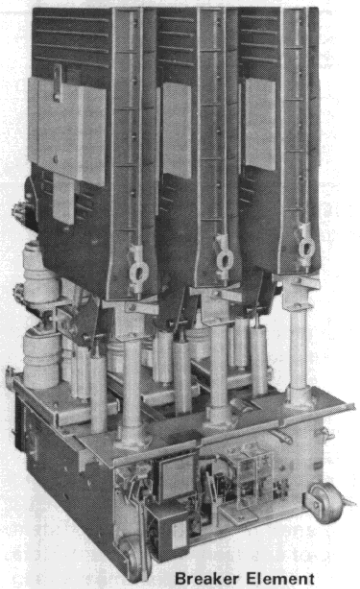
Westinghouse Electric Corporation
Switchgear Division
East Pittsburgh, Pa. 15112, U.S.A.

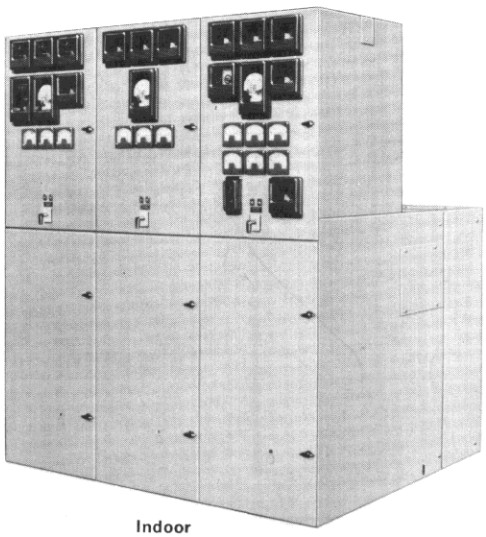
December, 1975
Supersedes Application Data 32-262
dated August, 1965 and
Application Data 32-263
dated February, 1972
E,D,C/1942/DB

75 to 1000 MVA Interrupting,
4160 to 13800 Volts
1200 to 3000 Amperes, Indoor and Outdoor

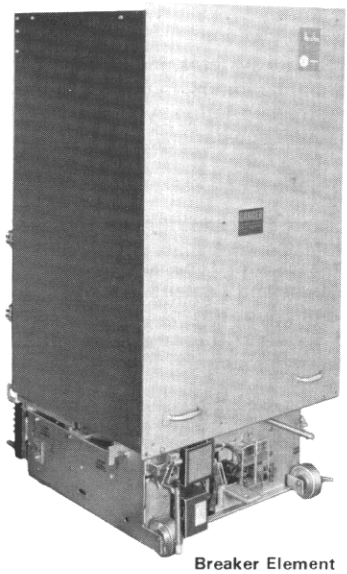
Standardized Type DHP Medium Voltage Metal-Clad Switchgear



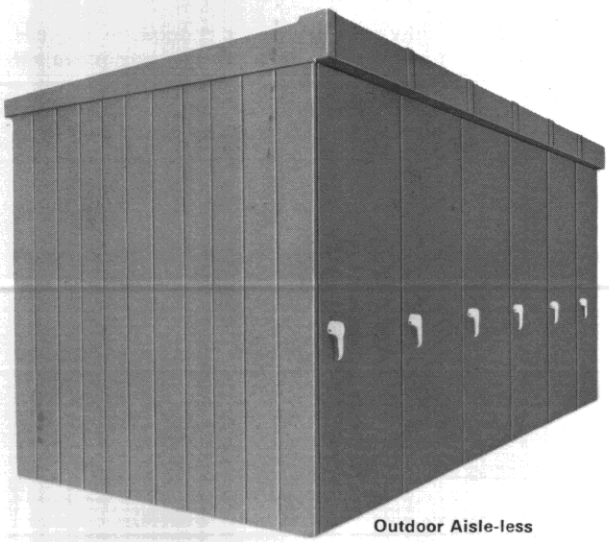
Breaker Element
with Barrier Removed



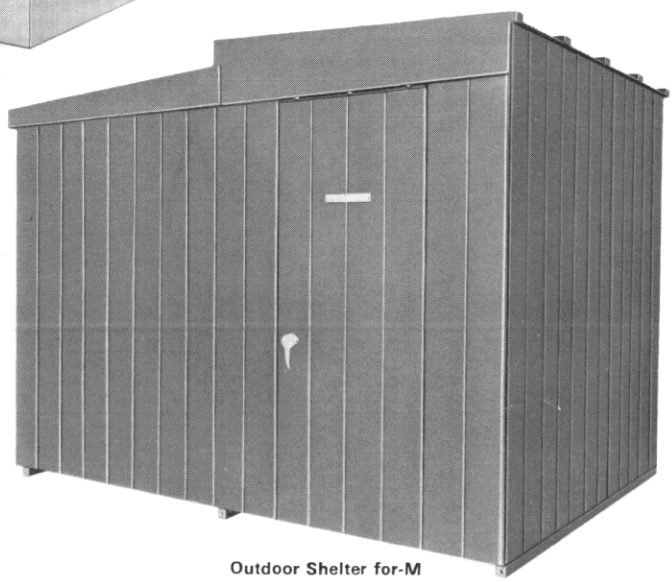
Indoor



Breaker Element
with Barrier



Outdoor Aisle-less



Outdoor Shelter for-M

Application

Westinghouse Porcel-line type DHP metal-clad switchgear with removable circuit breakers provides centralized control and protection for generators, motors, transformers, capacitors, and all types of feeder circuits. It is available in ratings of 4.16, 7.2 and 13.8 Kv with maximum interrupting capacities of 350 MVA, 500 MVA and 1000 MVA, respectively. It is available with air magnetic or vacuum circuit breakers for both indoor and outdoor applications.

Typical Applications

Electric utility systems, industrial plants, commercial buildings, municipal pumping stations, transportation systems, pipe line stations, unit substations.

In this Publication

Metal-Enclosed Group Phase (Non-Segregated Phase) Medium Voltage Bus, Indoor or Outdoor Service

Group Phase Bus Run
Meets ANSI standard for metal-enclosed non-segregated phase bus run with insulated bus conductor and connections.
Nominal Voltage Class
4.16 Kv 13.8 Kv
Rated Maximum Voltage
4.76 Kv 15 Kv
Kv BIL
60 95
Rated Continuous Current Amperes
1200, 2000, 3000, 4000, 5000
Conductor Material
Aluminum
Copper conductor available
Bus Supports
Glass Polyester
Porcelain bus supports available
Temperature Rise Above 40° Ambient
65°C
Momentary, 10 cycle
58 Ka rms Asym.
78 Ka momentary available to match rating of attached equipment.

Application
Bus runs are designed for use on circuits whose importance requires greater reliability than power cables provide. Typical of such applications are the connections from metal clad switchgear to transformers, generators and tie connections to other switchgear assemblies.

The length of bus run sections are eight feet or less. Standard provisions for supporting bus runs are:

Service	Type Support	Approx. Spacing
Indoor	Hanging Rod	4 Ft.
Outdoor	Support Frame	8 Ft.

Hangers or supports are not supplied with the bus run.

Where required, wall flange and vapor barriers for indoor to outdoor bus runs and expansion joints in all straight bus runs at approximately 50 foot intervals are provided.

Refer to page 17 for information on space heaters for bus runs.

Termination
Bus run terminations are available for most requirements. Bus run termination can be flexible shunts, potheads, cable lugs, porcelain bushings or bar extension.

