable makeup. Entrance from either top or bottom. Top sheet is easily removed for drilling. Key slots running the full height of the compartment provide a simplified means for mounting cable supports or other equipment. When bottom entrance is used there is room at the top for trunnion type PT's and other auxiliary equipment.

There is ample room for a single pothead in the standard 56 inch depth. When a double pothead is required the rear is extended 8 inches. Main bus compartment cover has been cut away in this view to show location of main bus. Cable lugs and vinyl termination covers (boots) illustrated at right, are available as optional equipment.



Compact outside, accessible inside

Safe compartmentation—complete accessibility

Each single 7.5 and 15 HK switchgear frame has complete steel side sheets, shown here cut-away to illustrate compartmentation. This unit is divided into five completely segregated areas, with front formed doors with concealed hinges.

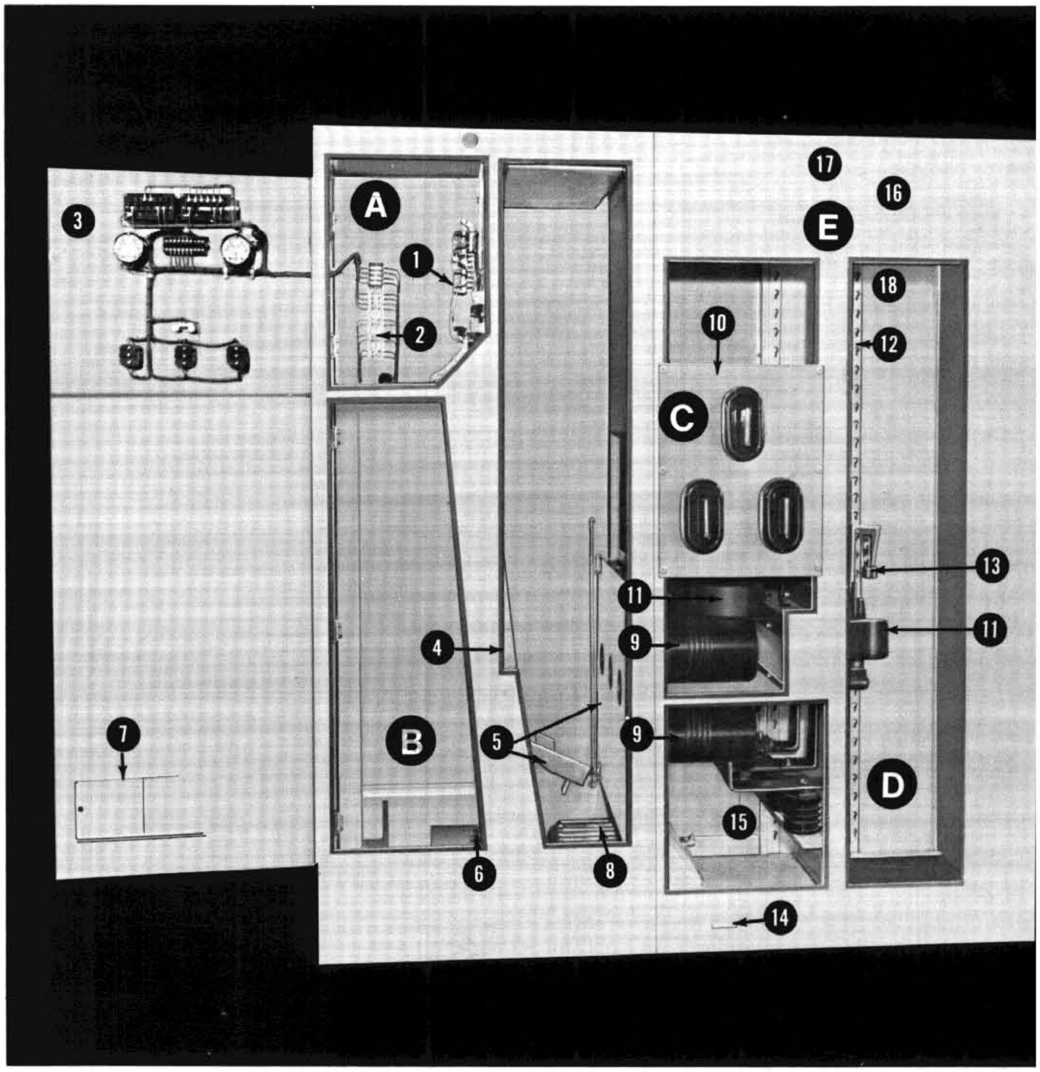
A. Instrument compartment
Isolated from high voltage
1. Ample Auxilary Switches
   Accessible Terminal Blocks
   Control Power Cutoff and Control Bus
2. CT Short Circuiting Blocks
3. Instruments, Relays, and Control Switches

B. Circuit breaker Compartment
4. Cable Trough for customer control cable (bottom entrance)
5. Positive Safety Shutter and Actuator
6. Auxiliary Switch Actuator
7. Sliding Panel for closed-door drawout
8. Secondary Disconnect

C. Bus compartment
Accessible from front and rear
9. Porcelain Primary Bushing embedded in flame retardant track-resistant polyester glass
10. Porcelain Bus Supports embedded in polyester-glass
    Molded-on Bus Insulation
    No Compound Bus Joint Covers

D. Cable compartment
11. Toroidal Type Current Transformers
12. Key Slotted Mounting Brackets
13. Cable Lugs (optional)
14. Ground Bus
15. Bus Mounted ground fault sensors

E. Auxiliary device compartment
Space for:
16. Trunnion Type Drawout Potential Transformers
17. Lightning Arresters
18. Bus Transition Space

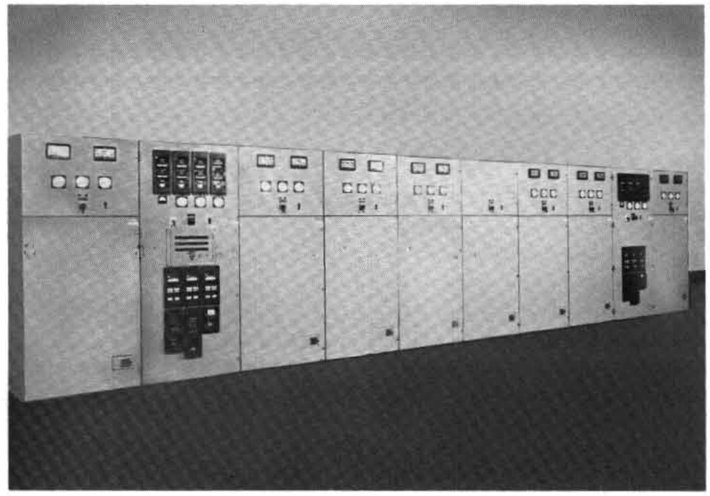


Side view 15 HK 500 switchg

7.5 & 15 HK

Traditional quality

Start with the frame. Made to exacting tolerances for assured interchangeability and with the strength and rigidity of welded deep flanged formed steel. Full side sheets enclose each frame and provide complete isolation with two separate painted steel barriers between each unit. The deep, oven-baked finish maintains its lustre for years and provides unexcelled corrosion resistance. The paint finish is applied by our exclusive processes. All surfaces are cleaned, coated with a corrosion resistant sealer and finished in semi-gloss, gray ANSI #61 finish. Outdoor equipment receives an additional coating of gray ANSI #61.

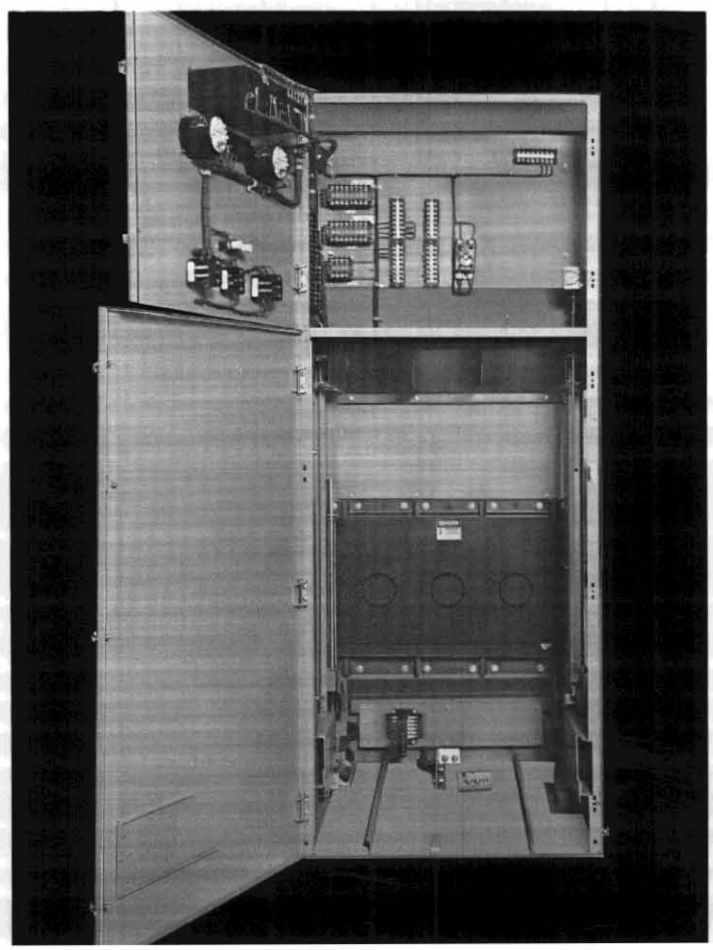


Separate instrument and breaker compartments

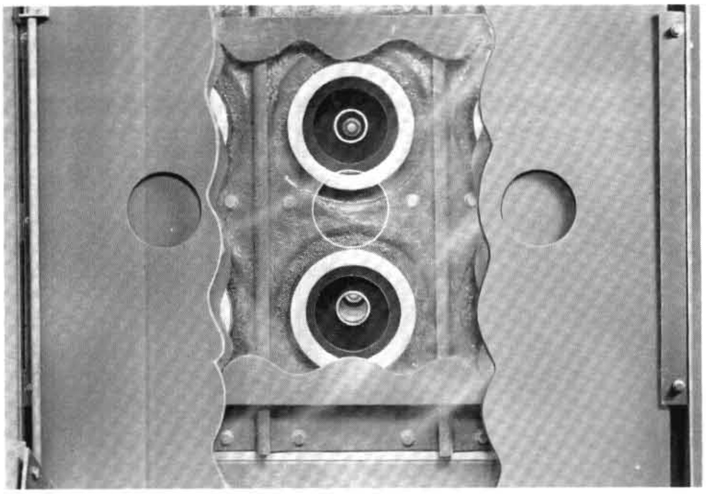
The separate instrument compartment is completely isolated from the high voltage. A wide variety of instrumentation and protection devices are available in customer-oriented configurations. All secondary wiring including terminal and CT shorting blocks, and other devices are readily accessible from the front. All secondary wiring lugs are of the looped tongue type for greater reliability. They are mounted on removable panels. Here is switchgear with ample room for construction and maintenance personnel.

Customer's wire may enter directly from the top or through a covered cable trough from the bottom. Opening in compartment floor is provided for several large conduits. Ample room is available for 24 auxiliary contacts on 7.5HK500, 15HK500 and 15HK750 switchgear. 15HK1000 units can accommodate up to 16 auxiliary contacts. When you need a 90-inch instrument panel, Brown Boveri Electric provides an 8-inch front extension with a full height front door on each frame of the line-up. The greatly reduced panel space required by I-T-E protective relays will minimize the need for a 90″ instrument panel.

A safety shutter covers all high-voltage primary connections. It is forced downward when the breaker is removed from the switchgear and covers the primary leads with the breaker in the test* or disconnected positions. With the circuit breaker removed, you can work in the circuit-breaker enclosure and be perfectly safe from contact with high voltage. On the lower left is the actuator which operates the auxiliary switches mounted in the instrument compartment. It responds to the opening and closing of the circuit breaker contacts when the breaker is in the connected position. An actuator which responds to breaker movement in and out of the switchgear can be furnished on the lower right hand side of the circuit breaker compartment.



* Disconnected position only, on 1000 MVA switchgear.



Safety Shutter

Porcelain bus supports

Operator safety — a prime requisite

A safety shutter covers all high-voltage primary connections. (Shown here in plexiglass to illustrate closed position.) It's forc closed when the breaker is removed from the switchboard. Prim lead bushings, behind shutter, are FULL-RATED PORCELAIN embedded in a flame-retardant, track-resistant polyester-glass molding for 7.5 and 15HK switchgear up to 750MVA. Primary disconnect housings for 15HK1000 switchgear are mounted on aluminum.

Bus accessible from front or back

This is a feature that makes switchgear installation and maintenance easier than ever. Bus can be reached after de-energization of the circuit from the back through the rear pa OR FROM INSIDE THE CIRCUIT BREAKER COMPARTMENT simply removing the isolating metal barrier (removed for photo) The bus itself, silver plated for high-conductivity connections, is fully insulated with flame-retardant, track-resistant epoxy resin molded insulation. Vinyl bus joint covers with corona-free, high-dielectric characteristics provide sealed joints without nee for compound.

Insulation

Bus supports throughout the entire compartment are porcelain. Main bus supports between frames are porcelain embedded in track resistant polyester-glass.

Wherever other bus supports are required, the same high quali porcelain stand-off insulators are used. You can be assured tha Brown Boveri Electric will continue to specify the best available insulation material for each voltage class.

Current Transformers

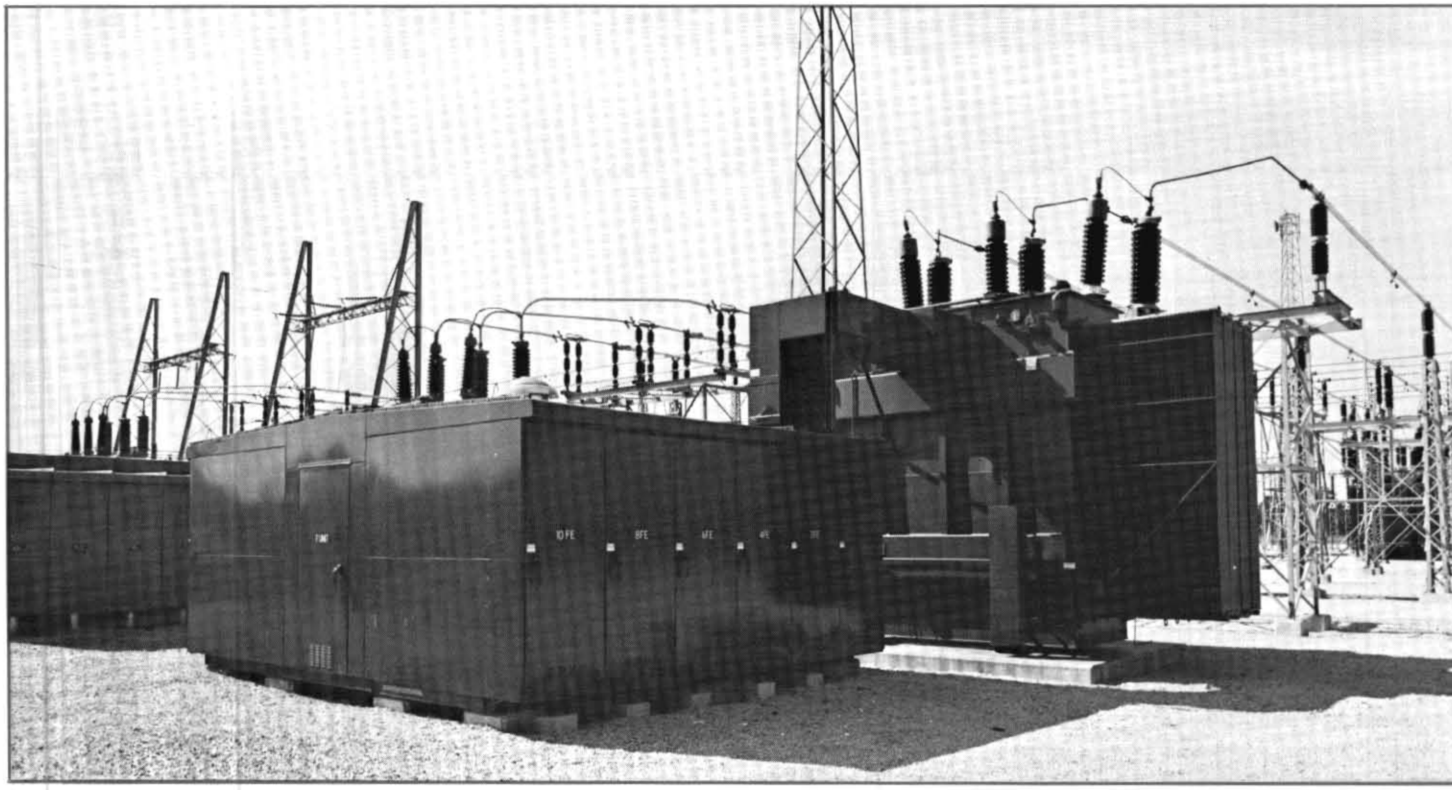
Toroidal current transformers can be located on the bus risers both line and load side of the circuit breaker. Transformers are insulated for full-voltage rating of the switchgear.

Accessibility for economical installation

No tight space when it comes to cable makeup. Entrance from either top or bottom. Top sheet is easily removed for drilling. Key slots running the full height of the compartment provide a simplified means for mounting cable supports or other equipm There is ample room for single pothead in the standard 81 incl depth. When an optional double pothead is required the rear is extended 8 inches.

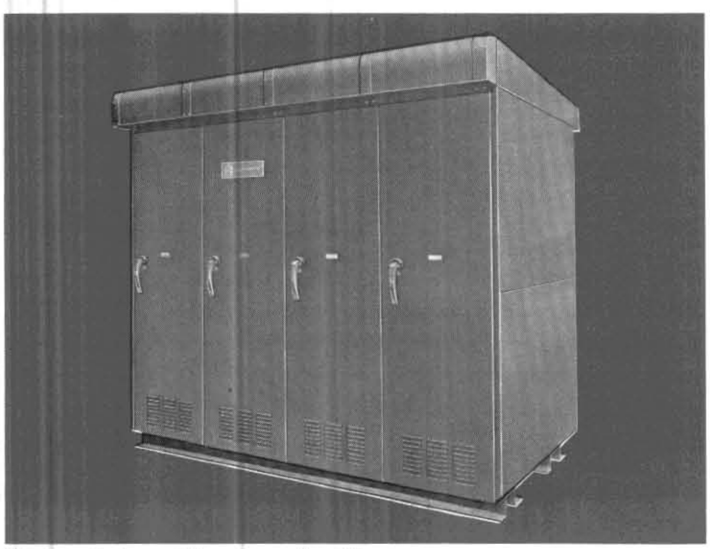
Outdoor switchgear

5, 7.5 & 15 HK



Only I-T-E Switchgear gives you all these advantages in Non walk-in and walk-in types

- Doors, side sheets and frames sealed with long-lasting gaskets.
- All parts treated for rust resistance, painted and baked prior to assembly to protect the metal against rust and corrosion, even between overlapping points.
- Bottom of the entire unit undercoated.
- Front and rear doors hinged and louvered. Louvers include a filter.
- Interiors equipped with lights, heaters, and convenience outlets.
- Structures strong enough to be pier mounted.



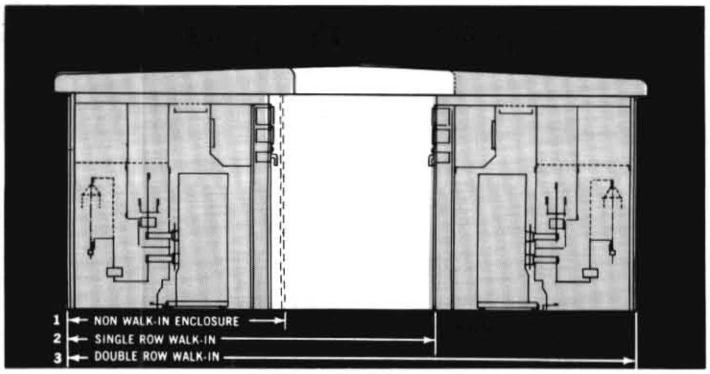
Non walk-in outdoor construction

For the ultimate in space savings, the non walk-in outdoor construction provides the user with maximum control and protection in minimum space. Access to both front and rear of switchgear is provided.