The connected equipment termination must be bus bar or spade type bushings. If connected equipment has stud type bushings, they must be furnished with spade type connectors.

When ordering bus run, furnish:
1. Identification of equipment to be connected by bus run. If of Westinghouse manufacture give reference to G.O. and S.O. numbers. For other manufacture, furnish outline drawing complete with flange and termination details.
2. Plan view drawing or sketch giving locating dimensions or clearance dimensions where required. Indicate elevation of equipment bases or include side view with locating dimensions.
3. When applicable, furnish system single line or three line drawing with angular displacement and connection.

Guide Specification
1—Set (indoor-outdoor) metal-enclosed group phase bus with insulated (aluminum-copper) conductor for ( ) Kv, 3 phase, 60 hertz service to connect metal-clad switchgear unit ( )to (Identify connected equipment)

Bus run to include:
( )—Feet ( ) ampere bus

( )—( ) A elbows

( )—( ) A tees

1—( ) A termination to switchgear

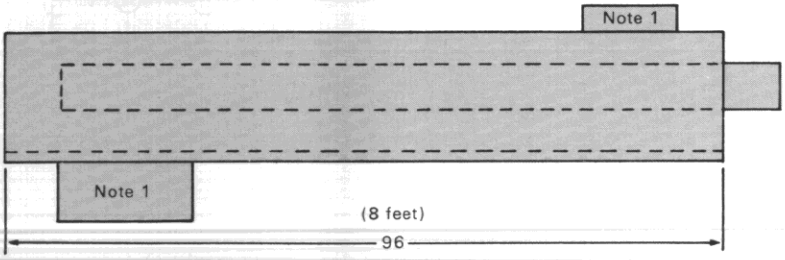
1—( ) A termination to (transformer-generator-switchgear)

Optional Items
1—Set uninsulated ground bus
1—Set ( ) ampere insulated neutral bus
1—Set (230-115) ac space heaters
1—Thermostat for above
1—Set bolted disconnect links for (describe purpose and location)

Approximate Weight & Dimension in Inches

Bus Run Ampere Rating	Wt. (lbs) per ft.	Fig.	3 Phase, 3 Wire A	B	C	3 Phase, 4 Wire with Insulated Neutral A	B	C
Aluminum Conductor								
1200	55	1	20	15.38	7.12	26	15.38	7.12
2000	65	1	20	17.38	8.12	26	17.38	8.12
3000	95	2	35.75	15.38	7.12	35.75	19	7.12
4000	105	2	35.75	17.38	8.12	35.75	19	8.12
Copper Conductor								
1200	65	1	20	15.38	7.12	26	15.38	7.12
2000	85	1	20	17.38	7.12	26	17.38	7.12
3000	100	1	20	17.38	7.12	26	17.38	7.12
4000	150	2	35.75	17.38	8.12	35.75	19	8.12
5000	170	2	35.75	17.38	8.12	35.75	21	8.12

Notes:
1. Heaters and ventilators for outdoor bus runs and indoor as required by customer conditions.
2. Hanger rods to be 5/8" diameter rods located 24" from each end of each bus length.
3. Position for uninsulated ground bus, if required.
4. Position for insulated neutral bus, if required.
5. Removable covers on the bottom are standard for indoor and outdoor bus. For covers on top (available indoor only) dimensions A and B increase approximately .25 inch and dimension C increases 1.38.



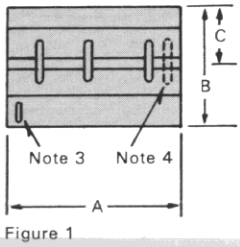


Figure 1

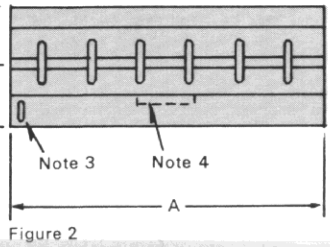
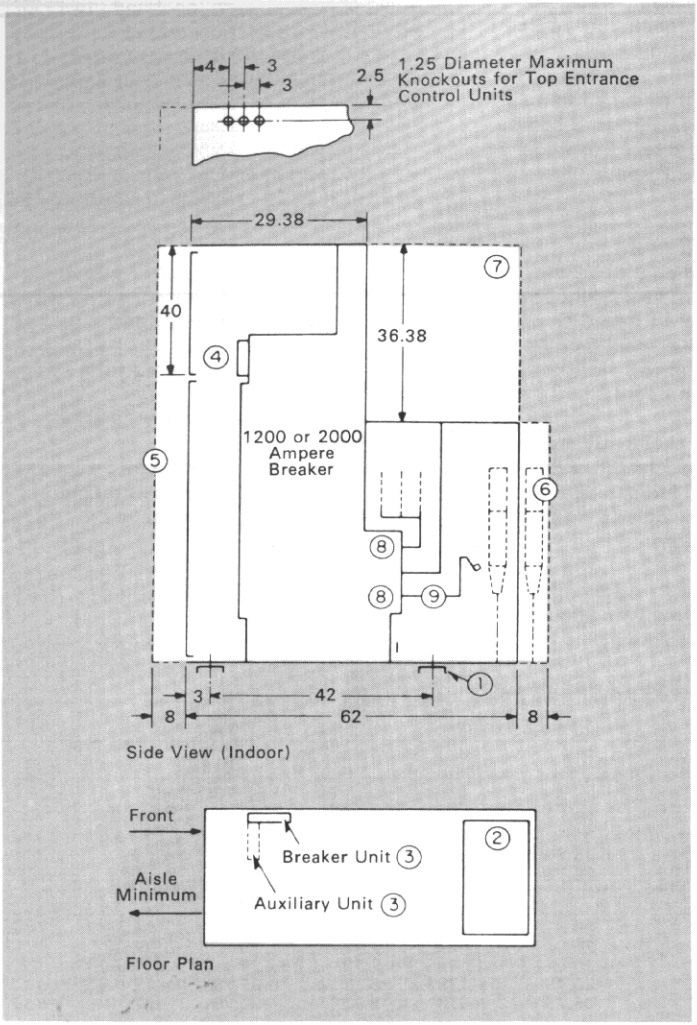


Figure 2

Type DHP Porcel-line® Metal-Clad Switchgear
Type 50 DHP 250 or 50 DHP 75



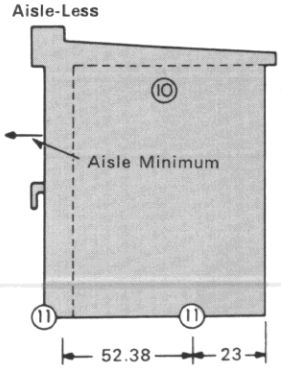
Approximate Weight and Dimensions in Inches

Ampere Rating	Wt. (Lbs.) Unit Less Breaker	Width of Unit	Depth	Height	Aisle Minimum
Indoor					
Aux.	2200	26	62	90.38	36
1200	1600		⑤		
2000	1800		⑥		
Outdoor Aisle-Less					
End Panel	300	1.5			
Aux.	2550	26	82.62	107	59
1200	1950		⑥		
2000	2150				
Outdoor Shelterfor-M					
End Panel	900	1.5			
Aux.	2750	26	151.5	111.75	73.5
1200	2150		⑥		
2000	2350				
Outdoor Common Aisle Shelterfor-M					
End Panel	1200	1.5			
Aux.	5200	26	228	111.75	72
1200	4000				
2000	4400		⑥		

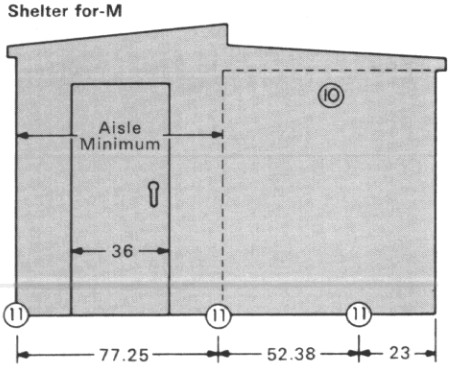
Ampere Rating	Wt. (Lbs.) Breaker	Type Circuit Breaker
1200	600	50 DHP 75
1200 2000	800	50 DHP 250
1200 2000	800	H 50 DHP 250

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers terminal blocks.
⑤ For full height instrument panel on all units add 8 inches.
⑥ Indoor add 8 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location, access door front.
⑧ Front accessible CT location.
⑨ CT location.
⑩ Side view unit same as indoor except space for two sets potheads.
⑪ Tie down clips supplied for purchasers foundation bolts.

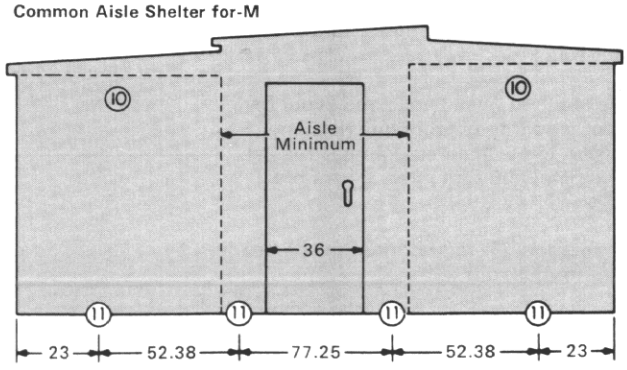
Aisle-Less



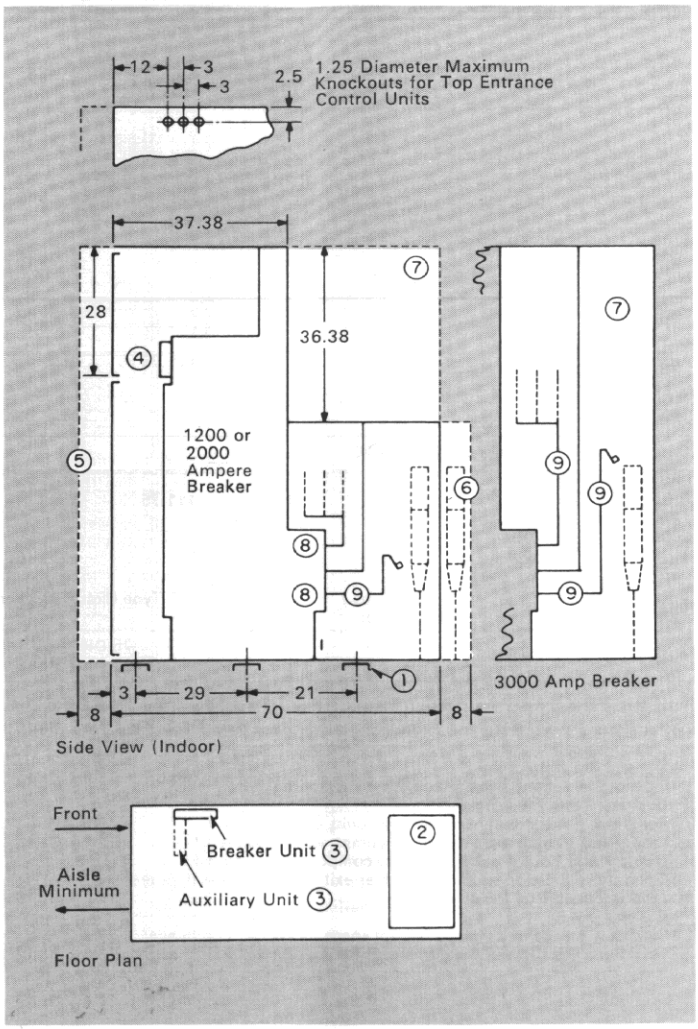
Shelter for-M



Common Aisle Shelter for-M



Type DHP Porcel-line® Metal-Clad Switchgear
Type 50 DHP 350



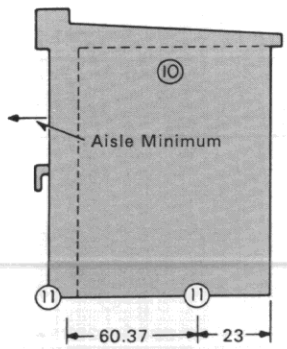
Approximate Weight and Dimensions in Inches

Ampere Rating	Wt. (Lbs.) Unit Less Breaker	Width of Unit	Depth	Height	Aisle Minimum
Indoor					
Aux.	2200	26	70	90.38	46
1200	1600		⑤		
2000	1800		⑥		
3000	2400	36			
Outdoor Aisle-Less					
End Panel	300	1.5	90.62	107	68
Aux.	2550	26	⑥		
1200	1950				
2000	2150				
3000	2800	36			80
Outdoor Shelterfor-M					
End Panel	900	1.5			
Aux.	2750	26	159.9	111.75	73.5
1200	2150		⑥		
2000	2350				
3000	3100	36			
Outdoor Common Aisle Shelterfor-M					
End Panel	1200	1.5			
Aux.	5200	26	244	111.75	72
1200	4000		⑥		
2000	4400				
3000	5800	36			

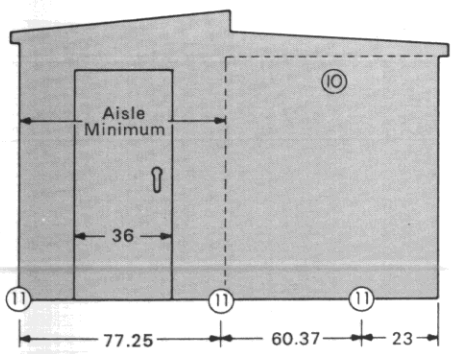
Ampere Rating	Wt. (Lbs.) Breaker	Type Circuit Breaker
1200	900	50 DHP 350
2000		
3000	1500	

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers, terminal blocks.
⑤ For full height instrument panel on all units add 8 inches.
⑥ Indoor add 8 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location when main cables exit bottom, access door rear.
⑧ Front accessible CT location 1200/2000A breakers.
⑨ CT location.
⑩ Side view unit same as indoor except space for two sets potheads.
⑪ Tie down clips supplied for purchasers foundation bolts.