Walk-in outdoor construction

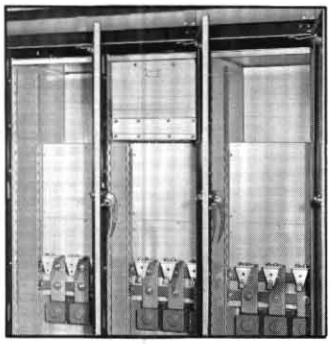
Modern method of enclosure construction to facilitate maintenance of switchgear in any weather. Wide aisle inside for complete circuit breaker withdrawal and space to store an extra breaker. Lights, heat and convenience outlets are provided. Unit is so sturdily built that it may be pier mounted. End doors are provided with panic bar that permits opening even if exterior handle has been padlocked. Hinged rear doors provide easy access to bus and cable compartments. They have provisions for padlocking to prevent unauthorized entrance which is standard for all front and rear doors having access to over 600 volts (both indoor and outdoor switchgear).

Features and Auxiliary equipment 5, 7.5 & 15



Building block construction

Outdoor construction consists of standard I-T-E Indoor Swit contained within an outdoor enclosure.
Non walk-in outdoor enclosure (1) can be modified to single ro walk-in (2) by the addition of the walk-in aisle. As load grows y add switchgear frame to opposite side of aisle to form double walk-in (3).

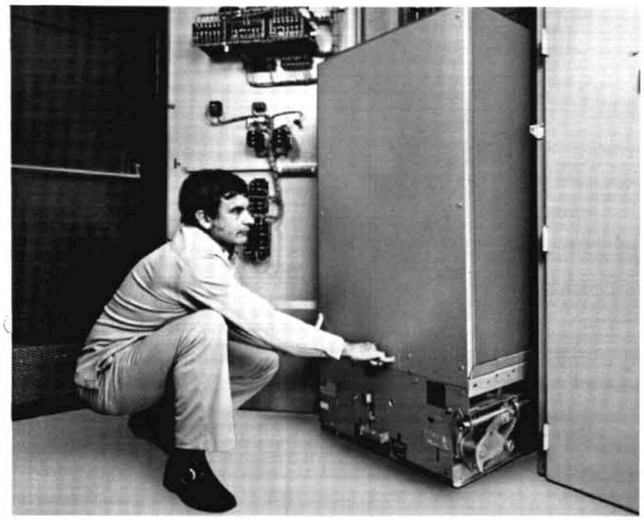


Auxiliary Device mounting space

Ample space is available in top rear compartment of circuit breaker unit for mounting potential transformers, lightning arresters and other auxiliary devices. Location charts for auxiliary devices are on pages 29 and 33.

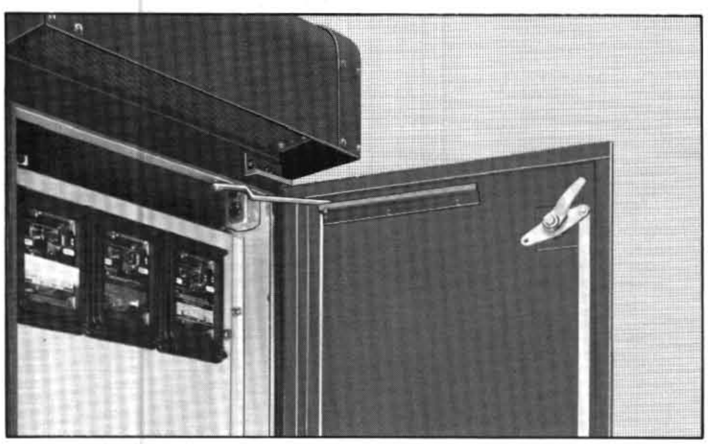
Trunnion-mounted drawout potential transformers

Heavy potential transformers are no longer a problem. Trunnion-type mounting at the center of gravity assures effortless drawout. For operator safety when disconnected, fuses and potential transformers are automatically grounded. A barrier prevents access to the primaries.



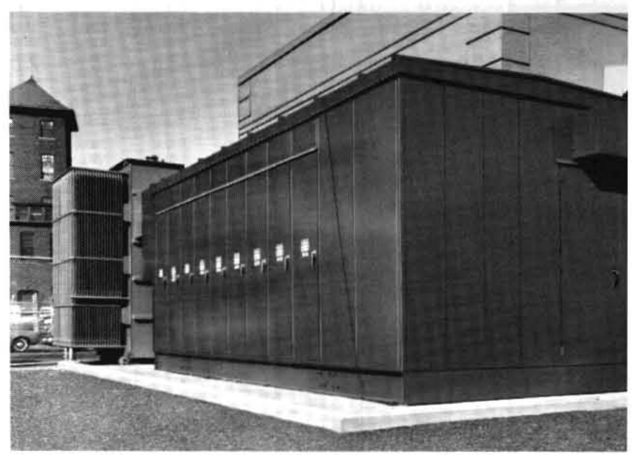
Roll out 15KV Circuit breaker

One man can easily move circuit breaker to aisle position for inspection and maintenance.



Ventilation and weatherproofing

Doors completely weather stripped for complete seal. Latches assure uniform tight fit. Generous filtered ventilation on door and overhead for maximum air circulation. Strip heaters prevent moisture and condensation inside the compartment.



Power Distribution Center

The I-T-E Power Distribution Center (PDC) provides a comple integrated control system designed and built specifically for ea utility or industrial application. The climatized PDC's are fact assembled, wired and pre-tested, in self-contained enclosur ready for immediate placement and connection.

Protective Relays with application flexibility 5, 7.5 & 15 HK

I-T-E Solid State Protective Relays can be ordered with all I-T-E metal-clad switchgear. This broad line of static protective relays offers many advantages over conventional electromechanical types:

- Shock and vibration proof-seismic capability to 10g.
- Full compliance with IEEE 344-1975 and proposed Power System Relay Committee Standard for Seismic Testing of Relays.
- No routine maintenance required.
- High immunity to dust and other contaminants.
- Flexible, easily made settings.
- Low burden — improves CT performance.
- Smaller size — better utilization of panel space.
- Built-in operational test to simplify routine testing.
- Improved characteristics for better protection.
- Most complete line of Solid State Relays in the industry.
- More than ten years of field proven experience.

To illustrate the improved characteristics provided by I-T-E Protective Relays, the type I-T-E 51 overcurrent relay offers:

- Narrow band — no overtravel.
- Fast reset.
- Universal precise instantaneous attachment.
- Conventional time current characteristics plus several new characteristic curves for improved motor protection.

Each of the protective relays in the I-T-E family offer similar improvements in dynamic performance or sensitivity, resulting in better protection.

Type ITE-51
Time-overcurrent Relay

Type ITE-25V
Synchronism Check Relay

Type ITE-47 Undervoltage and phase Sequence Relay

Test Accessory Type X51-C

May be mounted on the switchgear for convenient testing of all Type ITE-51 Overcurrent Relays.

Comparison of I-T-E Protective Relays With Competitive Types

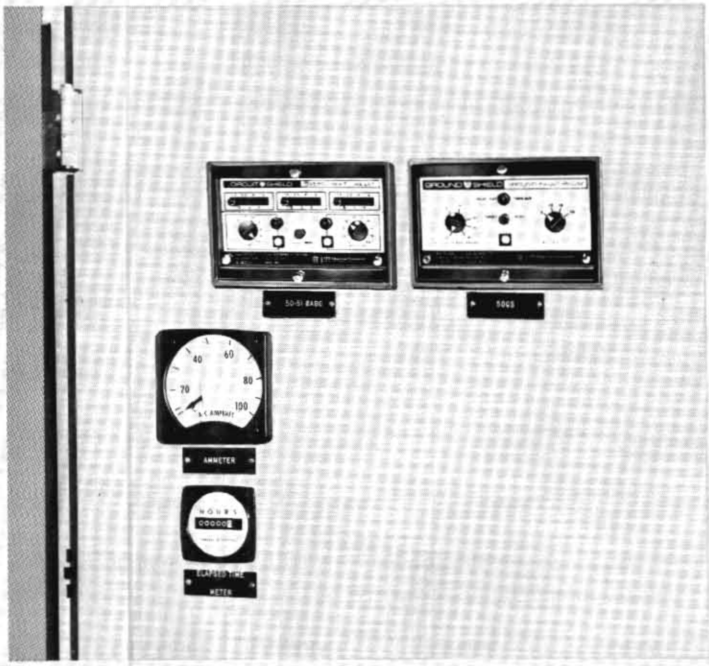
Device Number	Function	Brown Boveri Electric	GE	W	Catalog Section
25	Synchronism Check	ITE-25S	IJS-51	CVE	18.3
		ITE-25V	IJS-52D	CVE-1	
27	Undervoltage				
	Inverse Time Delay	ITE-27	IAV	CV	
	Instantaneous with Built-in Timer	ITE-27D	—	—	18.4
	Instantaneous	ITE-27H	NGV	SV, SVF	
27/59	Under and Overvoltage				
	Inverse Time Delay	ITE-27/59	IAV	CV	
	Instantaneous with Built-in Timer	ITE-27/59D	—	—	18.4
	Instantaneous	ITE-27/59H	CFV,NGV	SV,SVF-1	
32	Phase Directional	ITE-32	CAP,CCP	H-3	
	Reverse Power	ITE-32R	ICW	CRN-1	18.8
	Over/Under Power	ITE-32W	CFW	CW	
32N	Ground Directional				
	Dual Polarized	ITE-32D	CFPP	—	18.8
	Negative Sequence Polarized	ITE-32Q	—	—	
40	Loss of Excitation	—	CEH	KLF	—
46	Current Balance	ITE-46D	IJC	CM	
	Negative-Sequence Time OC	ITE-46Q	INC,SGC	COQ	18.6
	Negative-Sequence OC, High Speed	ITE-46H	—	POQ	
47	U.V. and Phase Sequence				
	Inverse Time Delay	ITE-47	ICR	CP,CVQ	
	High Speed	ITE-47H	CFV	—	18.4
	Instantaneous with Built-in Timer	ITE-47D	—		
49	Thermal Overcurrent	ITE-49	TMC	BL-1	18.7
	Temperature	ITE-49T	IRT	DT-3	
49/50/51	Motor Protection: overload, locked rotor and instantaneous	ITE-49	—	—	18.7
50	Instantaneous OC	ITE-50	PJC	SC,ITH	
	Inverse Instantaneous OC	ITE-50I	—	—	18.2
	High Dropout Inst. OC	ITE-50H	—	KO-3	
	High Dropout Inst. OC with Timer	ITE-50D	—	—	
	Time Overcurrent				
	Inverse	ITE-51I	IAC-51	CO-7	
50/51	Very Inverse	ITE-51Y	IAC-53	CO-9	
51	Extremely Inverse	ITE-51E	IAC-77	CO-11	
50/51N	Short Time	ITE-51S	IAC-55	CO-2	
51N	Definite Time	ITE-51D	—	CO-6	
	Fast Curve	ITE-51SP	—	—	18.2
	Long Time, Inverse	ITE-51IM	IAC-66A,B	CO-5	
	with overload alarm	ITE-51+50D ①	IAC-66K	COM-5	
	with timer (inrush)	ITE-51 ②	IAC-66M	COM-5w/t	
	Long Time, Very Inverse	ITE-51YM	—	—	
	Long Time, Extremely Inverse	[illegible]			

Device Number	Function	Brown Boveri Electric	GE	W	Catalog Section
51V	Voltage Controlled Time OC	ITE-47H&51 ①	IGCV	COV	18.2
	Voltage Restrained Time OC	③	IJCV	—	18.4
55	Power-Factor	—	—	—	—
59	Overvoltage				
	Inverse Time Delay	ITE-59	IAV	CV	
	Instantaneous with Built-in Timer	ITE-59D	—	—	
	Instantaneous	ITE-59H	NGV,PJV	SV,SVF	18.4
	Ground (Low Pickup)	ITE-59G	IAV51D,K	CV-8	
60	Voltage Balance, 2 Circuits	ITE-60	CFVB	—	18.4
	Phase Unbalance, with Timer	ITE-60Q	NBV+SAM	—	
62	Timing Relay				
	Delay on pickup	ITE-62K	SAM,RPM	TK,TD	18.7
	Delay on dropout	ITE-62K	—	—	
67	Directional Time-Overcurrent				
	Phase Protection	ITE-32&51 ①	IBC,JBC	IRV,CR	
	Ground, Dual Polarized	ITE-32D&51	IBCG,JBCC	IRD,CRD	18.2
	Ground, Neg. Seq. Polarized	ITE-32Q&51		IRQ,CRQ	
	Directional Instantaneous				
	Phase Protection	ITE-32&50 ①	CJC	KRV	
	Ground, Dual Polarized	ITE-32D&50	CJCG	KRD	18.8
	Ground, Neg. Seq. Polarized	ITE-32Q&50	CNP	KRQ	
76	DC Overcurrent				
	Inst. (High Speed)	ITE-76H	RBP,RBC	D-3,S	
	DC Relay (Inst., Time Delay, and/or Rate-of-Rise)	ITE-76T	—	—	18.5
79	Reclosing				
	Multi-Shot	ITE-79M	ACR, NLR	RC,DRC	18.3
	Single-Shot	ITE-79S	NSR,HGA	SGR	
81	Underfrequency	ITE-81	SFF,CFF	CF-1	18.4
87	Percentage Differential	ITE-87M	CFD	SA-1	
87B	Bus Differential High Impedance	ITE-87B	PVD,SBD	KAB	18.6
87T	Transformer Differential	ITE-87T	BDD,STD.	HU,HU-1	

❶ Use one each of indicated I-T-E types.
❷ Specifiy "Inverse instantaneous" element.
❸ Consult the nearest District Office.

Surface mounted relay

Drawout style relay



Solid state phase and ground protection

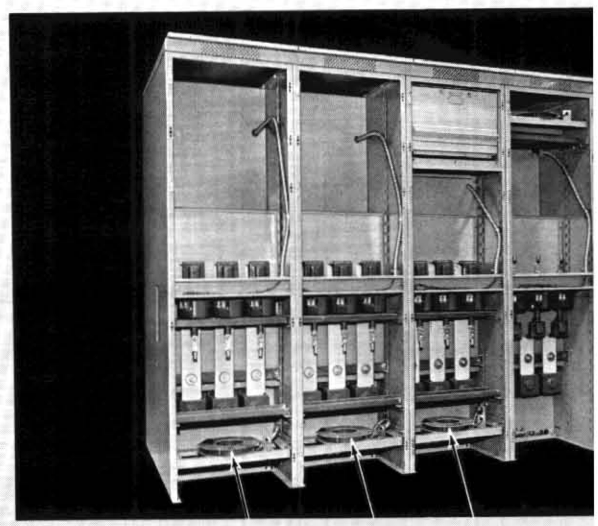
One three-phase I-T-E-51 overcurrent relay provides phase-to-phase overcurrent protection. Ground relay can be GROUND SHIELD (zero sequence) as shown or single-phase I-T-E-51 overcurrent relay in the conventional residual connection.

Ground fault protection

For complete ground-fault protection against normally unde tectable low-magnitude ground faults, I-T-E solid-state relay are employed in combination with a window-type core-balan sensor. The system called GROUND-SHIELD™ provides coo ground-fault protection for low and high-resistance grounde systems. The relay can be used optionally for sounding an a only.

A drawout relay for semi-flush panel mounting is availabl variety of ground fault sensitivities and time current charac are offered.

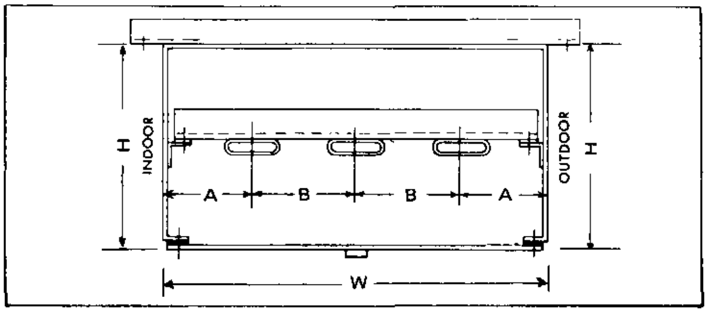
The core balance current sensors are available in a rang sizes. The compactness of the current sensor, compared tc balance C.T.'s used to drive electromechanical relays resul maximum available space for the installation of user's cable Rectangular ground sensors are standard on switchgear as simplifying installation.

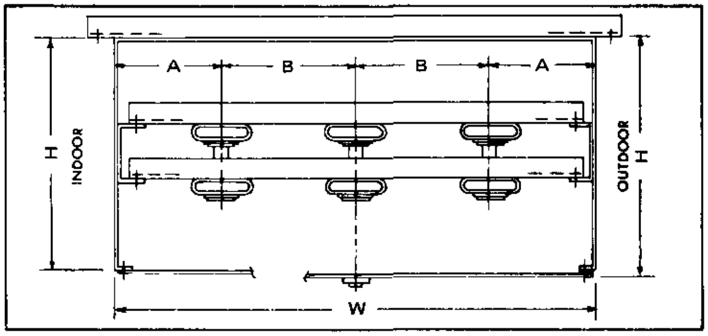


Round toroidal sensor for single or multi-conductor termi be supplied when specified or as required.

Nonsegregated Phase Bus Duct

5, 7.5 & 15 HK





Typical end views of bus showing phase spacing dimensions; 5kV supports shown

Dimensions & Weights†

KV	H (Indoor)	H (outdoor)	W	A	B	Amps	Wt/ft 3∅
						1200	52
5	13 1/8	13 3/8	26	6	7	2000	74
						3000	82
	19 9/16	19 3/4	36	8	10	4000	74
						1200	82
15	15 9/16	15 3/4	36	8	10	2000	91
						3000*	135
	20 3/16	20 3/8	42	9	12	4000	85

† Weights may vary from figures shown, depending upon material used.
* Dimensions same as 5kV, 3000A.

Note: Dimensions are approximate and subject to change without notice. Do not use for construction.

What bus duct is

Nonsegregated phase bus duct is one in which all phase conductors are in a common metal enclosure without barriers between phases. Its construction is consistent with either metal-enclosed or metal-clad switchgear standards, as required by the coordinated equipment.

How bus duct is used

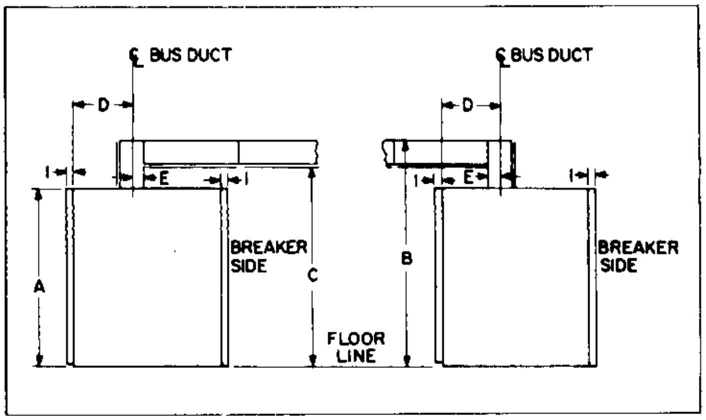
Medium-voltage (2.4 kV to 15 kV), nonsegrated phase bus (NSB) is used for small generator leads to transformers, for connecting transformers to medium-voltage switchgear assemblies for interconnecting medium-voltage switchgear assemblies, and for long or short distribution runs of medium-voltage power in power plants, factories and office buildings. The rectangular bus ducts are applied for short runs with a high ratio of elbows and tees. NSB provides a custom-designed, rigid conductor interconnection to give superior reliability in comparison to cable.