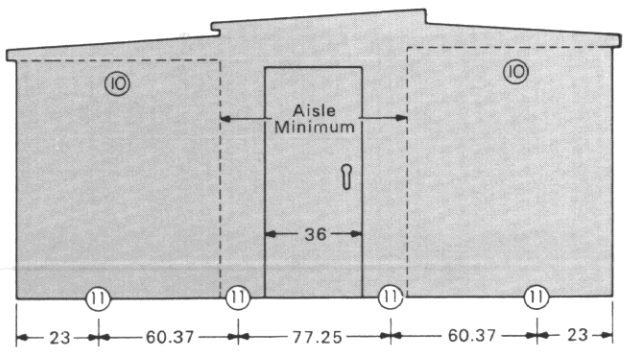
Aisle-Less



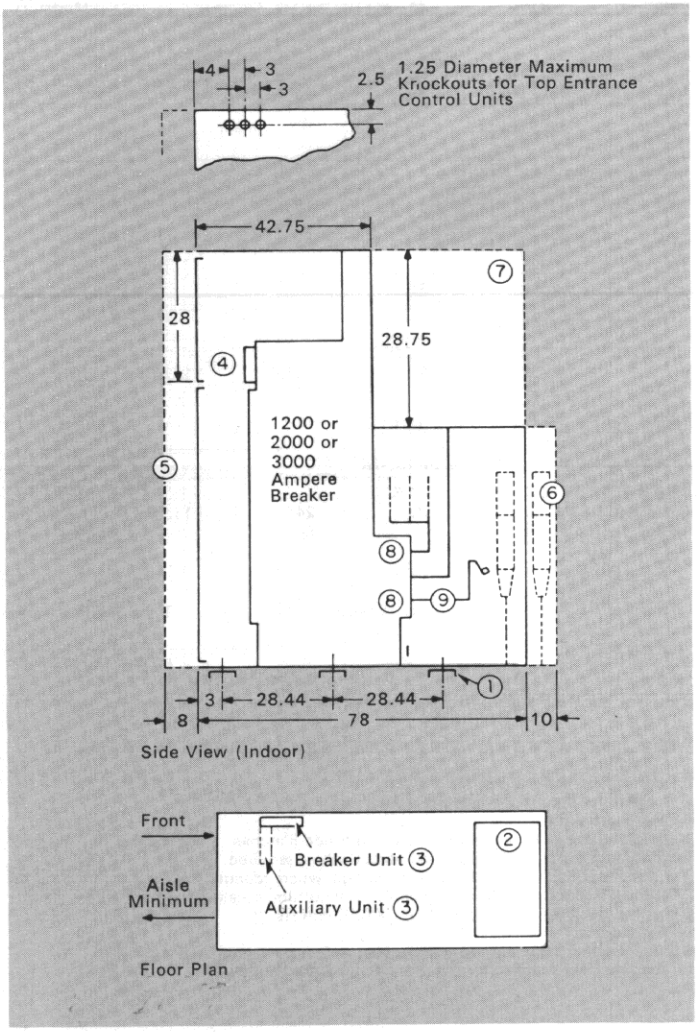
Shelter for-M



Common Aisle Shelter for-M



Type DHP Porcel-line® Metal-Clad Switchgear
Type 150 DHP 500 or 75 DHP 500



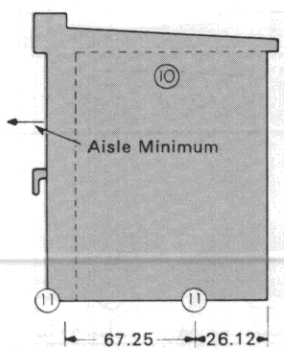
Approximate Weight and Dimensions in Inches

Ampere Rating	Wt. (Lbs.) Unit Less Breaker	Width of Unit	Depth	Height	Aisle Minimum
Indoor					
Aux.	2800	36	78	90.38	49
1200	2000		⑤		
2000	2200		⑥		
3000	2400				
Outdoor Aisle-Less					
End Panel	300	1.5			
Aux.	3200	36	100.62	107	80
1200	2400		⑥		
2000	2600				
3000	2800				
Outdoor Shelterfor-M					
End Panel	900	1.5			
Aux.	3500	36	169.5	111.75	73.5
1200	2700		⑥		
2000	2900				
3000	3100				
Outdoor Common Aisle Shelterfor-M					
End Panel	1200	1.5			
Aux.	6600	36	264	111.75	72
1200	5000		⑥		
2000	5400				
3000	5800				

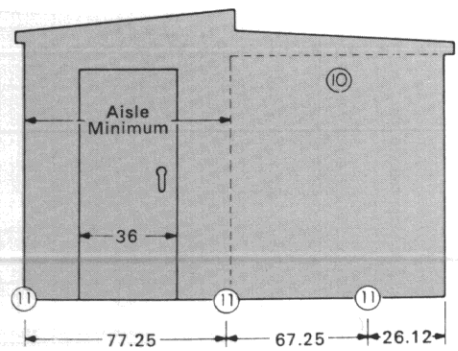
Ampere Rating	Wt. (Lbs.) Breaker	Type Circuit Breaker
1200	1400	75 DHP 500
2000		150 DHP 500
3000	1500	H 150 DHP 500

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers terminal blocks.
⑤ For full height instrument panel on all units add 8 inches.
⑥ Indoor add 10 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location when main cables exit bottom, access door rear.
⑧ Front accessible CT location.
⑨ CT location.
⑩ Side view unit same as indoor except space for two sets potheads.
⑪ Tie down clips supplied for purchasers foundation bolts.