Measure of bus duct performance

- I-T-E standardized bus complies with a set design which has been proven to meet thermal, dielectric and mechanical requirements.
- Failure-vulnerable medium-voltage stress cones are eliminated.
- Insulating materials are superior and incorporate advancements in the switchgear industry.
- All conductors and connections are easily accessible for inspection or addition of tap-offs.
- Disconnect links, switches and grounding studs can easily be provided and coordinated with the bus design.
- Each bus is custom engineered to suit your specific installation requirements.

Table 2 Nonsegregated phase bus duct technical data

Nominal System Voltage, kV	Bus Duct Nominal Voltage, kV	Bus Duct Maximum Voltage, kV	Continuous Current, A	Momentary Current Rating, kA	Insulation Level, kV Power. Frequency Withstand, kV (Dry, 1 Minute)	Insulation Level, kV Impulse Withstand, kV BIL	Bus Duct Conductor Temperature Rise, °C (over 40°C ambient)
2.4 4.16	4.16	4.76	1200 to 4000	20 to 80	19	60	65
7.2 13.8	13.8	15.0	1200 to 4000	20 to 80	36	95	

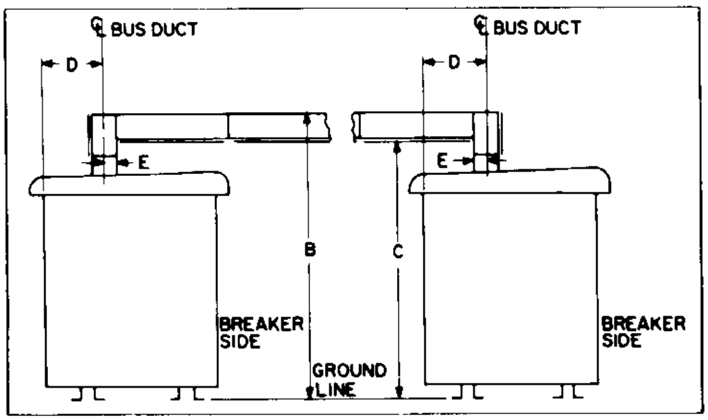


5, 7.5 & 15HK indoor switchgear connections, 1200 & 2

Type△	A	B	C	D†
5 HK-75 5 HK-250	80	106	$92\frac{7}{8}$	$13\frac{3}{8}$
7.5 HK-500 15 HK-500 15 HK-750	90	126	$110\frac{1}{2}$	$32\frac{5}{16}$

△ Refer to nearest district office for bus duct information relating to 5 HK-350 an
HK-1000 applications.

† Minimum and intermediate depth only. For extra depth switchgear, add 8″.

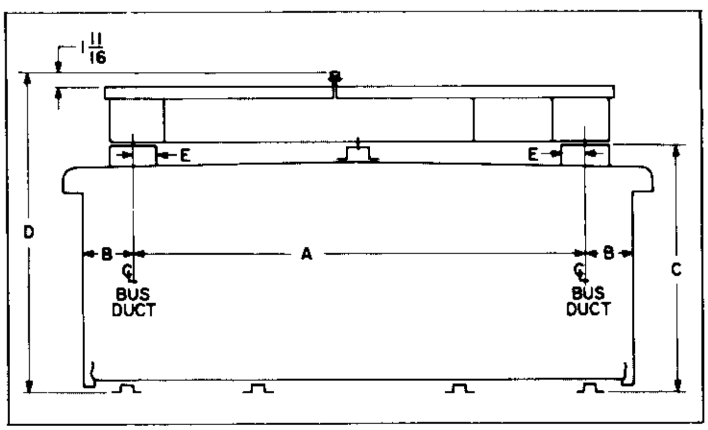


5, 7.5 & 15HK switchgear connections for outdoor non 1200 & 2000 A*

Type△	B	C	D†
5 HK-75 5 HK-250	131	$117\frac{1}{16}$	$16\frac{5}{8}$
7.5 HK-500 15 HK-500 15 HK-750	$153\frac{5}{8}$	$137\frac{15}{16}$	$35\frac{5}{16}$

△ Refer to nearest district office for bus duct information relating to 5 HK-350 an
HK-1000 applications.

† Minimum and intermediate depth only. For extra depth switchgear, add 8″.



* Dimensions are approximate and subject to change without notice. Do not use for construction. All dimensions are in inches.

5, 7.5 & 15HK cross-over bus duct (Outdoor walk-in, double row) 1200 & 2000 A*■

Type△	A°	B†	C	D
5 HK-75 5 HK-250	$161\frac{1}{4}$	$16\frac{5}{8}$	105	$120\frac{3}{4}$
7.5 HK-500 15 HK-500 15 HK-750	$152\frac{5}{8}$ $168\frac{5}{8}$	$45\frac{15}{16}$	$115\frac{5}{8}$	$133\frac{3}{4}$

△ Refer to nearest district office for bus duct information relating to 5 HK-350 an
HK-1000 applications.

° Minimum and intermediate depth only. For extra depth switchgear, add 16″.

† Minimum depth only. For intermediate and extra depth switchgear, add 8″.

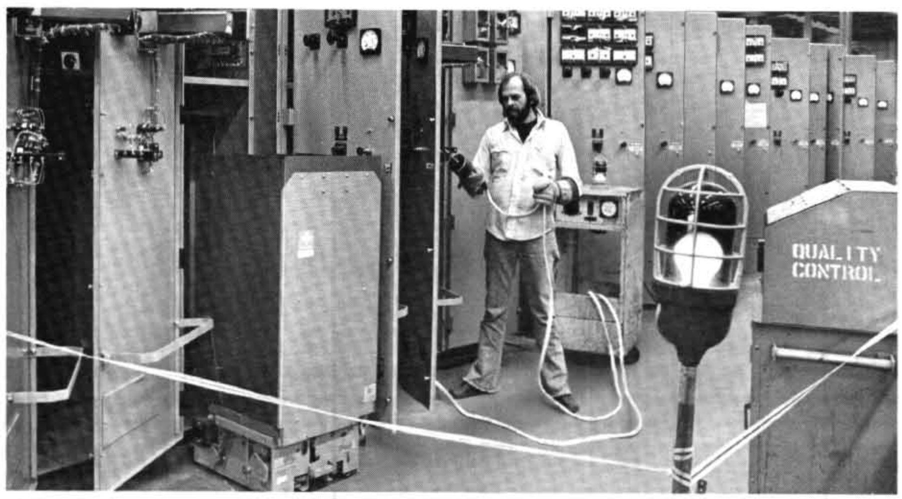
■ For 1200 or 2000 Ampacity, bus can be located inside walk-in housing. Consult nearest district office.

Careful manufacture with quality assurance every step of the way

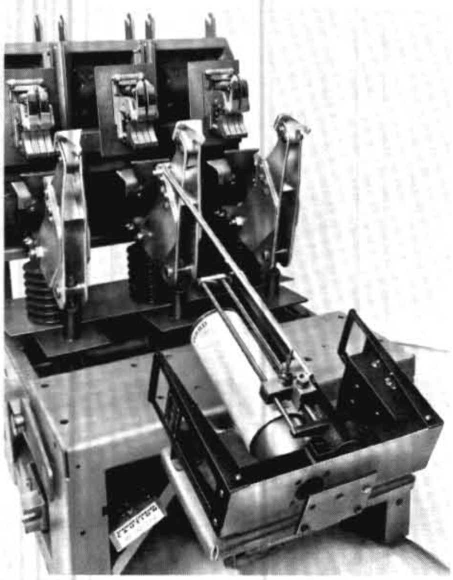
The quality concept is an inherent part of our products, from design through each of the various stages of manufacturing. The thorough quality assurance programs that have been established for I-T-E Metal-Clad Switchgear maintain a level of quality in the finished product that ensures safe, reliable protection of your electrical power system.

Testing Laboratory works constantly to assure process solutions, metals and materials used in manufacturing meet high quality standards.

Each circuit breaker manufactured is tested in special fixtures to assure dimensional accuracy and proper alignment of circuit breaker with the switchgear.

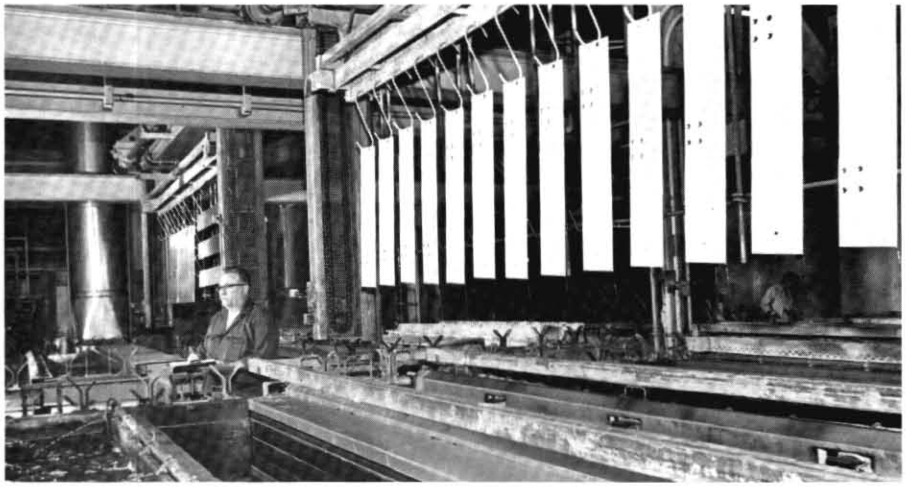


Each switchgear assembly is tested prior to shipment in accordance with appropriate NEMA and ANSI standards.



The Cincinnati analyzer is used to check velocity of moving contacts and produce travel time characteristic records of every circuit breaker.

Final production tests are made on each circuit breaker including Corona and High-Pot tests to industry standards.

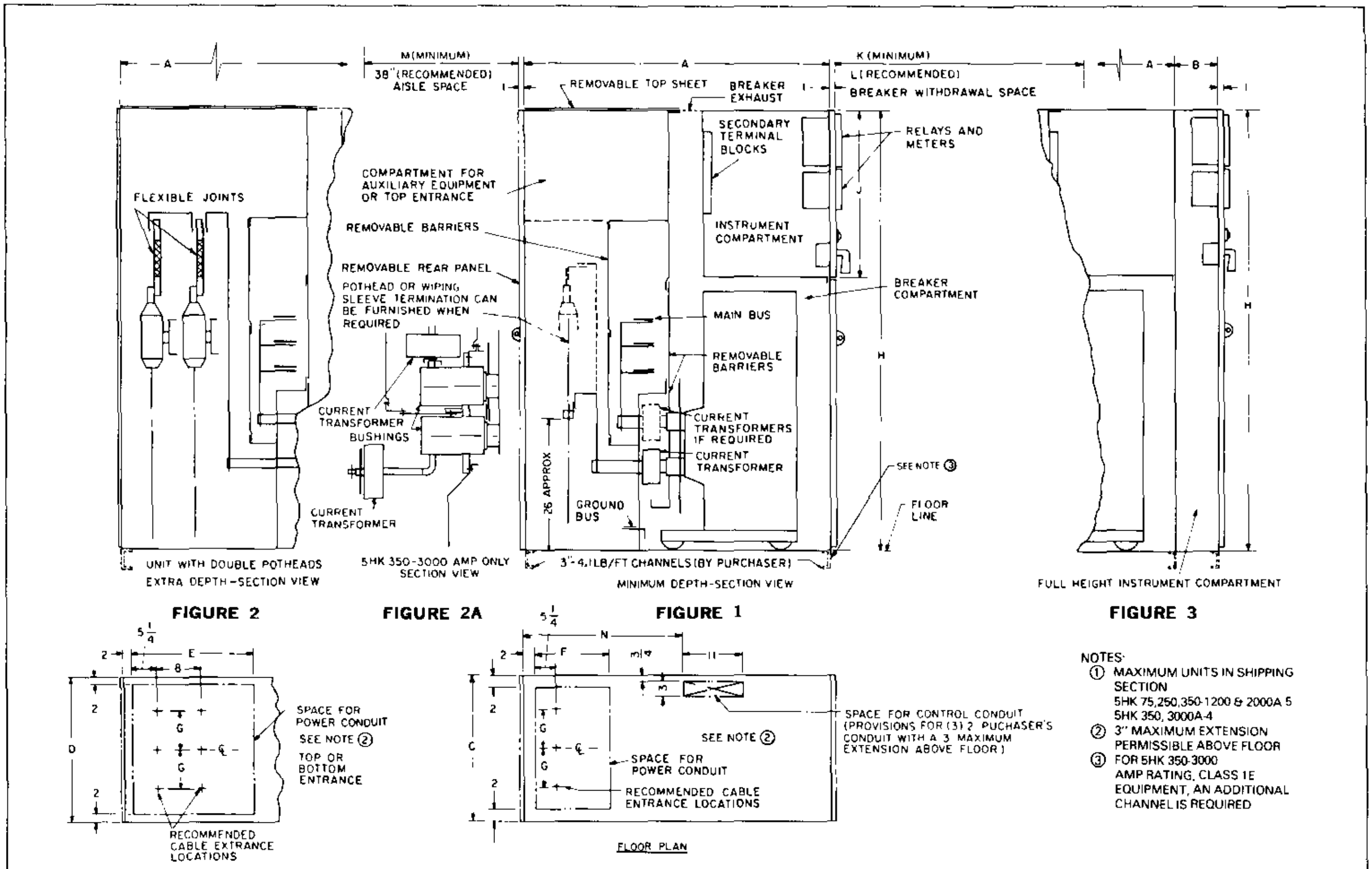


Electroplating equipment assures a uniform plating thickness on all surfaces of parts being processed.

Computerized tape controlled presses are used to accurately fabricate switchgear panels and subassembly parts.

Latest multi-stage cleaning and painting equipment operating under controlled standards provide uniform paint thickness on all parts.

Dimensions
5 HK Indoor Switchgear



DIMENSIONS

Dimensions

Breaker Type	Indoor Construction	A	B	C	D	E	F	G•	H	J	K	L	M	N
5 HK 75 1200 Amp	Minimum Depth Refer to Figure 1*	56	—	26	—	—	13½	7		30				29
5 HK 250 {1200 Amp / 2000 Amp}	Intermediate Depth‡ (Full Height Instrument Compartment) Refer to Figure 3		8						80	—				—
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear) Refer to Figure 2-3	64		—	26	21½	—	7			36	60	28	37
5 HK 350 {1200 Amp / 2000 Amp}	Minimum Depth Refer to Figure 1*	56	—	26	—	—	13½	7		30				29
	Intermediate Depth‡ (Full Height Instrument Compartment) Refer to Figure 3		8						90	—				—
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear) Refer to Figure 2-3	64		—	26	21½	—	7						
5 HK 350 3000 Amp	Minimum Depth Refer to Figure 2A	64	—	36	—	—	13½	10		28	52	66	38	37
	Intermediate Depth (Full Height Instrument Compartment) Refer to Figure 3		8				■							

* Add 4" to A when line-up includes minimum depth 5HK350, 3000A unit.
‡ Add 4" to B when line-up includes intermediate depth 5HK350, 3000A unit.
• Omit locations at G when cable mounted ground sensors are furnished.
■ Additional space may be required for 5HK350-3000 amp units to meet cable entrance requirements.

Dimensions
5 HK Outdoor Non Walk-in Switchgear

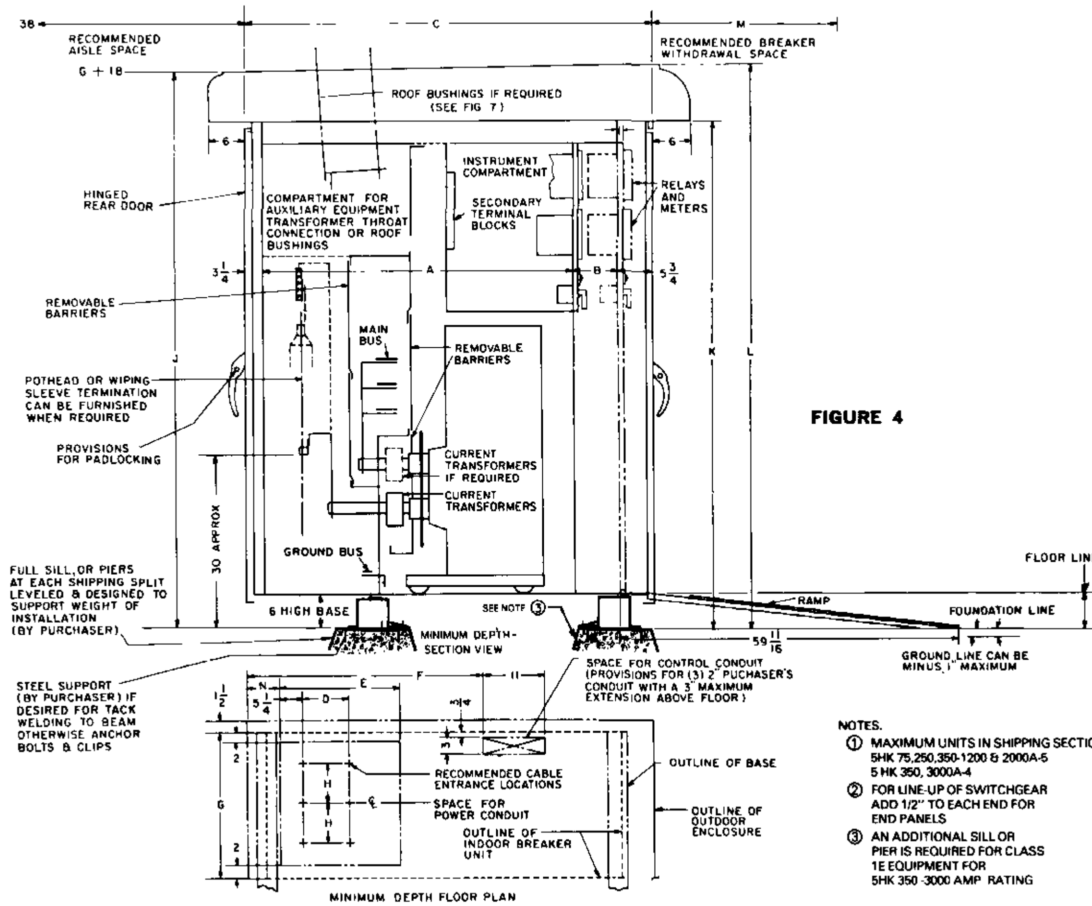


FIGURE 4

NOTES.
1. MAXIMUM UNITS IN SHIPPING SECTION 5HK 75,250,350-1200 & 2000A-5 5 HK 350, 3000A-4
2. FOR LINE-UP OF SWITCHGEAR ADD 1/2" TO EACH END FOR END PANELS
3. AN ADDITIONAL SILL OR PIER IS REQUIRED FOR CLASS 1E EQUIPMENT FOR 5HK 350 -3000 AMP RATING

Dimensions

Breaker Type	Outdoor Construction	A	B	C	D	E	F	G	H	J	K	L	M
5 HK 75 1200 Amp	Minimum Depth*	56	—	65	—	13½	32¼	26	7	98 5/16	90¼	101¾	12
5 HK 250 {1200 / 2000} Amp	Intermediate Depth‡ (Full Height Instrument Compartment)		8	73									
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8″ in Rear)	64		81	8	21½	40¼						
5 HK 350 {1200 / 2000} Amp	Minimum Depth*	56	—	65	—	13½	32¼			108 5/16	100¼	111¾	
	Intermediate Depth‡ (Full Height Instrument Compartment)		8	73									
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8″ in Rear)	64		81	8	21½	40¼						
5 HK 350 3000 Amp	Minimum Depth		—	73	—	13½		36	10				12
	Intermediate Depth (Full Height Instrument Compartment)		8	81									

* Add 8″ to A and C and 4″ to F and N when line-up includes minimum depth 5HK350, 3000A unit.
‡ Add 8″ to A and C and 4″ to F and N when line-up includes intermediate depth 5HK350, 3000A unit.
Dimensions are in inches. They are approximate and should not be used for construction.