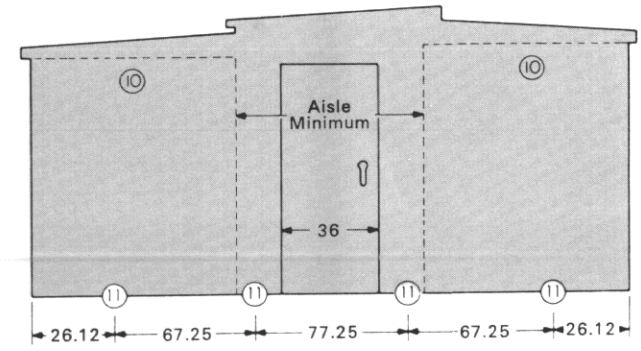
Aisle-Less



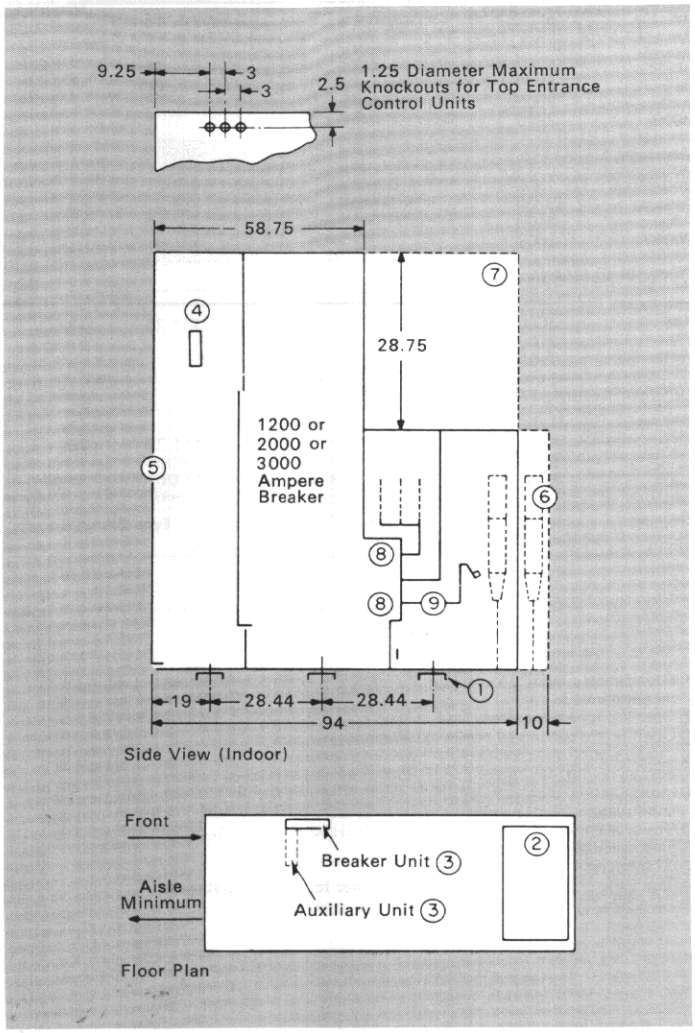
Shelter for-M



Common Aisle Shelter for-M



Type DHP Porcel-line① Metal-Clad Switchgear
Type 150 DHP 750 or 150 DHP 1000



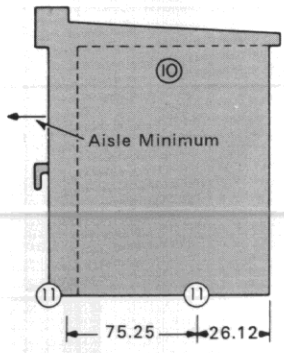
Approximate Weight and Dimensions in Inches

Ampere Rating	Wt. (Lbs.) Unit Less Breaker	Width of Unit	Depth	Height	Aisle Minimum
Indoor					
Aux.	2800	36	94	90.38	55
1200	2000		⑤		
2000	2200		⑥		
3000	2400				
Outdoor Aisle-Less					
End Panel	300	1.5			
Aux.	3200	36	108.62	107	85
1200	2400		⑥		
2000	2600				
3000	2800				
Outdoor Shelterfor-M					
End Panel	900	1.5			
Aux.	3500	36	185.5	111.75	81.5
1200	2700		⑥		
2000	2900				
3000	3100				
Outdoor Common Aisle Shelterfor-M					
End Panel	1200	1.5			
Aux.	6600	36	288	111.75	80
1200	5000		⑥		
2000	5400				
3000	5800				

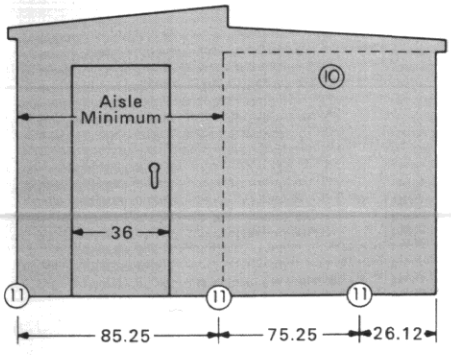
Ampere Rating	Wt. (Lbs.) Breaker	Type Circuit Breaker
1200	2200	150 DHP 750
2000		H 150 DHP 750
3000	2300	
1200	2350	150 DHP 1000
2000		
3000	2450	

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers terminal blocks.
⑤ Full height instrument panel on all units.
⑥ Indoor add 10 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location when main cables exit bottom, access door rear.
⑧ Front accessible CT location.
⑨ CT location.
⑩ Side view unit same as indoor except space for two sets potheads.
⑪ Tie down clips supplied for purchasers foundation bolts.

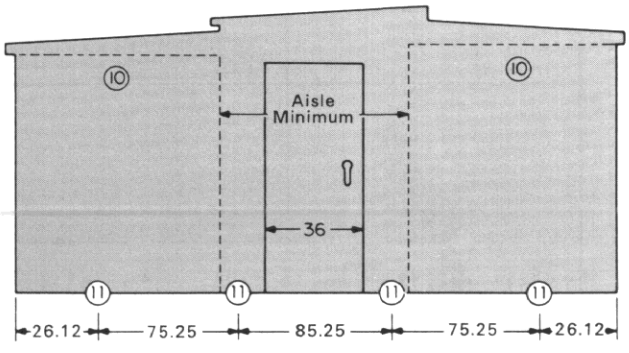
Aisle-Less



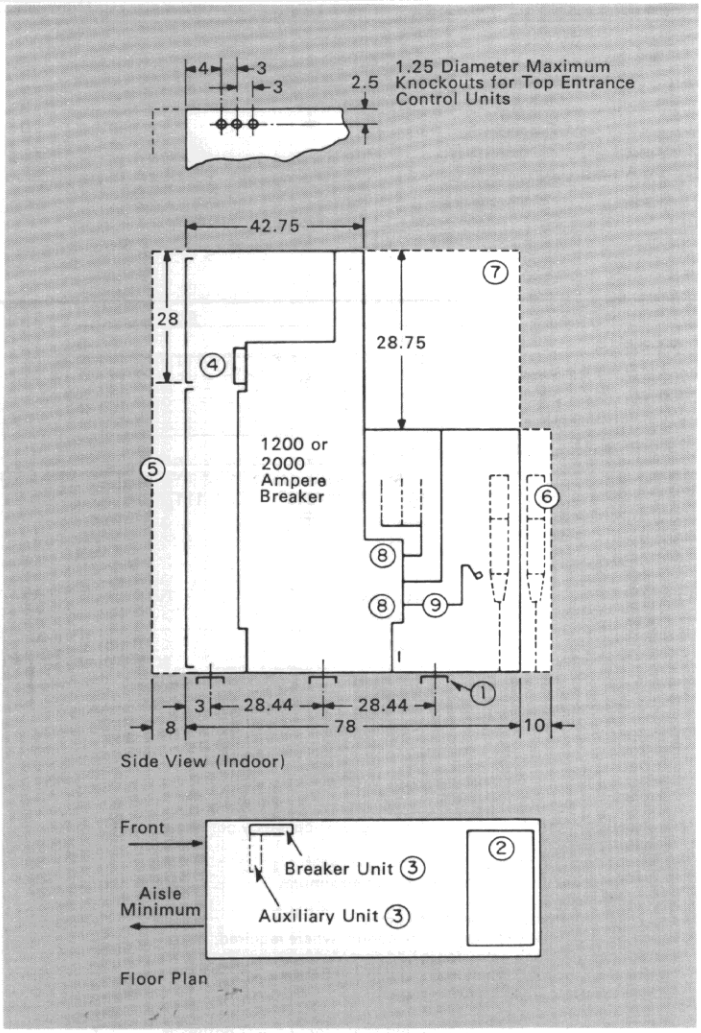
Shelter for-M



Common Aisle Shelter for-M



Vacuum Porcel-line® Metal-Clad Switchgear Type 150 DVP 500 or 150 DVP 750



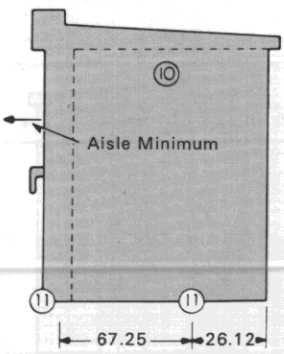
Approximate Weight and Dimensions in Inches

Ampere Rating	Wt. (Lbs.) Unit Less Breaker	Width of Unit	Depth	Height	Aisle Minimum
Indoor					
Aux.	2800	36	78	90.38	49
1200	2000		⑤		
2000	2200		⑥		
Outdoor Aisle-Less					
End Panel	300	1.5			
Aux.	3200	36	100.62	107	80
1200	2400		⑥		
2000	2600				
Outdoor Shelterfor-M					
End Panel	900	1.5			
Aux.	3500	36	169.5	111.75	73.5
1200	2700		⑥		
2000	2900				
Outdoor Common Aisle Shelterfor-M					
End Panel	1200	1.5			
Aux.	6600	36	264	111.75	72
1200	5000		⑥		
2000	5400				