Dimensions
5 HK Outdoor Walk-in Switchgear

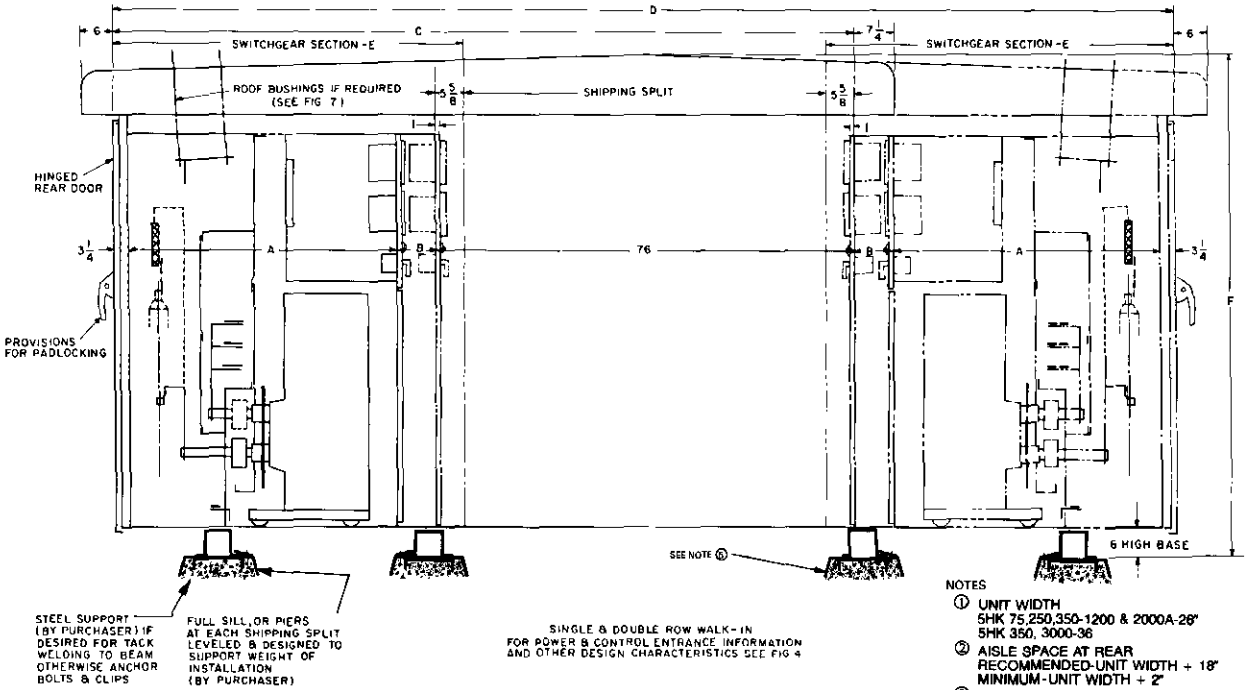


FIGURE 5

NOTES

① UNIT WIDTH
5HK 75,250,350-1200 & 2000A-26"
5HK 350, 3000-36

② AISLE SPACE AT REAR
RECOMMENDED-UNIT WIDTH + 18"
MINIMUM-UNIT WIDTH + 2"

③ FOR LINE-UP OF SWITCHGEAR ADD 1½" TO EACH END FOR END PANELS

④ MAXIMUM UNITS IN SHIPPING SECTION
5HK 75,250,350-1200 & 2000A-5
5HK 350,3000A-4

⑤ FOR 5HK 350-3000 AMP RATING, CLASS 1E EQUIPMENT, AN ADDITIONAL SILL OR PIER IS REQUIRED.

Dimensions

Breaker Type	Outdoor Construction	A	B	C	D	E	F
5 HK 75 1200 Amp	Minimum Depth*	56	—	135¼	194½	64⅞	
5 HK 250 {1200 / 2000} Amp	Intermediate Depth‡ (Full Height Instrument Compartment)		8	143¼	210½	72⅞	102¾
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)	64		151¼	226½	80⅞	
5 HK 350 {1200 / 2000} Amp	Minimum Depth*	56	—	135¼	194½	64⅞	
	Intermediate Depth‡ (Full Height Instrument Compartment)		8	143¼	210½	72⅞	
	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)	64		151¼	226½	80⅞	112¼
5 HK 350 3000 Amp	Minimum Depth		—	143¼	210½	72⅞	
	Intermediate Depth (Full Height Instrument Compartment)		8	151¼	226½	80⅞	

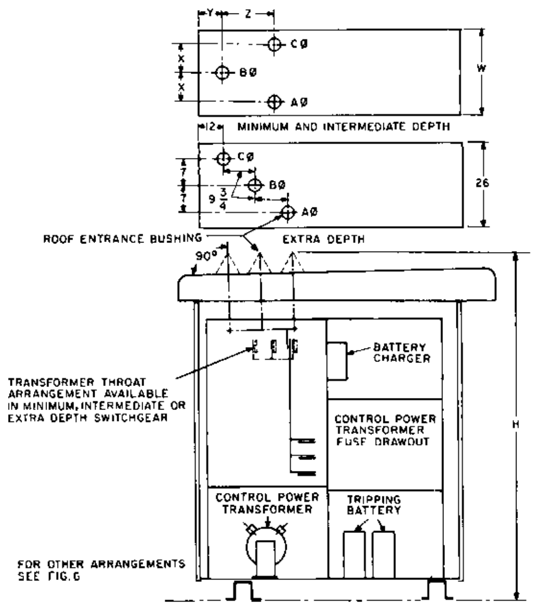
Single Row Walk-in Unit may be converted to Double Row Walk-in by adding additional switchgear section to other side of aisle as shown in phantom.

An additional sill or pier is required for the 5 HK 350 3000 Amp unit when said unit is subject to a seismic experience.

* Add 8" to A and C when line-up includes minimum depth 5 HK-350, 3000A, unit.
‡ Add 8" to A and C when line-up includes intermediate depth 5 HK-350, 3000A, unit.

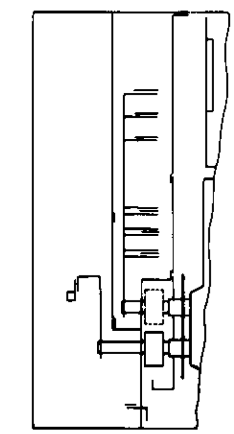
Dimensions are in inches. They are approximate and should not be used for construction.

Dimensions
5 HK Switchgear



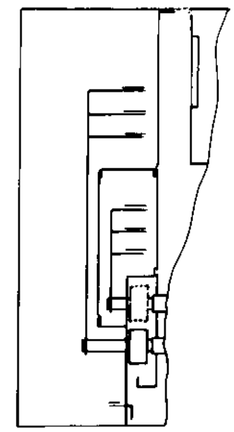
TYPICAL INCOMING LINE AUXILIARY UNIT WITH ROOF BUSHINGS OR TRANSFORMER THROAT

FIGURE 7



BREAKER UNIT ADJACENT TO BUS TIE UNIT WITH BUS TRANSITION (1200 OR 2000 AMP MAIN BUS)

FIGURE 8



BREAKER UNIT BUS TIE (1200 OR 2000 AMP MAIN BUS)

FIGURE 9

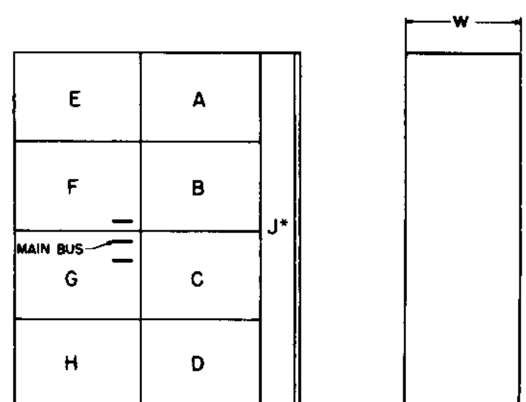
Location chart for 5 HK auxiliary units

Preferred Equipment Locations	
Equipment	**Order of Preference**
Incoming Line from Above	E, F, & G (All)
Incoming Line from Below	F, G, & H (All)
Relays & Instruments	A-B-C-D-J
Drawout Fuses & Mech. Interlocked ET Breaker (for Cpt.)	B-E-C { E Not Normally Used for Drawout Units in Walk-in Construction
Control Power Transformer*	C & D (Both) or G & H (Both)
Battery Charger	C-J
Control or Tripping Battery (48V)	C & D (Both)
1, 2 or 3 PT's	B-C-D-E-H { E, F, H & G Not Normally Used for Drawout Units in Walk-in Construction F & G May Be Used if There is No Main Bus
Lightning Arresters	H-E-D

Height & Depth Dimensions of Auxiliary Unit to Match Adjacent Breaker Unit.

* Limited to 25 kVA, 1 Ø max. For larger sizes, refer to nearest District Office.
Dimensions are in inches. They are approximate and should not be used for construction.

				W	
Breaker Type	**X**	**Y**	**Z**	**ACB**	**AUX**
5 HK 75 1200 A					
5 HK 250 1200 A					
5 HK 250 2000 A	7	11	12	26	26
5 HK 350 1200 A					
5 HK 350 2000 A					
5 HK 350 3000 A	10	11	$13\frac{5}{8}$	36	40

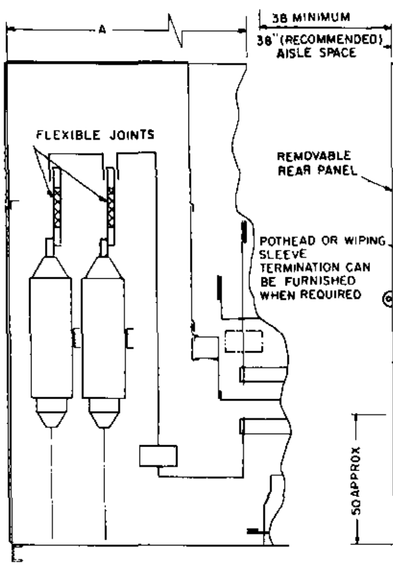


*FULL HEIGHT INSTRUMENT COMPARTMENT ONLY

BREAKER WITHDRAWAL SIDE

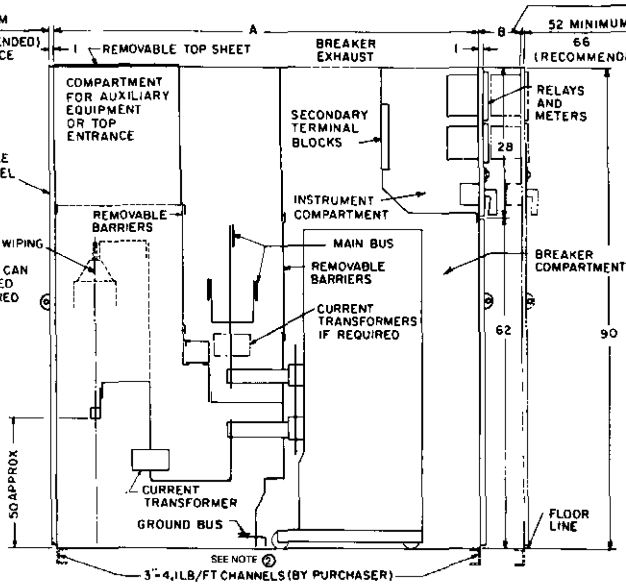
FIGURE 6

Dimensions
7.5 & 15 HK Indoor Switchgear



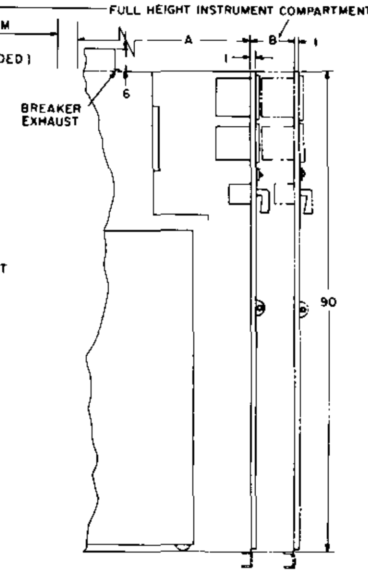
UNIT WITH DOUBLE POTHEADS EXTRA DEPTH-SECTION VIEW

FIGURE 11



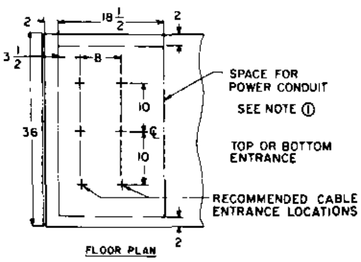
MINIMUM OR INTERMEDIATE DEPTH SECTION VIEW

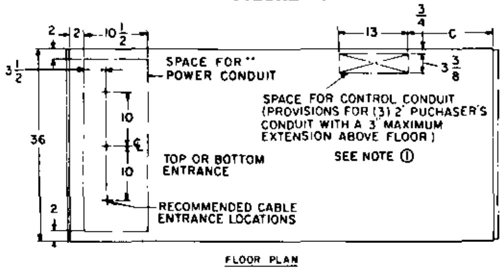
FIGURE 10



SECTION VIEW 750 MVA OTHERWISE SAME AS FIG 10

FIGURE 12





**3" MAXIMUM EXTENSION ABOVE FLOOR

NOTES:
① 3" MAXIMUM EXTENSION PERMISSIBLE ABOVE FLOOR. OMIT LOCATION AT 10" WHEN CABLE MOUNTED GROUND SENSORS ARE FURNISHED.
② ONE ADDITONAL CHANNEL IS REQUIRED FOR 15HK 750 UNITS. FOR CLASS 1E EQUIPMENT ONE ADDITIONAL CHANNEL IS REQUIRED, APPLICABLE TO ALL 15HK UNITS

Dimensions

Breaker Type		Indoor Construction	A	B	C
7.5 HK 500	1200 Amp 2000 Amp	Minimum Depth—Refer to Figure 10	81	—	16
		Intermediate Depth (Full Height Instrument Compartment) Refer to Figure 12		8	
15 HK 500	1200 Amp 2000 Amp	Extra Depth (Full Height Instrument Compartment) (Additional 8" in Rear) Refer to Figures 11 & 12	89		
15 HK 750	1200 Amp 2000 Amp	Minimum Depth—Refer to Figure 10		—	24
		Intermediate Depth (Full Height Instrument Compartment) Refer to Figure 12		8	
		Extra Depth (Full Height Instrument Compartment) (Additional 8" in Rear) Refer to Figures 11 & 12	97		

Dimensions are in inches. They are approximate and should not be used for construction.

Dimensions
7.5 & 15 HK Outdoor Switchgear

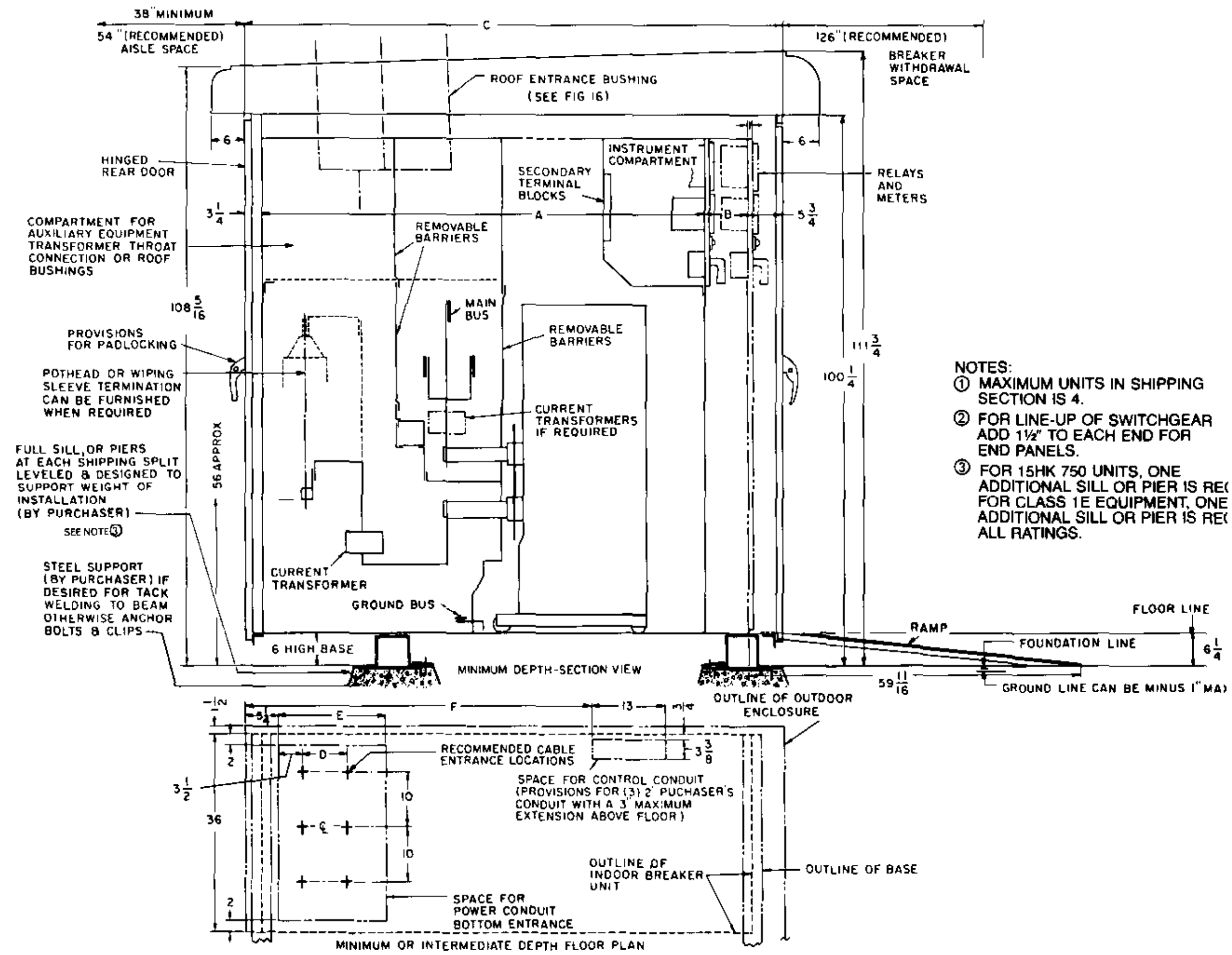


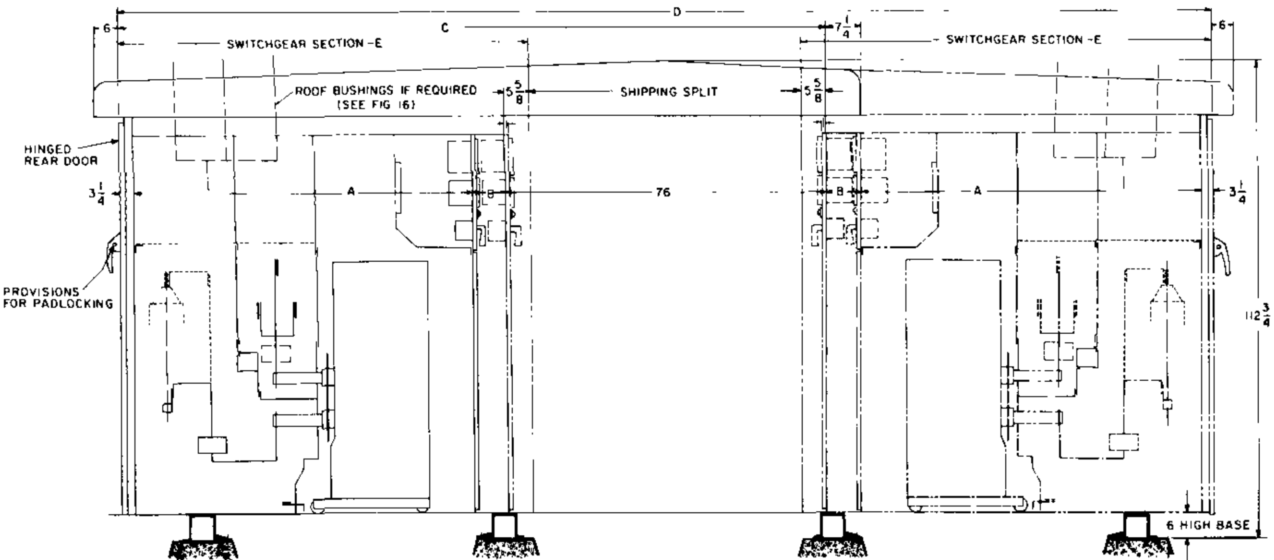
FIGURE 13

Dimensions

Breaker Type		Outdoor Construction	A	B	C	D	E
7.5 HK 500	1200 Amp / 2000 Amp	Minimum Depth	81	—	90	—	10½
		Intermediate Depth (Full Height Instrument Compartment)		8	98		
15 HK 500	1200 Amp / 2000 Amp	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)			106	8	18½
15 HK 750	1200 Amp / 2000 Amp	Minimum Depth	89	—	98	—	10½
		Intermediate Depth (Full Height Instrument Compartment)		8	106		
		Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)	97		114	8	18½

Dimensions are in inches. They are approximate and should not be used for construction.

Dimensions
7.5 & 15 HK Outdoor Walk-in Switchgear



STEEL SUPPORT (BY PURCHASER) IF DESIRED FOR TACK WELDING TO BEAM OTHERWISE ANCHOR BOLTS & CLIPS
SEE NOTE ④

FULL SILL, OR PIERS AT EACH SHIPPING SPLIT LEVELED & DESIGNED TO SUPPORT WEIGHT OF INSTALLATION (BY PURCHASER)

SINGLE & DOUBLE ROW WALK-IN FOR POWER AND CONTROL ENTRANCE INFORMATION AND OTHER DESIGN CHARACTERISTICS SEE FIG. 13

FIGURE 14

NOTES:
① AISLE SPACE AT REAR RECOMMENDED-54" MINIMUM-38"
② MAXIMUM UNITS IN SHIPPING SECTION IS 4.
③ FOR LINE-UP OF SWITCHGEAR, ADD 1½" TO EACH END FOR END PANELS.
④ FOR 15HK 750 UNITS, ONE ADDITIONAL SILL OR PIER IS REQUIRED. FOR CLASS 1E EQUIPMENT, ONE ADDITIONAL SILL OR PIER IS REQUIRED, ALL RATINGS.

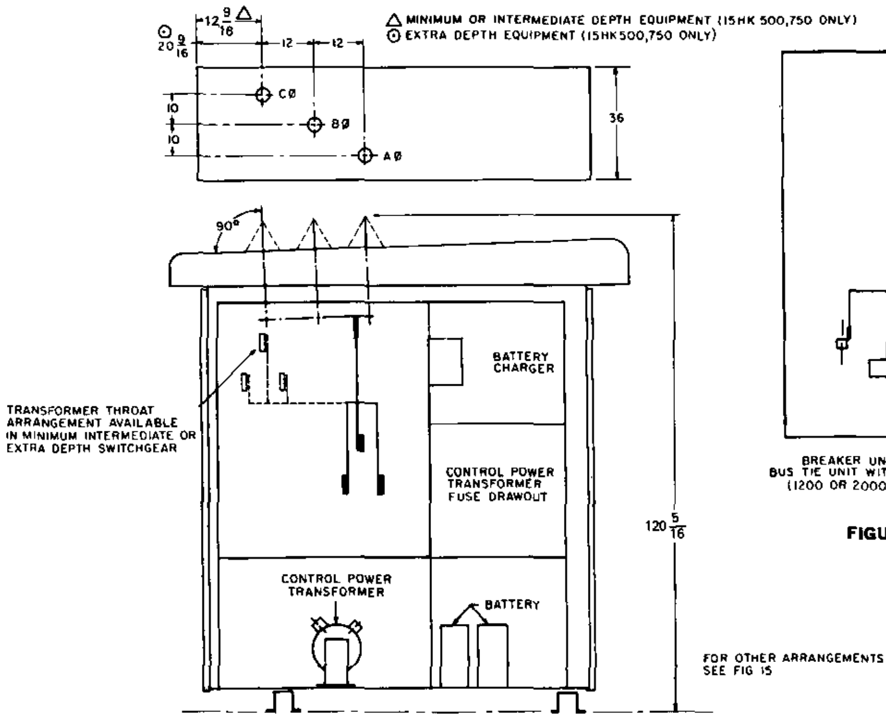
Dimensions

Breaker Type		Outdoor Construction	A	B	C	D	E
7.5 HK 500	1200 Amp 2000 Amp	Minimum Depth	81	—	160¼	244½	89⅞
		Intermediate Depth (Full Instrument Compartment)		8	168¼	260½	97⅞
15 HK 500	1200 Amp 2000 Amp	Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)			176¼	276½	105⅞
15 HK 750	1200 Amp 2000 Amp	Minimum Depth	89	—	168¼	260½	97⅞
		Intermediate Depth (Full Height Instrument Compartment)		8	176¼	276½	105⅞
		Extra Depth (Special Application) (Full Height Instrument Compartment) (Additional 8" in Rear)	97		184¼	292½	113⅞

Single Row Walk-in Unit may be converted to Double Row Walk-in by adding additional switchgear section to other side of aisle as shown in phantom.

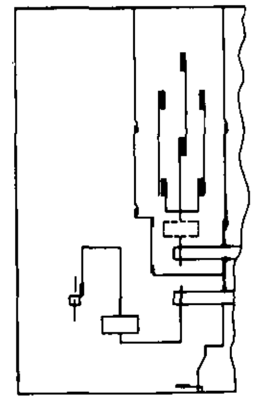
Dimensions are in inches. They are approximate and should not be used for construction.

Dimensions
7.5 & 15 HK Switchgear



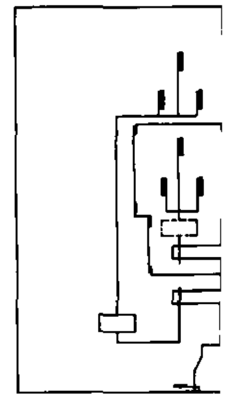
TYPICAL INCOMING LINE AUXILIARY UNIT WITH ROOF BUSHINGS OR TRANSFORMER THROAT

FIGURE 16



BREAKER UNIT ADJACENT TO BUS TIE UNIT WITH BUS TRANSITION (1200 OR 2000 AMP MAIN BUS)

FIGURE 17



BREAKER UNIT BUS TIE (1200 OR 2000 AMP MAIN BU!

FIGURE 18

Location chart for 7.5 & 15 HK auxiliary units

Preferred Equipment Locations	
Equipment	**Order of Preference**
Incoming Line from Above	D-E & G (All)
Incoming Line from Below	F-E & G (All)
Relays & Instruments	A-B-C-H
Drawout Fuses & Mech. Interlocked Molded Case Breaker (For C.P.T.)	B-F-C {F Not Normally Used for Drawout Units in Walk-in Construction
Control Power Transformers	C-F
Battery Charger	A-H
Control or Tripping Battery (48V)	C
1, 2 or 3 pts.	B-C-F-D {D & F Not Normally Used for Drawout Units in Walk-in Construction.
Lightning Arresters	F-D-C

Overall Dimensions of Auxiliary Unit to Match Adjacent Breaker Unit
* Limited to 25 kVA, 1Ø max. For larger sizes, refer to nearest District Office.

Dimensions are in inches. They are approximate and should not be used for construction.

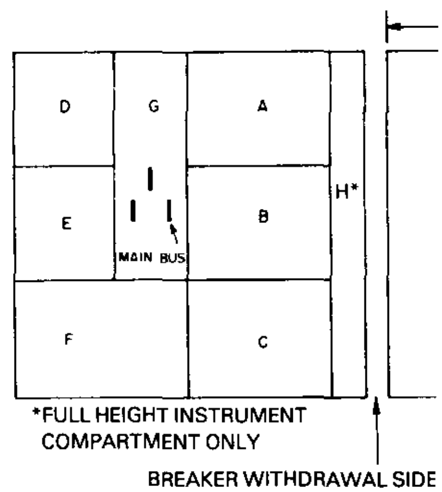
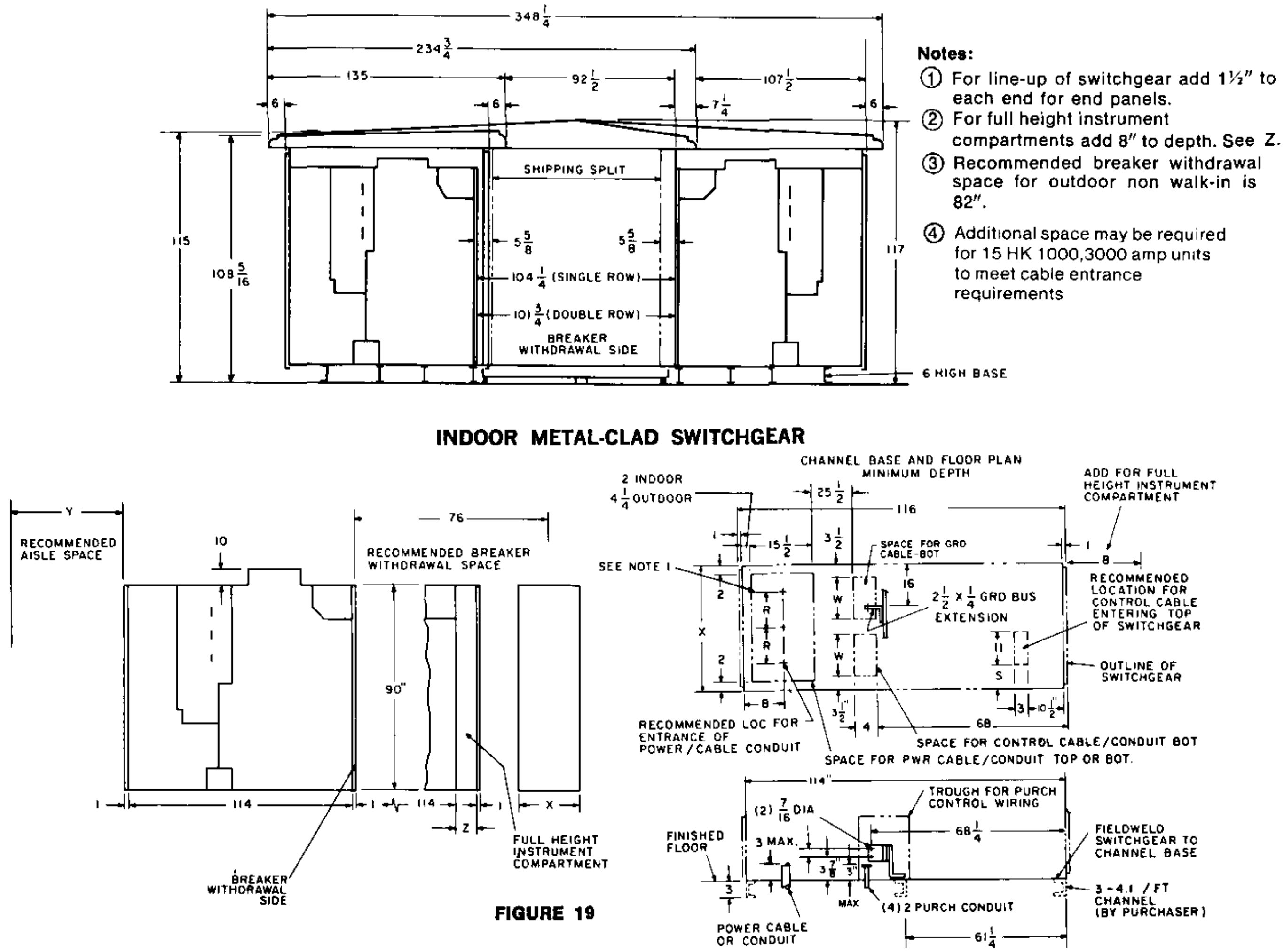


FIGURE 15

Dimensions
15 HK-1000 Indoor and Outdoor Switchgear



Notes:
1. For line-up of switchgear add 1½" to each end for end panels.
2. For full height instrument compartments add 8" to depth. See Z.
3. Recommended breaker withdrawal space for outdoor non walk-in is 82".
4. Additional space may be required for 15 HK 1000,3000 amp units to meet cable entrance requirements

FIGURE 19

Dimensions

Breaker Type	Construction	R▲	S	X	Y	Z	W
15 HK 1000 {1200 Amp. / 2000 Amp	Minimum Depth	10	6	36	38	—	14
15 HK 1000—3000 Amp.		14	9	46	48	—	16
15 HK 1000 {1200 Amp. / 2000 Amp.	Intermediate Depth	10	6	36	38	8	14
15 HK 1000—3000 Amp.	(Full Height Instrument Compartment)	14	9	46	48	8	16

▲ Omit locations at R when cable mounted ground sensors are furnished.

Dimensions are in inches. They are approximate and should not be used for construction.

Approximate Weights

Table of approximate net weights (lbs.)

Type of Breaker	Continuous Current Amperes	Breaker	Switchgear assembly—feeder, incoming line or auxiliary unit (Does not include breaker)										
			Indoor			Non Walk-In Outdoor			Single Row Walk-In Outdoor			Double Row W Outdoor	
			56″	64″	72″	65″	73″	81″	135¼″	143¼″	151¼″	194½″	210½″
5 HK 75	1200	605	1325	1400	1475	1690	1775	1860	2148	2233	2318	3633	3803
5 HK 250	1200	615	1325	1400	1475	1690	1775	1860	2148	2233	2318	3633	3803
5 HK 250	2000	645	1458	1533	1608	1823	1908	1993	2281	2366	2451	3899	4069
		Add Per Switchgear for End Panels				545	606	667	1626	1687	1748	2208	2330
5 HK 350	1200	747	1400	1485	1570	1790	1885	1980	2258	2353	2448	3823	4013
5 HK 350	2000	757	1533	1618	1703	1923	2018	2113	2391	2486	2581	4089	4279
5 HK 350	3000	1500	—	1995	2085	—	2495	2598	—	3050	3153	—	5240
		Add Per Switchgear for End Panels				590	650	710	1671	1731	1791	2298	2418
			81″	89″	97″	90″	98″	106″	160¼″	168¼″	176¼″	244½″	260½″
7.5 HK 500	1200	1070	2170	2260	2350	2675	2778	2880	3230	3333	3435	5600	5806
7.5 HK 500	2000	1095	2411	2501	2591	2916	3019	3121	3471	3574	3676	6082	6288
15 HK 500	1200	1060	2170	2260	2350	2675	2778	2880	3230	3333	3435	5600	5806
15 HK 500	2000	1085	2411	2501	2591	2916	3019	3121	3471	3574	3676	6082	6288
		Add Per Switchgear for End Panels				775	835	895	1912	1972	2032	2658	2778
			89″	97″	105″	98″	106″	114″	168¼″	176¼″	184¼″	260½″	276½″
15 HK 750	1200	1415	2260	2350	2440	2778	2880	2982	3333	3435	3537	5806	6010
15 HK 750	2000	1440	2501	2591	2681	3019	3121	3223	3574	3676	3778	6288	6492
		Add Per Switchgear for End Panels				835	895	955	1972	2032	2092	2788	2908
				114″			123″			226¼″			344½″
15 HK 1000	1200	2600		2650			3450			4950			8400
15 HK 1000	2000	2660		2900			3700			5200			8650
15 HK 1000	3000	3380		3300			4300			5900			10200
		Add Per Switchgear for End Panels					1200			2580			3780

5 HK—Potential transformer drawout unit with 3 PT's—216 lbs. Deduct 32 lbs. for each PT not required.
15 HK—Potential transformer drawout unit with 3 PT's—515 lbs. Deduct 85 lbs. for each PT not required.
5 & 15 KV—Stationary mounted control power transformers to 15 KVA—305 lbs.
5 HK—Drawout fuse unit—160 lbs.
15 HK—Drawout fuse unit—295 lbs.
Breaker Impact Loading—twice the breaker weight (vertical loading); Switchgear impact loading—switchgear weight.

Metal-Clad Switchgear Application Guide

General

Metal-clad switchgear featuring air-magnetic circuit breakers is most properly applied as protective equipment on power systems where the user requires (a) personnel safety; (b) system stability and reliability; (c) adaptability; (d) minimal maintenance; and, (e) low total cost. Personnel safety is one of the prime reasons for user insistence on metal-clad switchgear to perform the power system protective function. Electricity by its very nature is extremely dangerous and entails considerable personnel hazard if not adequately controlled. Metal-clad switchgear enhances system stability and reliability because of its basic construction features and flexibility derived from the multitude of main bus configurations available to the user. It is adaptable to many applications because it is easily expanded and can be specified and designed with load location and load characteristics in mind. Reduced maintenance cost is a result of the drawout features of metal-clad switchgear, as well as superior accessibility of most components. There is no oil to test periodically — no need to incur the expense of changing oil after a major interruption. All this at a reduced total cost to the user. On the average, metal-clad switchgear represents approximately 5% of plant cost. This class of switchgear is generally shipped factory assembled and reduces the need for expensive field assembly.

The application of metal-clad switchgear is a relatively simple procedure in most cases. The following steps are normally taken in applying this equipment:

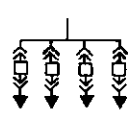
1. Develop single-line diagram and general arrangement (see page 45).
2. Determine required breaker based on continuous current and interrupting capability (see page 42)
3. Select main bus rating.
4. Select current transformers.
5. Select potential transformers.
6. Select protective relays, (see page 20).
7. Determine closing, tripping and power requirements.
8. Consider special applications.

Bus arrangements

Essentially all recognized basic bus arrangements are available in metal-clad switchgear to insure the desired system reliability and flexibility. A choice is made based on an evaluation of initial cost, operating procedures and system requirements. Refer to following for some basic bus arrangements and considerations to evaluate when making the ultimate choice.

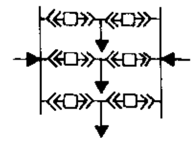
Common bus arrangements

Straight Bus (Radial)



ADVANTAGES: • Low initial cost • Readily adapts to standard indoor or outdoor construction • High reliability factor due to simplicity of system design • Simplified coordination.
DISADVANTAGES: • Inspection, maintenance or repair requires interruption of service • Selectivity between feeders and main crucial if shutdown is to be prevented.

Double Bus - Double Breaker

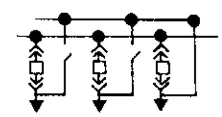


ADVANTAGES: • Good reliability factor • Lends itself to either outdoor (double row walk-in) or indoor metal-clad construction • Provides physical isolation between source buses • Allows inspection and maintenance without load interruption.
DISADVANTAGES: • High cost factor • Increased floor area • Complex operating procedures.

Breaker and Half Scheme

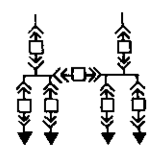
ADVANTAGES: • Good reliability factor • Inspection and maintenance without load interruption • Lends itself to a continuous line arrangement.
DISADVANTAGES: • High cost factor • Additional floor area may be required, depending on final equipment layout.

Main and Transfer Bus



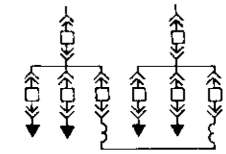
ADVANTAGES: • Provides switching flexibility at reduced cost • Can be provided in a continuous line arrangement • Adaptable to either indoor or outdoor construction • Breakers and disconnect switches can be located in common unit.
DISADVANTAGES: • Interlocking required involving sequential operation of breaker with interlocked switch • Breaker and switch operating mechanism on opposite sides of assembly • Relaying through transfer bus impractical with two or more switches closed • Fault condition on one circuit may cause interruption to several circuits being served by transfer bus.