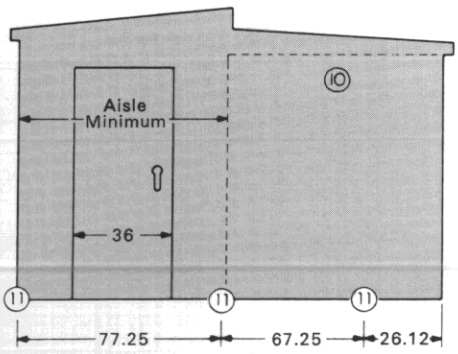
Ampere Rating	Wt. (Lbs.) Breaker	Type Circuit Breaker
1200	900	150 DVP 500
2000		
1200	950	150 DVP 750
2000		

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers terminal blocks.
⑤ For full height instrument panel on all units add 8 inches.
⑥ Indoor add 10 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location when main cables exit bottom, access door rear.
⑧ Front accessible CT location.
⑨ CT location.
⑩ Side view unit same as indoor except space for two sets potheads.
⑪ Tie down clips supplied for purchasers foundation bolts.

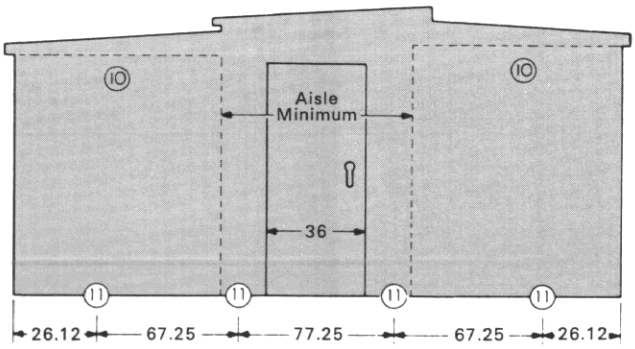
Aisle-Less



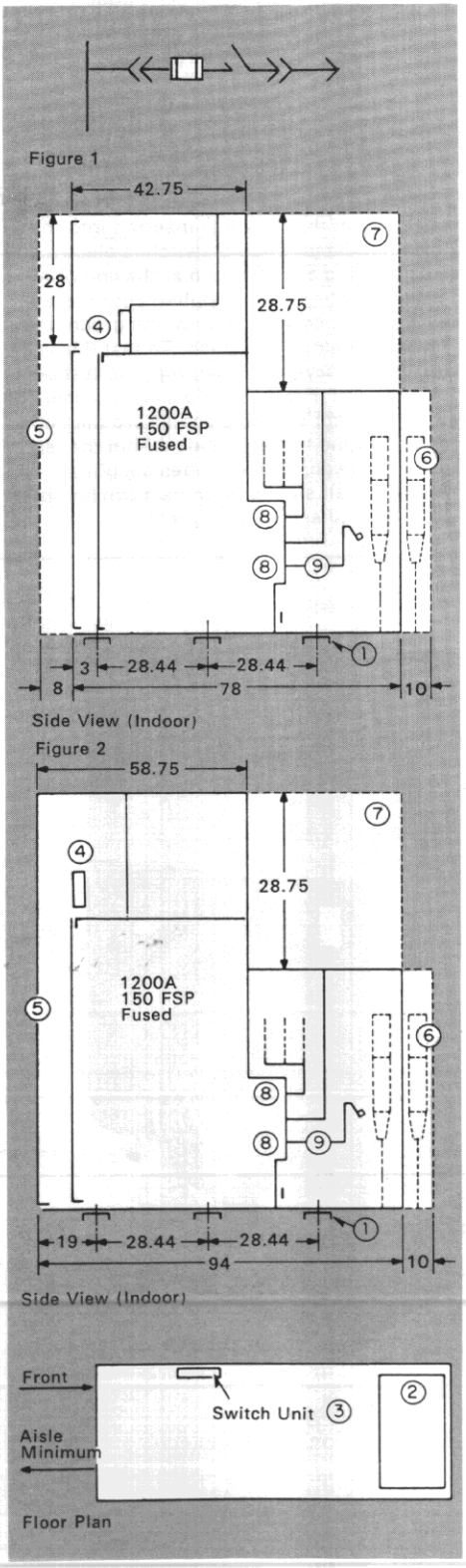
Shelter for-M



Common Aisle Shelter for-M



Type DHP Porcel-line® Metal-Clad Switchgear with Type 150 FSP Load Interrupter Switch



Application

The 150 FSP load interrupter switch with current limiting fuses is applied in 500, 750 or 1000 Mva class switchgear for protection of transformer loads where economics does not require circuit breaker protection. The ratings listed are for the unfused switch which may be applied only with 37 Ka or 58 Ka close and latch capability switchgear. Refer to Application Data 36-661 A WE A High Voltage current limiting power fuses for fuse application.

Current Limiting Fuses

Service	Rating	Type	Interrupting Rating rms Sym.
13.8 Kv	30E, 40E, 50E, 65E 80E, 100E, 125X 150E, 175/200X	CLE-1 CLE-2 CLT-2	85 Ka 85 Ka 50 Ka
6.9 Kv	30E to 125E 150E, 200E	CLE-1 CLE-2	50 Ka 40 Ka

Ratings

Nominal Voltage Class	13.8 Kv
Rated Maximum Voltage	15 Kv
Rated Continuous Current at 60 Hz	1200 A
Load Break Rating	600 A
No. of Load Break Operations	
600 Ampere 80% P.F.	100
1200 Ampere 80% P.F.	10
Magnetizing Current Break	Yes
Momentary 10 Cycle	61 Ka rms Asym.
3-Second Short-time Carrying Capability	38 Ka rms Sym.
Fault Closing Capability	61 Ka rms Asym.

Operating Mechanism

The standard manual operating mechanism is quick-make, quick-break. Optional stored energy manually operated mechanism and optional stored energy electrically operated mechanisms are also available.

Approximate Weight & Dimension in Inches

Type 150FSP			In Lineup With					
			Type 150DHP500 or 75DHP500 150DVP500 or 150DVP750			Type 150DHP750 or 150DHP1000		
Ampere Rating	Wt. (Lbs.) Unit Less Switch	Width of Unit	Depth ⑩	Height	Aisle Minimum	Depth	Height	Aisle Minimum
Indoor			Figure 1			Figure 2		
1200	2000	36	78 ⑤ ⑥	90.38	55	94 ⑥	90.38	55
Outdoor Aisle-Less								
End Panel 1200	300 2400	36 1.5	100.62 ⑥	107	90	108.62 ⑥	107	90
Outdoor Shelterfor-M								
End Panel 1200	900 2700	36 1.5	177.5 ⑥	111.75	81.5	185.5 ⑥	111.75	81.5
Outdoor Common Aisle Shelterfor-M								
End Panel 1200	1200 5000	1.5 36	272 ⑥	111.75	80	288 ⑥	111.75	80