Sectionalized Bus



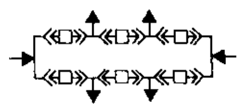
ADVANTAGES: • Single bus provides reduced cost over double bus arrangement • Intermediate flexibility and reliability attained through power transfer equipment • Extended reliability can be provided by paralleling feeders to critical loads • Adapts readily to standard construction configurations.
DISADVANTAGES: • Momentary load interruption probable during transfer operation • Delay in transfer may be required to allow decay in residual voltage on down side of this breaker • Momentary paralleling of supplies may exceed breaker rating

Synchronizing Bus



ADVANTAGES: • Basic advantages duplicate those of the sectionalized bus but with increased reliability through the addition of sources. Prime advantage is that reactor bus allows strategic installation of current limiting reactors.
DISADVANTAGES: • Basic disadvantages duplicate those of sectionalized bus with increased complexity in relaying of power transfer.

Ring Bus



ADVANTAGES: • Good reliability and flexibility • Low initial cost when compared to a double bus arrangement • Can be arranged in single row line-up when main bus is rated less than 3000 amperes • Adapts to either indoor or outdoor construction • Can be designed to accommodate a multiple-source arrangement.
DISADVANTAGES: • Main bus of 3000 amperes requires overhead bus duct • Relaying increases in complexity as sources are added.

Breaker selection

Usually, the principal function of power circuit breakers is to carry load current and provide a means for the interruption of short-circuit current. Continuous current ratings of power circuit breakers are generally contingent on feeder and main breaker loading. The breaker interrupting capacity (IC) must be sufficient to safely interrupt the maximum short circuit current that the power system can deliver with a three phase bolted fault applied to the terminals of the circuit breaker. Sometimes frequent switching or reclosing may be the determining factor in breaker selection, rather than the requirements of continuous current rating and/or short-circuit current interruption.

Unusual service conditions as defined in ANSI C37.04 must be considered when applying power circuit breakers. Such conditions should be brought to the attention of the circuit breaker manufacturer at the earliest possible time. Some special application considerations and unusual service conditions are discussed on page 41 and 42.

Power circuit breakers are sometimes used for reclosing duty to maintain service continuity. When applied in this manner the interrupting capacity of the breaker must be derated in accordance with Figure 1.

A complete line of HK air-magnetic power circuit breakers is available. They are listed in Table 7. Repetitive duty capability and normal maintenance requirements are listed in Table 3, page 38.

Capability factors for automatic reclosing circuit breakers

The following standard capability factors apply to all a-c high-voltage circuit breakers as shown in American National Standard Schedules of Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers. C37.06 - 1966, which are rated below 72.5 kV and have continuous current ratings of 1,200 amperes and below. Breakers with continuous current ratings above 1,200 amperes are not intended for reclosing service applications. When such applications arise, contact the nearest district office.

A duty cycle shall not contain more than 5 opening operı
All operations within a 15-minute period are considered part of the same duty cycle.

General:

The circuit breaker may be applied at the determined operatii voltage and duty cycle to a circuit whose calculated short circ does not exceed the symmetrical interrupting capability as determined.

If the X/R ratio for the circuit exceeds 15, refer to ANSI C37.010 — 1972 for complete information.

Step #1 Determine the breaker symmetrical interrupting capability at the operating voltage from Table 6.

Step #2 Determine the factor of d_1 from the reclosing caı curve in Fig. 1 for the current value determined in step #1.

Step #3 The symmetrical interrupting capability of the breaker for the operating voltage and duty cycle desired is nc determined by multiplying the step #1 symmetrical interruptiı capability by reclosing capability factor R from Fig. 2 (for duty cycles listed).

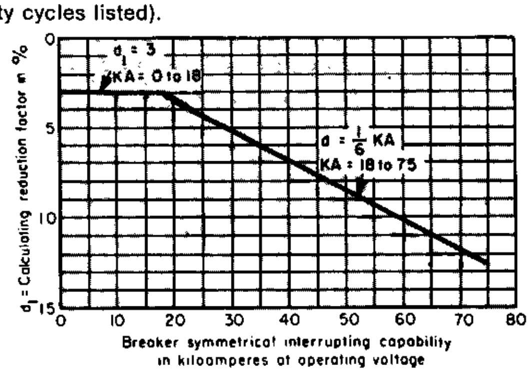


FIG. 1 AC High-Voltage Circuit Breaker Interrupting Capability for Reclosing Service

$R = 100 - D(\%)$

$D = d_1 (n - 2) + d_1 \frac{(15 - t_1)}{15} + d_1 \frac{(15 - t_2)}{15} + \ldots$

D = total reduction factor in percent

d_1 = calculating factor for D in percent of breaker symmetrical intı ing capability at operating voltage

n = total number of openings

t_1 = first time interval less than 15 sec.

t_2 = second time interval less than 15 sec.

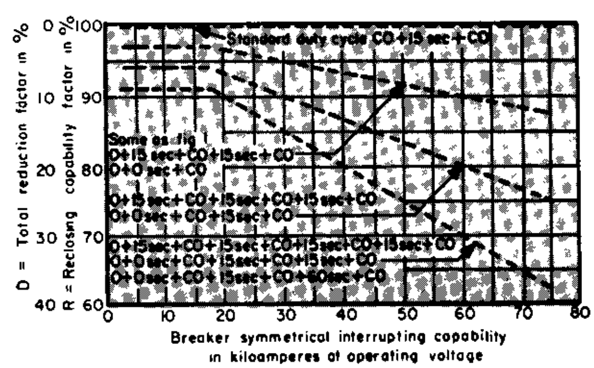


FIG. 2 Examples of Popular Reclosing Capabilities

Application Guide

Repetitive duty and normal maintenance for other than arc furnace switching

HK air-magnetic circuit breakers, when operating under usual service conditions, are capable of operating the required number of times given in Table 3. The operating conditions and the permissible effect upon the breakers are specified in the notes.

For each column, all notes listed must be given consideration. (Reference ANSI C37.06 —1971.) As a guide for **capacitor or reactor switching,** use values listed in column 5 only. For back-to-back switching applications refer to the nearest district office.

Table 3*

Breaker Type	Breaker Continuous Current, A	Maximum No. of Operations Between Servicing (Note A)	No load Mechanical (Notes B, E, F, G, H, I)	Full-load Non-Fault (Notes C, E, F, G, H, J)	Full-load Fault (Notes D, E, F, G, H, I, K)	Inrush Non-Fault (Notes D, E, F, G, H, J)	Inrush Fault (Notes D, E, F, G, H, I, K)
Column 1		Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
5HK-75	1200	2000	10000	5000	1000	3000	750
5HK-250	1200			5000		3000	
5HK-250	2000			3000		2000	
5HK-350	1200	1000	5000	2500	500	1500	400
5HK-350	2000						
5HK-350	3000						
7.5HK-500	1200	2000	10000	5000	1000	3000	750
7.5HK-500	2000			3000		2000	
15HK-500	1200	2000	10000	5000	1000	3000	750
15HK-500	2000			3000		2000	
15HK-750	1200	2000	10000	5000	1000	3000	750
15HK-750	2000			3000		2000	
15HK-1000	1200	1000	5000	2500	500	1500	400
15HK-1000	2000						
15HK-1000	3000						

* Additional ratings not listed above are also available. Consult nearest District Office.

Servicing

A. Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by Brown Boveri Electric. The operations listed are on the basis of servicing at intervals of six months or less.

Circuit Conditions

B. When closing and opening no load.
C. When closing and opening currents up to the continuous current rating of the breaker at voltages up to the maximum design voltage and at 80 per cent power factor or higher.
D. When closing currents up to 600 per cent and opening currents up to 100 per cent (80 per cent power factor or higher) of the continuous current rating of the breaker at voltages up to the maximum design voltage.

Operating Conditions

E. With up to rated control voltage applied.
F. Frequency of operation not to exceed 20 in 10 minutes or 30 in 1 hour. Rectifiers or other auxiliary devices may further limit the frequency of operations.
G. Servicing at not greater intervals than shown in Column 2.

Condition of the Breaker After the Operations Shown in the Table.

H. No parts shall have been replaced.
I. The breaker shall meet all of its current, voltage and interrupting ratings.
J. The breaker shall meet all of its current and voltage ratings but not necessarily its interrupting ratings.

Operation Under Fault Conditions

K. If a fault operation occurs before the completion of the permissible operations, it is not to be inferred that the breaker can meet its interrupting rating or complete its number of operations without servicing and making replacements if necessary.

Main bus rating

The continuous current rating of the switchgear main bus should normally match that of the main circuit breaker. With a single incoming line, HK switchgear has standard, 60 Hz continuous current ratings of 1200, 2000 and 3000 amperes.

The rated continuous current of a switchgear assembly is the maximum current in rms amperes, at rated frequency, which can be carried continuously by the primary circuit components without causing temperatures in excess of limits specified in ANSI C37.20.

The main bus will be designed and rated for the full ampere capacity specified and will not be tapered for the purpose of reducing current densities. As power system facilities must be increased from time to time to serve larger loads, it is advisable to consider future expansion when selecting the bus continuous current rating.

The switchgear assembly should have momentary and short-time ratings equal to the close and latch capability and short-time rating of the circuit breaker. Applicable ratings of HK circuit breakers are listed in Table 6.

Current transformers

(See Table 10)

Current transformers are used to transform primary currents into secondary terms, usually 5 amperes. They are used in the application of instruments meters and relays. In switchgear applications, they are of the toroidal-type construction. They are also manufactured in single-secondary, double-secondary and multi-ratio types, whichever is required. The double secondary type may be used where two transformers of the same ratio are required in the same location. This affords a saving of space.

Current transformers are used to isolate the primary circuit from the secondary auxiliary equipment and to lower the applicable amperes to a safe and usable value. They are selected so that all ratings such as impulse, dielectric and voltage are to be equal to or greater than that of the circuit breaker; the primary current rating to be equal to approximately 125 per cent of the normal primary current in the circuit; the mechanical strength of the transformer is to be equal to or greater than that of the breaker; and, the metering and/or, relaying accuracy must be adequate for the imposed burdens.

Potential transformers (See Table 13, page 43)

Potential transformers are used to transform primary voltages into secondary terms, usually 120 volts. The primary rating of a potential transformer is that which is equal to, or higher than the system voltage. For instance, on a 13,800 volt system, a potential transformer with a standard 14,400 volt primary rating is used. As in the use of current transformers, potential transformers are used for instrumentation, metering or relaying.

Potential transformers are used to isolate the primary circuit from the secondary auxiliary equipment and to lower the voltage to a safe and usable value. They are selected so that all ratings such as impulse, dielectric, etc., must be equal to or greater than the breaker; the accuracy of the transformers must be adequate; and, the primary voltage rating must be equal to or greater than the system voltage.

Control power requirements (See Table 8, page 43)

General

The choice of the source of closing and tripping power used in metal-clad switchgear depends upon many factors. Among these factors are the number of circuit breakers in the installation, the number of breakers required to close simultaneously, control power requirements needed for purposes other than operating the circuit breakers, type of circuit breaker mechanism, availability of adequate housing facilities for a battery and its associated charging equipment and future expansion of the system to justify a shift in economic preference from an a-c to d-c control power source.

HK air-magnetic power circuit breakers are held in the closed position by a mechanical latch. They are designed to close and latch up to the "close and latch" rating listed in Table 6. There is no requirement for a continuous supply of electric power to hold the circuit breaker in the closed position. This allows the circuit breaker to provide maximum continuity of service and speed of operation. However, closing power and a fully reliable source of electric power for tripping are needed. Closing and tripping power requirements of HK breakers are listed in Tables 7 & 8, page 43.

Closing Power

Due to the low-energy closing requirements of the HK stored-(mechanism, a 48-volt d-c operating battery is an acceptable s(of tripping power for many applications of metal-clad switchg(However, some applications, such as large industrial plants, a where d-c power will be used for circuit breaker tripping and (or operating control, a 125-volt or 250-volt battery may be preferable. There are also instances where a dependable sour auxiliary control power may be required for various emergenc services. A station battery is generally the only practical sourc of electric power for these requirements. See Table 7 page 43.

Often, the investment required to provide d-c closing pow is unwarranted when compared to the initial cost of metal-clac switchgear. In these instances, a-c closing power supplied fro control power transformers connected to the switchgear's pow system is more economical, with capacitor tripping utilized for safety.

Some basic configurations for providing closing power ar shown in Figures 3, 4, 5 and 6 below. Figure 3 represents a sin fied schematic of a typical d-c closing power arrangement. Figure 4 shows a-c closing power derived from a control powe transformer connected directly to the power system. Also, a-c operation of the stored-energy mechanism can be taken from (lighting or some other general purpose source as illustrated in Figure 5. The energy for the next closing operation is automati stored in the closing springs, thereby allowing a trip-close-trip sequence of operations if closing power should be lost immedi following closure of the circuit breaker. The stored-energy mechanism also allows for complete manual operation as shov Figure 6.

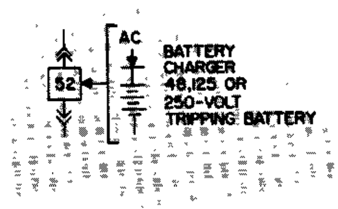


FIG. 3. D-C stored-energy close

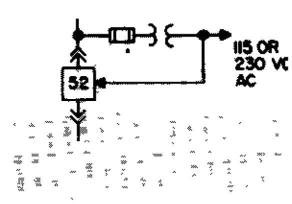


FIG. 4. A-C stored-energy cl

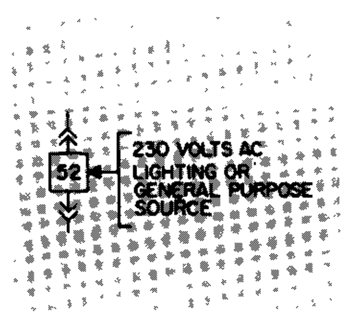


FIG. 5. A-C stored-energy close

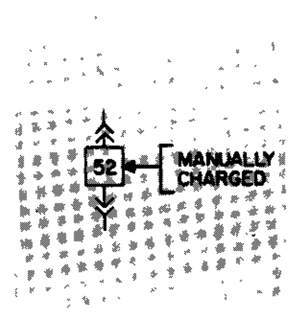


FIG. 6. Manually stored-en close

Application Guide

Tripping Power

Since a battery is not affected by the power circuit voltage and current conditions during time of fault, it is considered the most dependable source of tripping power. The battery is sometimes further provided with sufficient ampere-hour capacity to carry emergency lighting loads if a protected outage of a-c power should occur.

Metal-clad switchgear applied in many electrical installations employs a 125- or 250-volt operating battery as the source of tripping power. Most of the smaller metal-clad switchgear installations, however, generally use 230-volt a-c power for control, indication and circuit breaker closing purposes, with a 24- or 48-volt tripping battery as the source of reliable power for circuit breaker tripping.

When a 125- or 250-volt d-c battery is used for closing power, it is generally also utilized for the breaker tripping circuits. A 48-volt tripping battery is recommended for tripping power applications where a 125-volt or 250-volt battery is not available or is not justifiable. It is particularly satisfactory if more than one lineup of metal-clad switchgear is being served or where appreciable distances are involved. 48 v spring charging is not recommended.

Reliable tripping power requires that the battery be properly maintained. Proper maintenance includes keeping the battery fully charged and the electrolyte maintained at the required level and density to ensure a long life. Also, care should be taken to avoid exposure of the battery to extremely low ambient temperatures which cause reduced voltage output, thereby jeopardizing the battery's circuit breaker tripping capability.

Capacitor Trip

As discussed above, a tripping battery requires some maintenance if it is to remain a dependable source of tripping power. Consequently, on some smaller metal-clad switchgear installations, a capacitor energized trip device has been employed. This device has the advantages of reduced space and minimum maintenance requirements. However, it has the serious limitation of being able to provide ample tripping power from the capacitor charge for only a short time should the a-c control voltage fail. Tripping power from the capacitor trip unit may not be available to trip a breaker when an attempt is made to re-energize a bus if a fault had occurred on a circuit while the bus was dead. This could occur during maintenance, construction or reconstruction, test operation or during a storm.
This limitation has further prevented the use of capacitor tripping schemes for many applications. It is important to note that when a capacitor-energized trip device is applied as a source of tripping power, it must be supplied for each breaker, in its respective cubicle.

Power for other uses

Closing or tripping power may be used for purposes other than closing or tripping power circuit breakers. Power for various control purposes such as space heaters, convenience outlets, lighting, indicating-lamp circuits, exhaust fan motors, sequential and interlocking circuits of automatic equipment, etc. is generally derived from the closing power source. However, should the circuits involved be an integral part of the protective scheme and not embody a continuously energized device, tripping power is used as the source of control power.

Space heaters are supplied as standard on outdoor metal-clad switchgear in accordance with Table 11. Often, ambient temperature or other environmental conditions dictate the use of space heaters in indoor metal-clad switchgear as well. When space heaters are furnished, it is recommended that they be continuously energized by an a-c power source. If a-c closing power is available, this source can also be used for the heaters provided it is of sufficient capacity to supply the continuous current requirements of the space heaters and the inrush loading of breaker closing.

Quality assurance

Brown Boveri Electric fully complies with the requirements of NCR Regulation 10CFR50 Appendix B, ANSI Standard N45.2 — 1971, MIL-I-45208 and ANSI Z1.8 — 1971, with our quality assurance program.

The intent of the Quality Assurance Program provides assurance that the finished switchgear and associated accessories performs and conforms to all applicable specifications and drawings prior to shipment and assures that all items reach their destination in the condition ready for service. It is also the intent of the quality control system to employ sufficient control throughout the various stages of manufacturing, assembly and testing to assure that the quality level of the finished products is achieved in the most efficient and economical manner.

Seismic qualification

The purpose of seismic qualification per IEEE 344-1975 is tc demonstrate that Class 1E equipment will meet its performance requirements, both during and following an SSE (Safe Shutdown Earthquake). Seismic qualification can be demonstrated or proven by tests, analysis, or a combination of analysis and tests.*

Extensive testing and analysis has been performed on products in accordance with IEEE 344 and the users RRS (Required Response Spectrum). As new equipment is specified for use in Class 1E applications or the Seismic Response Spectra increase in value, additional testing and analysis will be accomplished to demonstrate that these equipments are seismically qualified.

Switchgear system qualification with IEEE 323-1974

Data to support the conclusion that all items of safety related switchgear are capable of performing their design safety functions under the normal and accidental environmental conditions, has been accumulated, analyzed and is available as a Qualification Summary Report if specified by the user.* The Qualification Summary Report contains a summary of the qualification tests and analysis performed. It also references in detail, the test plans and test reports. If the user follows the recommendations for maintenance, inspection and periodic testing, the switchgear can be maintained in a fully operational condition throughout its installed life.

* Optional adder

NEC & OSHA requirements

NEC generally describes parameters and techniques for a safe installation, which is also the concern of OSHA. Our switchgear is provided with the provisions for safe installation. If there are any questions regarding I-T-E equipment relative to above requirements, contact the nearest District Office for latest information.

Special application considerations

Reactor switching

HK air-magnetic power circuit breakers are capable of switching reactive load current up to their full continuous current rating. Reactor switching applications wherein the reactor(s) are in close proximity (within ten feet) of the circuit breaker(s) should be referred to the nearest District Office for consideration.

Capacitor switching

Standard HK circuit breakers are capable of switching capacitors, single or back-to-back, in accordance with the data outlined in Table 4 below.

Capacitor installations are generally applied on both utility and industrial power systems to improve voltage regulation, enhance system stability and to provide for system expansion.