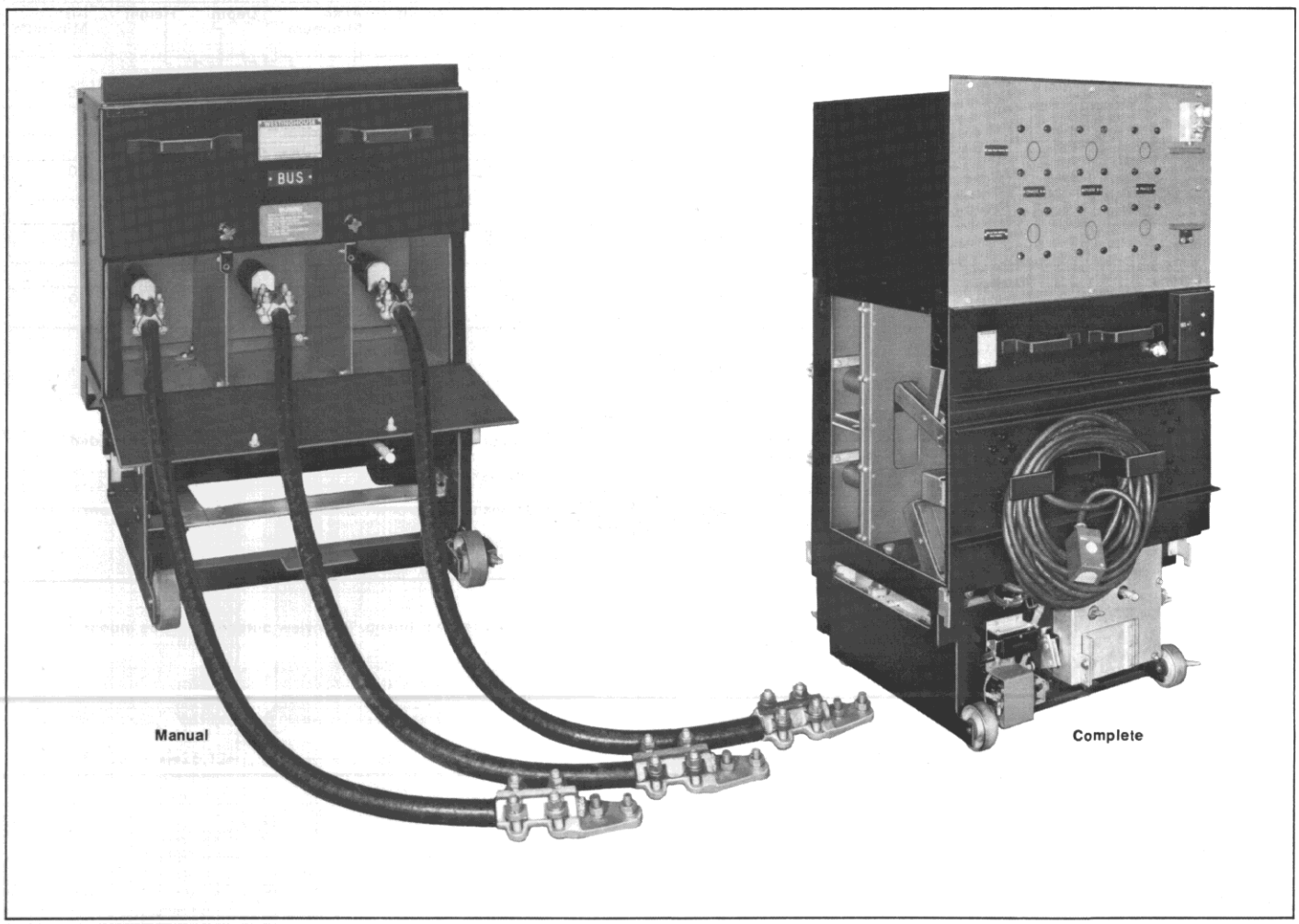
Ampere Rating	Wt. (lbs.)	Type Switch
1200	1050	150FSP

① Foundation supports for Indoor Switchgear supplied by purchaser, steel channel recommended.
② Opening for main cables.
③ Opening for secondary conduits, 2 inch maximum.
④ Customers terminal blocks.
⑤ 150FSP with 500 MVA units, add 8 inches to depth of all units where switch must have both disconnect and operating positions.
⑥ Indoor add 10 inch extra depth line compt. where required.
Outdoor add 12 inch extra depth line compt. where required.
⑦ Optional PT location when main cables exit bottom, access door rear.
⑧ Front accessible CT location.
⑨ CT location.
⑩ 150FSP unit depth determines depth of switchgear lineup. Side view outdoor same as indoor except space for two sets of potheads.

Grounding and Testing Devices
A grounding and testing device is a drawout element that may be inserted into a metal-clad switchgear housing in place of a circuit breaker to provide access to the primary circuits to permit the temporary connection of grounds or testing equipment to the high voltage circuits. High potential testing of cable or phase checking of circuits are typical tests which may be performed. The devices are insulated to suit the voltage rating of the switchgear and will carry required levels of short circuit current. Before using grounding and testing devices it is recommended that each customer develop detailed operating procedures consistent with safe operating practices. Only qualified personnel should be authorized to use grounding and testing devices.

Manual Device: The manual grounding and testing device includes six bushings for connection to primary circuits and a ground bar for connection to the switchgear ground bus. All circuit elements are separated from each other by insulating barriers. For grounding, cables are connected between either the bus side terminals or the line side terminals of the device and the device's ground bar while the grounding and testing device is outside the switchgear. The device is then inserted into the connected position in the selected housing. For testing, a similar procedure is followed with customer's test cables connected to appropriate terminals of the device.

Complete Device: The complete grounding and testing device includes six bushings for connection to primary circuits, a sliding contact assembly for connection to the switchgear ground bus, a three-pole two-position manually operated primary selector switch and a stored energy operated grounding switch. Shuttered test ports are provided for access to primary circuit test terminals. Test probes for use with customer's test cables are provided for connection to the test terminals. All primary elements are separated from each other and from ground by insulating barriers. Interlocks are provided to insure proper operating sequences. The stored energy mechanism operated grounding switch is capable of closing and latching against a "live" circuit. Power to operate the grounding switch mechanism is supplied through a disconnecting secondary plug. The selector switch is manually operated while the grounding and testing device is outside of the switchgear, and its selected position cannot be changed after the device is inserted into the housing. To ground the selected primary circuit after the device is inserted into the housing, the grounding switch is electrically closed using a pushbutton at the end of a remote control cable supplied with the device. To remove the ground, the grounding switch is manually tripped. To test the selected primary circuit, appropriate test port shutters are manually unlocked and opened. The customer's testing cables are then connected to the test terminals within the test ports by means of the probes supplied. Access to all six test terminals can be obtained for phase checking tests.