The shunt bank or back-to-back capacitor switching application means either connecting or disconnecting a capacitor bank to or from a bus to which a single bank, equal to or less than the switching bank, is already connected. Generally, HK air-magnetic circuit breakers can switch any capacitor bank as long as the breaker's continuous current rating equals or exceeds 1.35 times the nominal current rating of the capacitor bank. However, for complex capacitor switching applications or where frequent switching is contemplated, contact the nearest district office for recommendations.

Table 4—Maximum 3-phase, single-capacitor-bank switching

Capacitor Voltage, Volts	HK Breaker Continuous Current Rating* 1200A		2000A	
	Capacitor Bank KVAR	Capacitor Switching Capability, A	Capacitor Bank KVAR	Capacitor Switching Capability, A
2400	3700	890	6200	1480
4160	6400	890	10700	1480
4800	7400	890	12300	1480
7200	11100	890	18500	1480
12470	19200	890	32000	1480
13800	21500	890	35400	1480

NOTES: Ratings are subject to the following conditions:

1. The transient voltage from line to ground shall not exceed 3 times maximum design line-to-ground crest voltage measured at the breaker terminals.
2. The number of restrikes or reignitions shall not be limited as long as the transient voltage to ground does not exceed the value given in Note 1.
3. The capacitor rating applies only to "Single Bank Switching" as noted herein.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.

* For 3,000A, refer to the nearest district office.

Automatic bus transfer times for station auxiliaries

Importance of bus transfer times

Bus transfer can be initiated under two conditions. The first condition is called **routine transfer** and is done when the generating unit is started up or shut down. The second conditi is called **emergency transfer** and is necessary upon failure of the normal source of power. Routine transfer can be handled in many ways and the problems incurred are generally minor. However, automatic bus transfer of station auxiliaries under emergency conditions, whether for conventional steam or nuclear stations, must be accomplished with a minimum dead bus time. Dead bus time is more critical for nuclear stations because coolant pump motors are involved. If the coolant pum are lost, the nuclear reactor must be shut down!

Bus transfer times should be held to some low value because motors slow down and go out of phase. With these conditions, if the emergency source is energized, there will be large inrush currents. This is undesirable and could result in total loss of the bus under certain conditions. Consequently, there must be a coordinated bus transfer time to keep these conditions to a minimum.

Required dead bus transfer times

There seems to be two prevalent choices of required dead bus time: 50ms (three cycles) or 100ms (six cycles). Of these 100ms (six cycles) is indicated to be generally preferred. Accordingly, this can be thought of as a significant level of comparison with the dead bus transfer times of the HK air-magnetic circuit breakers listed in Table 5.

HK breaker dead bus transfer times

Table 5 lists the dead bus transfer times of HK air-magnetic circuit breakers normally applied on generating station auxiliary circuits:

Table 5—HK breaker dead bus transfer times

Breaker Type	Continuous Current Rating, A	Dead bus transfer time, ms (cycles) Δ* Simultaneous Trip & Close (No arcing)	Simultaneous Trip & Close (With arcing)	Trip then Close using Standard "b" Contact (With arcing)	Trip then Close using Early "b" Contact (With arcing)
5 HK 350	1200	50(3)	20(1.2)	85(5.1)	45(2.7)
	2000	50(3)	20(1.2)	85(5.1)	45(2.7)
	3000	55(3.3)	25(1.5)	120(7.2)	80(4.8)
7.5 HK 500	1200 2000	95(5.7)	55(3.3)	130(7.8)	90(5.4)
15 HK 500	1200 2000	95(5.7)	60(3.6)	145(8.7)	105(6.3)
15 HK 750	1200 2000	95(5.7)	55(3.3)	130(7.8)	90(5.4)

Δ All times shown are nominal.
Tolerance on dead time is ± 16.7ms (1 cycle).

* Special interlocking is available to prevent closing of second b first breaker would fail to open on 7.5 and 15 HK type.

Application Guide

Unusual service conditions

High altitude

American National Standards Institute (ANSI) Standard C37-04-1964, paragraph 04-3.2.2, indicates that high-voltage a-c power circuit breakers applied at altitudes greater than 3,300 feet must have their **dielectric withstand, continuous current,** and **voltage** ratings derated as follows:

Altitude (ft.)	Rating Correction Factor*	
	Continuous Current	Voltage & Dielectric Withstand
3,300 (and below)	1.00	1.00
5,000	0.99	0.95
10,000	0.96	0.80

* Values for intermediate altitudes may be derived from linear interpolation.

When applying these rating correction factors to voltage, always use the circuit breaker maximum design voltage. When derating continuous current, be careful that the derated value is not less than required full load currents. Be especially alert to dual-rated breakers with forced-air cooling.

25 Hertz application

HK circuit breakers are rated at 60 Hertz, but can be applied as low as 50 Hertz without derating. For 25 Hertz application, however, there is a derating factor which must be applied to the breaker's interrupting rating as follows:

Type Breaker	Interrupting Rating MVA	Derating Factor
5 HK	75	1.00
	250	1.00
	350	0.85
7.5 HK	500	0.85
15 HK	500	0.75
	750	0.75
	1000	0.75

Forced air cooling

Additional ratings are available, utilizing forced air cooling, for even greater ampacity. Consult the nearest District Office for latest data.

The full line of I-T-E Type HK Circuit Breakers is rated on a true symmetrical basis

Application data

Table 6—Air magnetic power circuit breakers—Ratings on a symmetrical basis.

Type of Breaker	Nominal Rating: Three-Phase MVA	Nominal Rating: Voltage KV-RMS	Rated Continuous Current 60 Hertz AMPS-RMS	Rated Voltages: Maximum Voltage KV-RMS	Rated Voltages: K-Factor Max. KV Min. KV	Rated Voltages: Minimum Voltage KV-RMS	Insulation Level Rated Withstand: Low Frequency KV-RMS	Insulation Level Rated Withstand: Impulse△ 1.2x50 MS KV-Crest	Interrupting Ratings† AMPS-Symmetrical: Maximum KV AMPS-RMS	Interrupting Ratings† AMPS-Symmetrical: Nominal KV AMPS-RMS	Interrupting Ratings† AMPS-Symmetrical: Minimum KV AMPS-RMS	Asymmetrical○ Rating Factor	Short Time Rating 3 Sec. AMPS-RMS	Close and Latch Rating AMPS-RMS	Interrupting Time Cycles
5 HK 75	75	4.16	1,200	4.76	1.36	3.50	19.	60.	9,100	10,500	12,500	1.2	12,500	20,000	5
5 HK 250	250	4.16	1,200	4.76	1.24	3.85	19.	60.	30,300	35,000	37,500	1.2	37,500	60,000‡	5
5 HK 250	250	4.16	2,000	4.76	1.24	3.85	19.	60.	30,300	35,000	37,500	1.2	37,500	60,000‡	5
5 HK 350	350	4.16	1,200	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
5 HK 350	350	4.16	2,000	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
5 HK 350	350	4.16	3,000	4.76	1.19	4.00	19.	60.	42,400	48,600	50,000	1.2	50,000	80,000	5
7.5 HK 500	500	7.20	1,200	8.25	1.25	6.6	36.	95.	35,000	40,000	44,000	1.2	44,000	70,000	5
7.5 HK 500	500	7.20	2,000	8.25	1.25	6.6	36.	95.	35,000	40,000	44,000	1.2	44,000	70,000	5
15 HK 500	500	13.8	1,200	15.0	1.30	11.5	36.	95.	19,300	21,000	25,000	1.2	25,000	40,000*	5
15 HK 500	500	13.8	2,000	15.0	1.30	11.5	36.	95.	19,300	21,000	25,000	1.2	25,000	40,000*	5
15 HK 750	750	13.8	1,200	15.0	1.30	11.5	36.	95.	28,900	31,500	37,500	1.2	37,500	60,000‡	5
15 HK 750	750	13.8	2,000	15.0	1.30	11.5	36.	95.	28,900	31,500	37,500	1.2	37,500	60,000‡	5
15 HK 1000	1,000	13.8	1,200	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5
15 HK 1000	1,000	13.8	2,000	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5
15 HK 1000	1,000	13.8	3,000	15.0	1.30	11.5	36.	95.	38,500	42,000	50,000	1.2	50,000	80,000	5

Notes: †—For operating voltages other than those listed, the interrupting Current=Amps at Max. KV $\frac{\text{Max. KV}}{\text{Operating KV}}$ but in no case can this current exceed the interrupting Current at Minimum KV.

*—60,000 Amp also available. ‡—80,000 Amp also available.

○—Rating factor is based on breaker speed from initiation to contact parting with ½ cycle relay time. Multiply factor X symmetrical current to obtain asymmetrical current interrupting capability of breaker.

Notes: △—**These values apply with circuit breaker in or out of switchboard.**

Table 7—Operating Voltage Range

Nominal Control Voltage	Spring Charging Motor	Close Coil	Trip Coil	Under Voltage Pick-Up Maximum	Under Voltage Drop-Out
* 24 V DC	—	—	14- 30	21	7- 14
Δ 48 V DC	† 35- 50	35- 50	28- 60	41	15- 29
125 V DC	90-130	90-130	70-140	106	38- 75
250 V DC	180-260	180-260	140-280	212	75-150
115 V AC	95-125	95-125	‡ 95-125	98	35- 96
230 V AC	190-250	190-250	‡190-250	196	69-140

NOTES:
* Unless the circuit breaker is located close to the battery and protective relay and adequate electrical connections are provided between the battery and trip coil, 24 volt DC tripping is not recommended.
† 48VDC spring charging is not recommended.
‡ AC tripping is not recommended (see page 39).

Table 8—Current Values—Voltage shown in Table

Spring Charging Motor	Close Coil	Trip Coil	Lockout Coil	Under Voltage	N F
—		22.0		0.9	
†20.0	10.7	10.7	0.15	0.5	
10.0	5.0	5.0	0.06	0.2	
5.0	2.2	2.2	0.03	0.1	
10.0	4.5	4.5	0.04	0.2	
5.0	2.3	2.3	0.20	0.1	

§ Current values are average steady state values—momentary I currents for all charging motors and AC coils are approximate times these values, an important consideration when sizin battery.

Δ 48 volt tripping or closing functions are not recommended, e when the device is located near the battery or where special ef made to insure the adequacy of conductors between batter control terminals.

Table 9—HK Breaker Time Characteristics

Breaker	Av. Closing	Av. Tripping	Av. Spring Charging	Interrupting Time 0-100% of Rating
5 HK	4.5 Cycles	1.5 Cycles	2 Seconds	5 Cycles
7.5 & 15 HK	7.5 Cycles			
15 HK 1000	6 Cycles	2.0 Cycles	2 Seconds	5 Cycles

Closing Time—Between energizing closing coil and making of arcing contacts.
Tripping Time—Between energizing of trip coil and parting of arcing contacts.
Interrupting Time—Between energizing trip coil and complete interruption.

Table 10—Current Transformers MC-5, MC-15A1

Ratio*	Relay† Accuracy	Metering Accuracy† BO.1	BO.2	BO.5	B1
75/5	C10	1.2	1.2	—	—
100/5	C10	0.6	1.2	—	—
150/5	C20	0.3	0.6	1.2	—
200/5	C20	0.3	0.6	1.2	—
300/5	C50	0.3	0.3	0.3	1.2
400/5	C50	0.3	0.3	0.3	0.6
600/5	C100	0.3	0.3	0.3	0.3
800/5	C100	0.3	0.3	0.3	0.3
1200/5	C200	0.3	0.3	0.3	0.3
1500/5	C200	0.3	0.3	0.3	0.3
2000/5	C200	0.3	0.3	0.3	0.3
2500/5	C200	0.3	0.3	0.3	0.3
3000/5	C200	0.3	0.3	0.3	0.3
4000/5	C200	0.3	0.3	0.3	0.3

* Front mounted Current Transformers are available only up to 200
† For higher accuracies refer to nearest district sales office.

Table 11—Space Heaters for Outdoor Equipment*

Type Unit	No. of Heaters Per Frame	Total Watts Per Frame
5 HK	2	300
7.5 & 15 HK	3	450

* Space heaters on indoor equipment are an optional addition.

Table 12 Standard Single Phase Control Power Transformers

KVA	Voltage
5	2400—240/120
	4160—240/120
10	4800—240/120
	7200—240/120
15	8400—240/120
	13200—240/120
25	13800—240/120

Table 13 Standard Potential Transformers

Voltage Rating
2400/4160y—120
2400—120
4200—120
4800—120
7200—120
8400—120
12000—120
14400—120

Let's examine the difference between asymmetrical, "class" symmetrical and "true" symmetrical interrupting ratings.

Until mid-1964, ANSI standards called for asymmetrical ratings on all circuit breakers from 5 kV-75 MVA through 15 kV-1000 MVA. To achieve this rating, the circuit breaker MVA was calculated by use of the following formula:

Applied Voltage $\times$ Highest Asym. Phase Current $\times$ $\sqrt{3}$=MVA

This approach led to some misapplication since it did not duplicate the conditions that occur on an actual system. The recovery voltage on a test circuit might drop considerably below the applied voltage. This is contrary to a real system where the recovery voltage would be almost equivalent to the applied voltage. We pioneered the use of recovery voltage (instead of applied voltage) and symmetrical currents (in place of asymmetrical) to calculate breaker ratings, and in 1959 began to test all breakers on this basis. Methods used in all tests produced recovery voltages equal to applied voltages.

Following this approach, Brown Boveri Electric used the following formula to calculate its ratings.

Recovery Voltage × Average Sym. Current × $\sqrt{3}$ = MVA

It is now easy to see that when these two methods are compared, the ratings were considerably different. I-T-E circuit breakers had a great plus value and the application to the system to be protected was considerably simplified.

Let's compare with the following example:

Test generator voltage (applied)	17.2 kV
Recovery voltage (normal frequency)	15.0 kV
Short-circuit current: Phase A	26.6 kA
Phase B	25.5 kA
Phase C	21.2 kA
Average a-c component (symmetrical)	21.2 kA
Total current (asymmetrical)	26.6 kA

From the following calculation, we will see that a circuit breaker could be rated 750 MVA on an asymmetrical basis; whereas, Brown Boveri Electric would only rate the breaker 500 MVA symmetrical.

"TRUE" MVA = 21.2 kA × 15.0 kV × 1.73 = 790 MVA symmetrical

ANSI allowable MVA=26.6 kA $\times$ 17.2 kV $\times$ 1.73=790 MVA asymmetrical

Further, the "true" asymmetrical rating of this breaker (using recovery voltage) should be only 690 MVA, i.e., "True" asymmetrical MVA=26.6kA $\times$ 15.0 kV $\times$ 1.73=690 MVA

In 1964 ANSI converted to a symmetrical system with the use of recovery voltage, but only on part of the full breaker line, 5 kV-75 MVA, 5 kV-250 MVA and 15 kV-500 MVA. Then in 1968 they added the 5kV-350 MVA, 7.5 kV-500 MVA and the 15 kV-750 MVA.

In 1969 ANSI also converted the 15 kV-1000 MVA breaker to a symmetrical current rating basis.

To further complicate matters, ANSI symmetrical calculations still do not fully meet the "true" symmetrical test. A compromise method of rating was reached whereby an arbitrary MVA value has been assigned.

EXAMPLE: on a 15 kV-500 MVA Breaker:
ANSI Standards Requirement—18,000 Sym. Ampere Interrupting
"TRUE" Symmetrical Requirement—19,300 Sym. Ampere Interrupting

When you calculate the MVA rating of the breaker, you see that:
15 kV $\times$ 19,300 $\times$ $\sqrt{3}$=500 MVA — This is a full symmetrical rating which meets the "TRUE" symmetrical test

BUT:

15kV $\times$ 18,000 $\times$ $\sqrt{3}$=468 MVA — This is all that is required by ANSI to call this a 500 MVA breaker.

Because the ANSI requirement does not meet a full symmetrical MVA rating, ANSI has introduced a new term to the industry called "Class" MVA.

Therefore, a breaker may be designated a 500 MVA "class" even though it cannot achieve a "true" full 500 MVA symmetrical rating.

Brown Boveri Electric was the only one to rate its breakers on the "true" symmetrical basis.

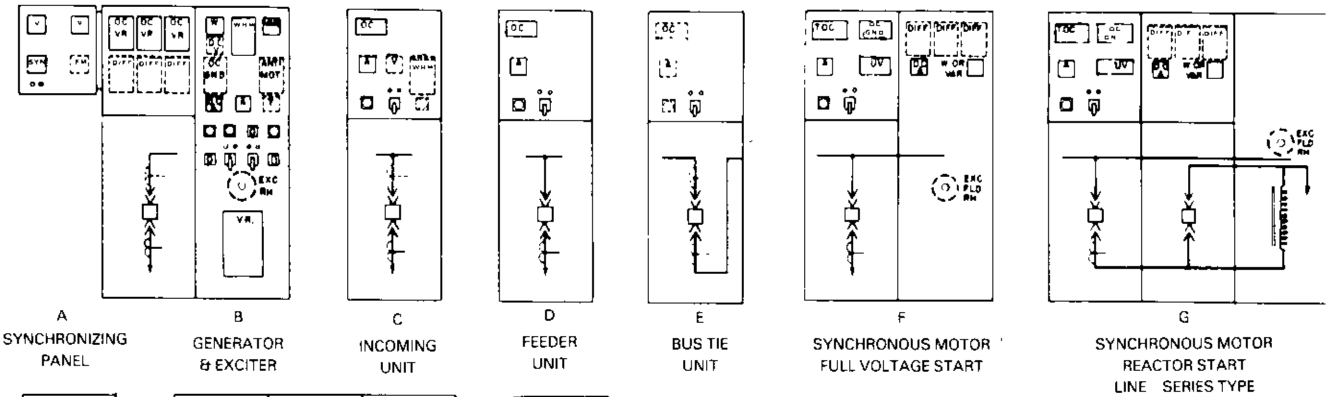
The following table demonstrates the superiority of our ratings compared with the present ANSI standards.

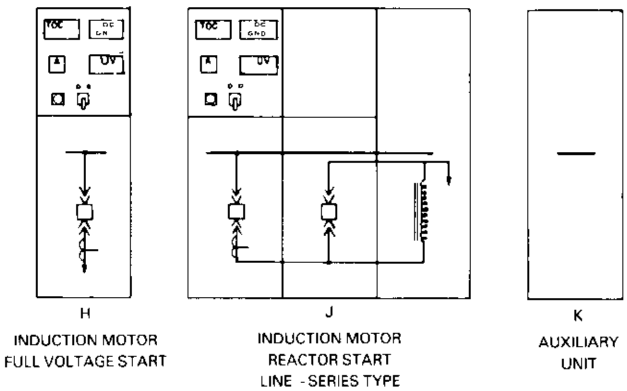
ANSI "Class" symmetrical standard vs. Brown Boveri Electric "True" symmetrical standard

Type	ANSI "Class" Inter. Amperes Sym.	Brown Boveri Electric Inter. Amperes Sym.	Calculated MVA of ANSI "Class" Ratings: "Class" Sym.	Calculated MVA of ANSI "Class" Ratings: Calculated Sym.	Brown Boveri Electric "True" MVA Sym.
5HK-75	8,800	9,100	75	72.6	75
5HK-250	29,000	30,000	250	239.1	250
5HK-350	41,000	42,400	350	338.0	350
7.5HK-500	33,000	35,000	500	471.5	500
15HK-500	18,000	19,300	500	467.7	500
15HK-750	28,000	28,900	750	727.4	750
15HK-1000	37,000	38,500	1000	960.2	1000

Remember, only I-T-E circuit breakers fulfill the "true" symmetrical rating throughout the entire line.

Panel arrangements



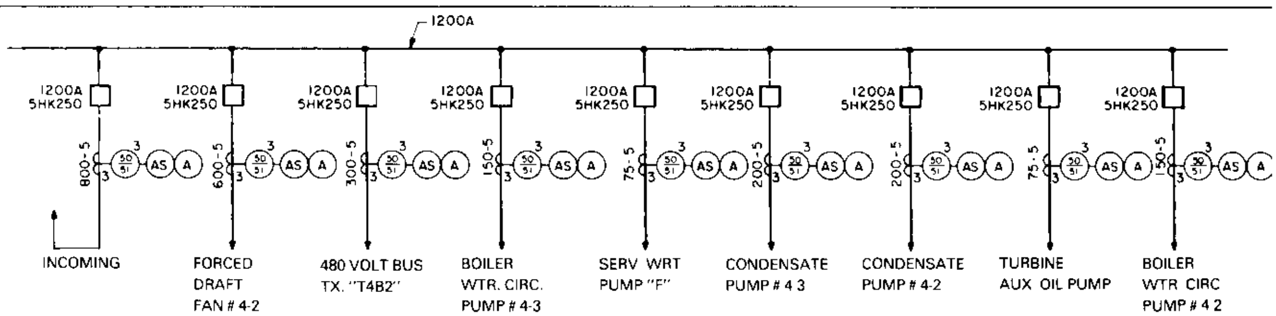


SYMBOLS

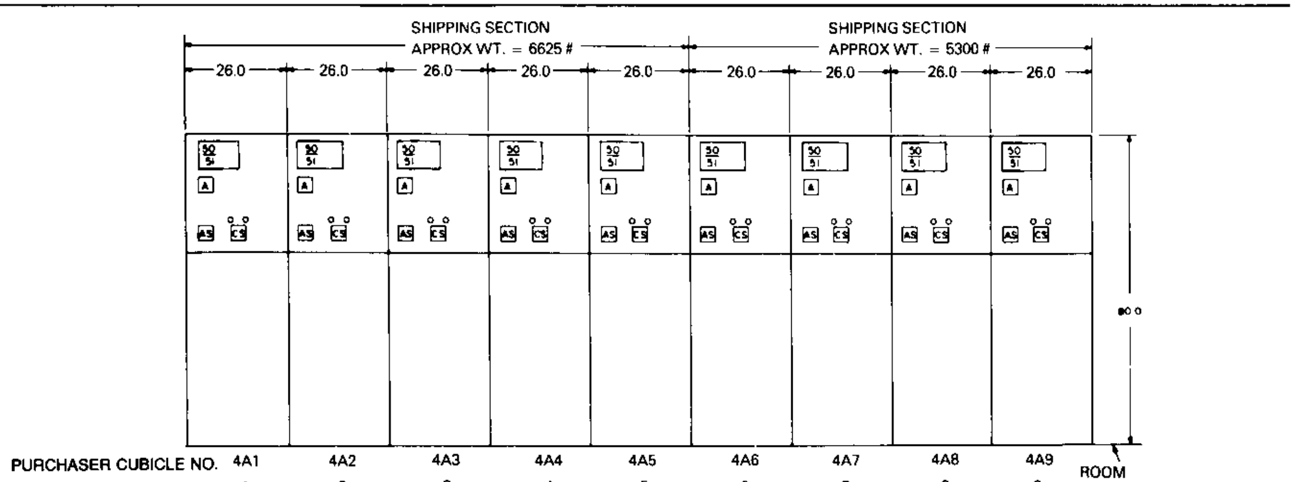
A	AMMETER (A. C. IF NOT MARKED)
V	VOLTMETER (A. C. IF NOT MARKED)
W	WATTMETER
VAR	VARMETER
WHM	WATTHOUR METER
T	TEMPERATURE METER
FM	FREQUENCY METER
SYN	SYNCHROSCOPE
VR	VOLTAGE REGULATOR
OC	OVERCURRENT RELAY
OC-GND	GROUND (RESIDUAL) O-C RELAY
TOC	THERMAL OVERCURRENT RELAY
OC-VR	OC RELAY WITH VOLT. RESTRAINT
UV	UNDERVOLTAGE RELAY
DIFF	PERCENTAGE DIFFERENTIAL RELAY
ANTI MOT	ANTI-MOTORING (POWER DIR.) RELAY

Complete description of panel arrangements A through K appear in specifications on pages 46 and 47.

Typical single-line diagram



Typical general arrangement drawing



Typical 5, 7.5 & 15 HK Metal-Clad Switchgear specifications

NOTE: Blue color denotes information to be supplied by purchaser regarding either:

1. Choice of alternates
2. Addition of optional features
3. Specific information

General

(Indoor — outdoor — outdoor walk-in) metal-clad switchgear described in this specification is intended for use on a (2400 — 4160 — 4800 — 6900 — 13800) volt 3-phase (3 — 4) wire (grounded — ungrounded) 60 Hertz system. The switchgear shall be rated (4160 — 7200 — 13800) volt and have horizontal drawout air-magnetic circuit breakers. The switchgear and circuit breaker either individually or as a unit shall have an impulse rating of (60—95) kV. The entire switchgear, including air circuit breakers, meters, relays, etc., shall be completely factory tested and breakers of like ratings shall be interchangeable.

Applicable standards

The switchgear equipment covered by these specifications shall be designed, tested and assembled in accordance with the latest applicable standards of ANSI, IEEE and NEMA.

Stationary structure

The switchgear shall consist of ( ) breaker units and ( ) auxiliary units assembled to form a rigid self-supporting completely metal-enclosed structure providing two thicknesses of painted steel between units. Each breaker unit structure shall be segregated by metal-sheets into the following separate compartments:

(1) Circuit breaker
(2) Main bus
(3) Instrument
(4) Current transformer (5HK only)
(5) Auxiliary device
(6) Cable

Circuit breaker compartment

Each circuit breaker compartment shall be designed to house a horizontal drawout (4160 — 7200 —13800) volt air-magnetic circuit breaker. The stationary primary disconnecting contacts shall be constructed of silver-plated copper. All movable contact fingers and springs shall be mounted on the circuit breaker where they may easily be inspected.
The entrance to the stationary primary disconnecting devices shall be automatically covered by a shutter when the circuit breaker is withdrawn to the test position,* disconnected position or removed from the switchgear.

*Except 1000 MVA rating.

Cable compartment

The lower primary disconnecting contacts shall be supported by means of flame-retardant, track-resistant polyester glass (5 HK) or porcelain (15 HK) bushings which extend into the cable compartment. (Clamp type cable terminals will be bolted to the outgoing bus by means of an adapter) (_ _ ___ potheads suitable for terminating _ ____ cable will be furnished.) A completely silver-plated ground bus shall extend through the length of the switchgear.

Bus compartment

Removable panels shall be provided for access to the bus compartment. The main bus shall be rated (1200 — 2000 — 3000) amperes. All bus bars shall be silver-plated, and bolted connections shall be used. The conductors shall be insulated by means of flame-retardant, track-resistant epoxy insulation. Flame-retardant, track-resistant polyester glass (5 HK) or porcelain (15 HK) bus supports shall support the insulated bus.

Doors and panels—Indoor

The relays, meters, instruments, control switches, etc. shall be mounted on a formed front hinged panel. The cable compartment shall have a removable panel. All surfaces shall be phosphate treated and painted with an oven baked corrosion resistant epoxy enamel finish. Color of finish shall be light gray, ANSI #61.

Doors and panels—outdoor

The relays, meters, instruments, control switches, etc. shall be mounted on a formed hinged panel. The panel shall be mounted in a compartment located on the same side of the switchgear as the circuit breaker compartment.
All weatherproof exterior doors shall be provided with suitable fasteners. Cleanable metallic filters shall cover the louvers. All surfaces shall be phosphate treated and one finish coat of oven baked, corrosion resistant acrylic enamel paint shall be applied to all surfaces. The color of the finish coats shall be gray, ANSI #61.

Circuit breakers

The circuit breakers shall be rated (4160 — 7200 — 13800) volts, 60 Hertz, having a continuous current rating of (1200 — 2000 — 3000) amperes and interrupting rating of (75 — 250 — 350 — 500 — 750 — 1000)) MVA. All circuit breakers of equal rating shall be completely interchangeable.
The circuit breaker shall be operated by means of a stored-energy mechanism, which is normally charged by a small universal motor, but which can also be charged by a manual handle for emergency manual closing or test. The mechanism shall be so arranged that the closing speed of the contacts is independent of both control voltage and of the operator.

The circuit breaker shall have three independent arc chutes, each containing face wound blowout coils to produce transverse flux during

The circuit breaker shall be equipped with secondary disconnecting contacts which shall automatically engage in the operating and test position to complete circuits as required. The contacts shall automatically disengage when the circuit breaker is withdrawn to the disconnect position.
The circuit breaker shall have a means for racking in and out of the compartment and between positions. It shall furthermore be provided with a means for holding the circuit breaker in the compartment in all positions.
Interlocking shall be provided making it impossible to rack a closed circuit breaker to or from any position. As an optional feature, it is possible to padlock the circuit breaker in either the disconnect or the test position. An additional interlock shall be provided which shall assure automatic discharging of the closing springs upon insertion or removal of the breaker into or out of the compartment.
The circuit breaker shall be equipped with means for manually closing and manually opening the contacts and also to close the contacts slowly for inspection purposes.
The circuit breaker control voltage shall be: (48 — 125 — 250 d-c; 115 — 230 a-c, 60 Hertz) volts. (For 48 v d-c application, battery should be mounted in the switchboard.)

Instrument transformers

Current transformers—The current transformers shall have ratios as indicated in the details of each switchgear unit. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers. The current transformers shall be insulated for full voltage rating of the switchgear. Relay and metering accuracy shall be as indicated on the details for each switchgear unit. Means shall be provided in the switchgear for conveniently shorting the secondary winding.

Potential transformers—The potential transformers shall be of the drawout type, equipped with current limiting fuses. They shall have an accuracy as required by the details of each switchgear unit. The ratio shall also be as indicated in each switchgear unit specification.

Control Wiring

Switchgear wire shall be #14 AWG, except where larger is specified. The switchgear shall be provided with terminal blocks for outgoing control connections. All wiring shall be terminated in looped tongue type lugs.

Drawings

Promptly upon award of the contract, the manufacturer shall furnish drawings for (approval — record) showing the General Arrangement and Schematic Diagrams. These drawings shall supply all installation and coordination data required by Purchaser for the preparation of electrical and mechanical details necessary to the installation of the switchgear by Purchaser.

Inspection

The completed switchgear shall be available for Purchaser's inspection at the manufacturer's plant before shipment, if specified. The manufacturer shall submit satisfactory test data to the Purchaser, if required, to prove operation and performance of the switchgear in accordance with the specifications.

Unit A—Swinging instrument panel

A swinging steel instrument panel shall be mounted on the (right — left) hand end of the switchgear for the following instruments:

2 — Voltmeters, 0-____ _ volt scale.
1 — Synchroscope
2 — Indicating lights for synchronizing
1 — Frequency meter (optional)

Unit B—Generator and exciter panels

The metal-clad switchgear for the control of one generator and one exciter shall consist of two housings. The breaker unit shall contain:

1 — (4160 — 7200 — 13800) volt air circuit breaker, _________ amp, 3 pole, electrically operated stored energy.
1 — Set of insulated bus, _________ amp.
3 — Current transformers, ________ -5 ratio for overcurrent relays and instruments.
1 — Current transformer, _________-5 ratio for voltage regulator. (required for parallel opertaion)
3 — Relays, time overcurrent with voltage restraint and instantaneous element, or equivalent three phase relay system.

For generators rated above 500 KVA for voltages 5000 volts and below and for generators of all ratings at service voltages above 5000 volts the following is recommended.

1 — Three phase generator differential relay (high speed relay recommended for 2000 KVA and above).
3 — Current transformers _________-5 ratio for differential relay.
3 — Current transformers _________-5 ratio to be connected in generator neutral for differential protection.

The auxiliary unit shall contain:

1 — A-c, ammeter, 0-________ scale.
1 — Polyphase indicating wattmeter.
1 — Polyphase watthour meter, ____ ____ element.
1 — Polyphase varmeter.
1 — D-c field ammeter, 0-_ _______ scale, and shunt.
1 — D-c voltmeter, 0-_ ______ _ scale (optional).
1 — Temperature indicator, 0-_ _ _____ degrees scale (optional).
1 — Auxiliary tripping relay for differential protection (optional).
1 — Anti-motoring relay (required for parallel operation).
1 — Overcurrent ground relay (optional).
1 — Voltmeter switch

1 — Synchronizing switch.
1 — Governor motor control switch.
1 — Field breaker control switch with red and green indicating lights.
1 — Generator breaker control switch with red and green indicating lights.
1 — Regulator transfer switch
1 — Temperature indicator switch (optional)
1 — Rheostat control consisting of one of the following:
(a) Handwheel ( ) and provision for mounting of exciter field rheostat having not more than two plates of 12-inch maximum diameter (rheostat furnished by customer).
(b) Control switch for electrically operated remote mounted rheostat.
1 — Space and mounting for voltage regulator.
1 — Provision for mounting field discharge resistor.
2, 3 Drawout type potential transformers, _ _ -120 volt with current limiting fuses.
1 — Drawout type potential transformer, -120 volt with current limiting fuses for use with voltage regulator.
2, 3 Drawout type potential transformers, -120 volt (optional for bus potential)
1 — Set of insulated bus, amp.
1 — Drawout field breaker, electrically operated.

Unit C—Incoming line unit.

The metal-clad switchgear for the control of an incoming line shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, amp.
3 — Current transformers, -5 ratio.
1 — 3 phase overcurrent relay, instantaneous and time overcurrent.
1 — Breaker control switch with red and green indicating lights.
1 — Ammeter, 0- _ scale.
1 — Ammeter transfer switch.
1 — Voltmeter (optional).
1 — Voltmeter switch (optional)
1 — Watthour meter, __ __ __ element (optional).
3 — Directional overcurrent relays (with — without) instantaneous trip. (optional)
2, 3 Drawout potentail transformers. -120 volt ratio (optional)
Necessary cable terminations.

Unit D—Feeder unit

The metal-clad switchgear for the control of a feeder circuit shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, _ __ ___ amp, 3-pole, electrically operated-stored energy.
1 — Set of insulated bus, __ ___ amp.
3 — Current transformers -5 ratio.
1 — 3 phase overcurrent relay, instantaneous and time overcurrent.
1 — Breaker control switch with red and green indicating lights.
1 — Ammeter.
1 — Ammeter transfer switch.
Necessary cable terminations.

Unit E—Bus sectionalizing unit___

The metal-clad switchgear for bus sectionalizing shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, ——— amp, 3-pole, electricaly operated stored energy.
1 — Set of insulated bus, amp.
1 — Breaker control switch with red and green indicating lights.
3 — Current transformers _ _ __-5 ratio (optional).
1 — 3 phase overcurrent relay, instantaneous and time overcurrent (optional)
1 — Ammeter (optional)
1 — Ammeter switch (optional)

Unit F—Synchronous motor control—full voltage___

The metal-clad switchgear for the control of a synchronous motor and its excitation shall consist of two housings. The breaker unit shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, ——— amp, 3-pole, electrically operated stored energy.
1 — Set of insulated bus, _ _ _ amp.
2 — Current transformers, -5 ratio, phase.
1 — Three phase motor overload relay with overload and instantaneous functions (optional locked rotor or starting function)
1 — Solid state ground fault relay with adjustable sensitivity and operating time.
1 — Current sensor (zero sequence type) for use with ground fault relay.
1 — Phase sequence and undervoltage relay.
1 — A-c ammeter, 0-__ _ scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.
1 — Current transformer _ _ _ -5 ratio (optional for use with long time and instantaneous current relay).
The auxiliary compartment for the field equipment shall contain:
1 — Field ammeter, 0-___ _ amp. and shunt.
1 — Wattmeter or varmeter.
1 — Field failure relay.
1 — Automatic field application relay.
1 — Field thermal relay (where necessary) field forcing equipment (where necessary) thermal type incomplete sequence and/or out of step relays.
1 — Field contactor.
1 — Field discharge resistor.
1 — Rheostat control consisting of one of the following:
(a) Handwheel (when necessary) and provision for mounting of exciter field rheostat having not more than two plates of 12-inch maximum diameter (rheostat furnished by customer).
(b) Control switch for electrically operated remote mounted rheostat.

1 — Set of insulated bus, amp.
2, 3 Drawout potential transformers, -120 volt (optional, if needed for relaying)
Field forcing relays when required.
3 — Lightning arresters
1 — Surge capacitor, 3-phase
Necessary cable terminations.
For motors rated above 1500 HP and for motors rated above 500 HP the service voltage exceeds 5 KV the following is recommended:
1 — 3 Phase current balance relay.
1 — Current transformer, _ -5 ratio, phase for current balanc relay
1 — Lockout relay.
1 — Three phase motor differential relay—high speed.
3 — Current transformers, -5 ratio (for differential relays).
3 — Current transformers, -5 ratio, for mounting at motor (1 differential relays).

Unit G—Synchronous motor control—reactor start___

(Line Series — Line Parallel — Neutral)
The following additional equipment (see Unit F) is required for reacto starting of a synchronous motor. The reactor shorting breaker unit sh contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, amp, 3 electrically operated stored energy.
1 — Timing relay and necessary auxiliary relays.
1 — Set of insulated bus, ——— amp.
1 — Set of necessary primary connections to reactor.
3 — Current transformers, -5 ratio (optional— necessary foi parallel-type connections).
The reactor unit shall contain: (In some cases this may be combined the auxiliary compartment indicated as part of Unit F)
1 — 3-phase starting reactor, duty.
1 — Set of necessary primary connections to shorting breaker.

Unit H—Induction motor control—full voltage___

The metal-clad switchgear for the control of an induction motor shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, _ _ amp, 3 electrically operated stored energy.
1 — Set of insulated bus, _ amp.
2 — Current transformers, _ __ -5 ratio, phase.
1 — Three phase motor overload relay with overload and instantaneoı functions (optional—locked rotor or starting function)
1 — Solid state ground fault relay with adjustable sensitivity and operating time.
1 — Current sensor (zero sequence type) for use with ground fault rel
1 — Phase sequence and undervoltage relay.
1 — A-c ammeter, 0- scale.
1 — Ammeter switch.
1 — Breaker control switch with red and green indicating lights.
1 — Current transformer, -5 ratio (optional, for use with lor time and instantaneous overcurrent relay)
3 — Lightning arresters.
1 — Surge capacitor, 3-phase.
Necessary cable terminations.
For motors rated above 1500 HP and for motors rated above 500 HP whe a service voltage exceeds 5 kV the following is recommended:
1 — 3 phase current balance relay.
1 — Current transformer, -5 ratio, phase for current balanc relay.
1 — Lockout relay.
1 — Three phase motor differential relay—high speed.
3 — Current transformers, -5 ratio (for differential relays).
3 — Current transformers, -5 ratio, for mounting at motor (f differential relays).

Unit J—Induction motor control—reactor start

(Line Series — Line Parallel - Neutral)
The following additional equipment (See Unit H) is required for reactc starting of an induction motor. The reactor shorting breaker unit shall contain:
1 — (4160 — 7200 — 13800) volt air circuit breaker, _ ___ amp, 3 electrically operated stored energy.
1 — Timing relay and necessary auxiliary relays.
1 — Set of insulated bus, amp.
1 — Set of necessary primary connections to reactor.
3 — Current transformers, -5 ratio (optional—necessary fo parallel type connection).
The reactor unit shall contain: (In some cases this may be combined the auxiliary compartment indicated as part of Unit H)
1 — 3-phase starting reactor, duty.
1 — Set of necessary primary connections to shorting breaker.

Unit K—Auxiliary compartment

Auxiliary units shall be furnished (as required) to house the following equipment:
( ) Drawout potential transformers with current limiting fuses
( ) Stationary mounted control power transformer with drawout curr limiting fuses (2400 — 4160 — 7200 — 13800 V)
( ) Tripping battery and charger.
( ) Bus Entrance.
( ) Lightning arresters.
( ) Instruments. ( ) Meters.
( ) Utility company revenue metering.
( ) Annunciators.
( ) Surge capacitors.
( ) Relays.

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