Type DHP Medium Voltage Porcel-line® Switchgear

Maximum Panel Equipment: Typical Arrangement

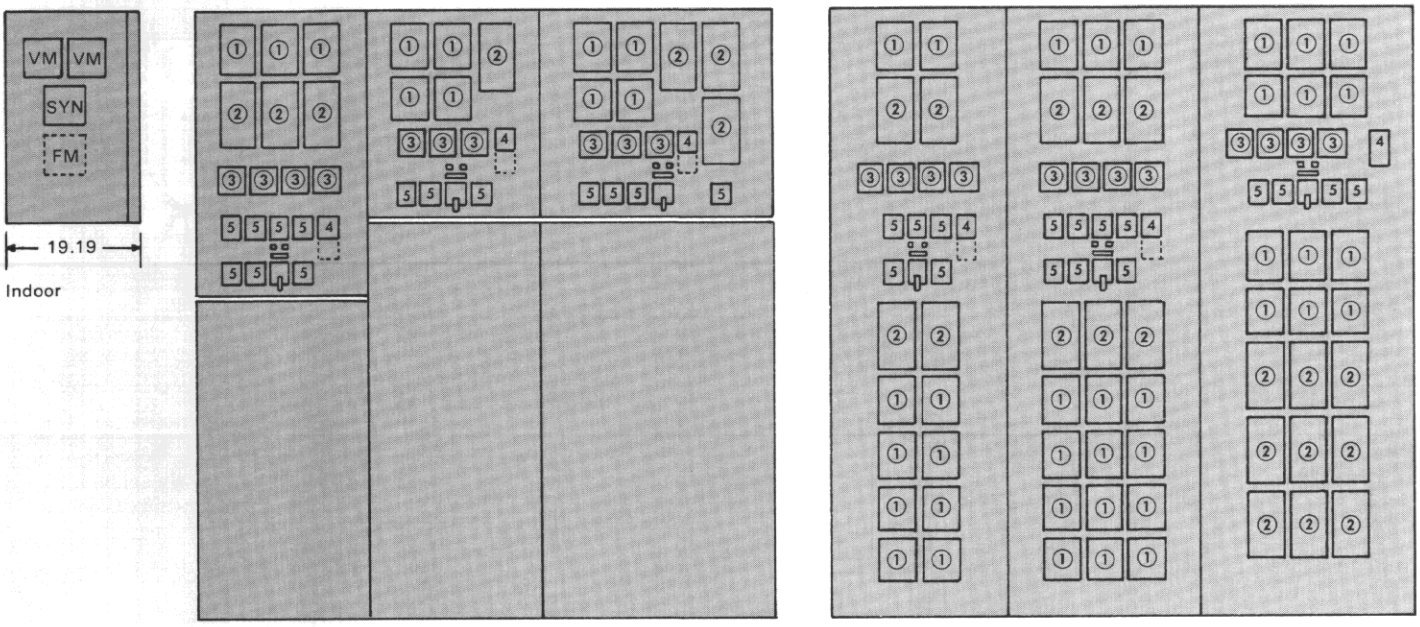
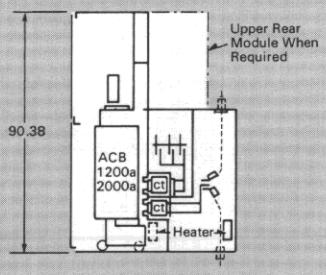


Figure A B C D E F

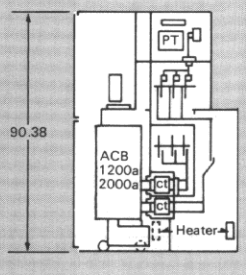
① FT-11
② FT-21
③ K-221 Instrument
④ WL Relay
⑤ W-2 Switch
Indicating Lites
Circuit Nameplate
W-2 Control Switch

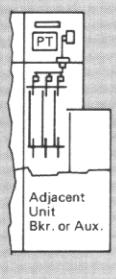
Type of Unit	Ampere Rating	Indoor & Shelterfor-M: Minimum Depth Unit	Indoor & Shelterfor-M: Full Height Instr. Panel	Aisle-less
		Panel Figure Number		
50 DHP 75 50 DHP 250	1200 1200 2000	A	D	D
50 DHP 350	1200 2000	B		
	3000		E	E
75 DHP 500 150 DVP 500 150 DHP 500 150 DVP 750	1200 2000 3000	C	F	
150 DHP 750	1200 2000 3000	F		
150 DHP 1000	1200 2000 3000			

Standard Sections: 5 Kv

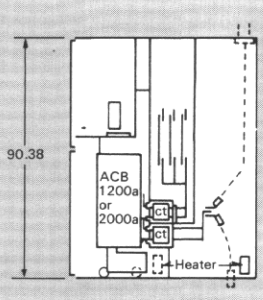


Feeder or Incoming Line

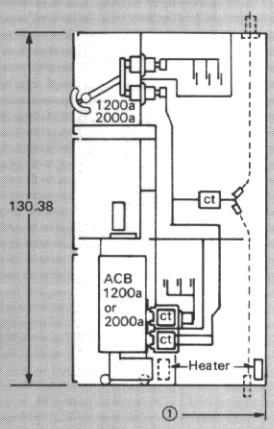




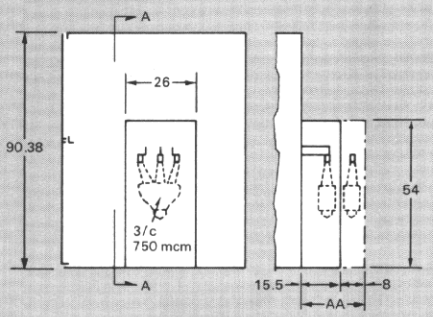
Bus Sectionalizing



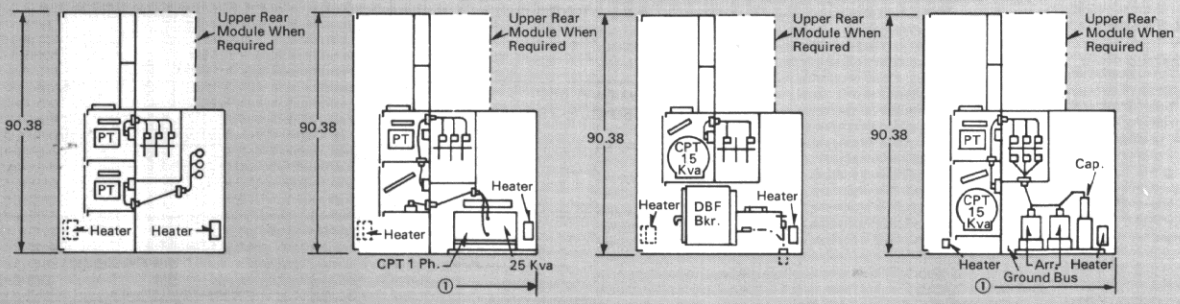
4000 Amp Main Bus

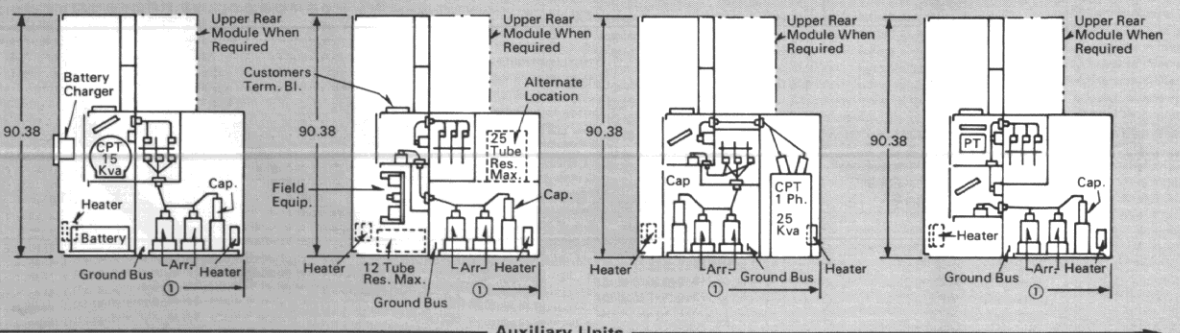


Transfer Bus with Disconnect Switch



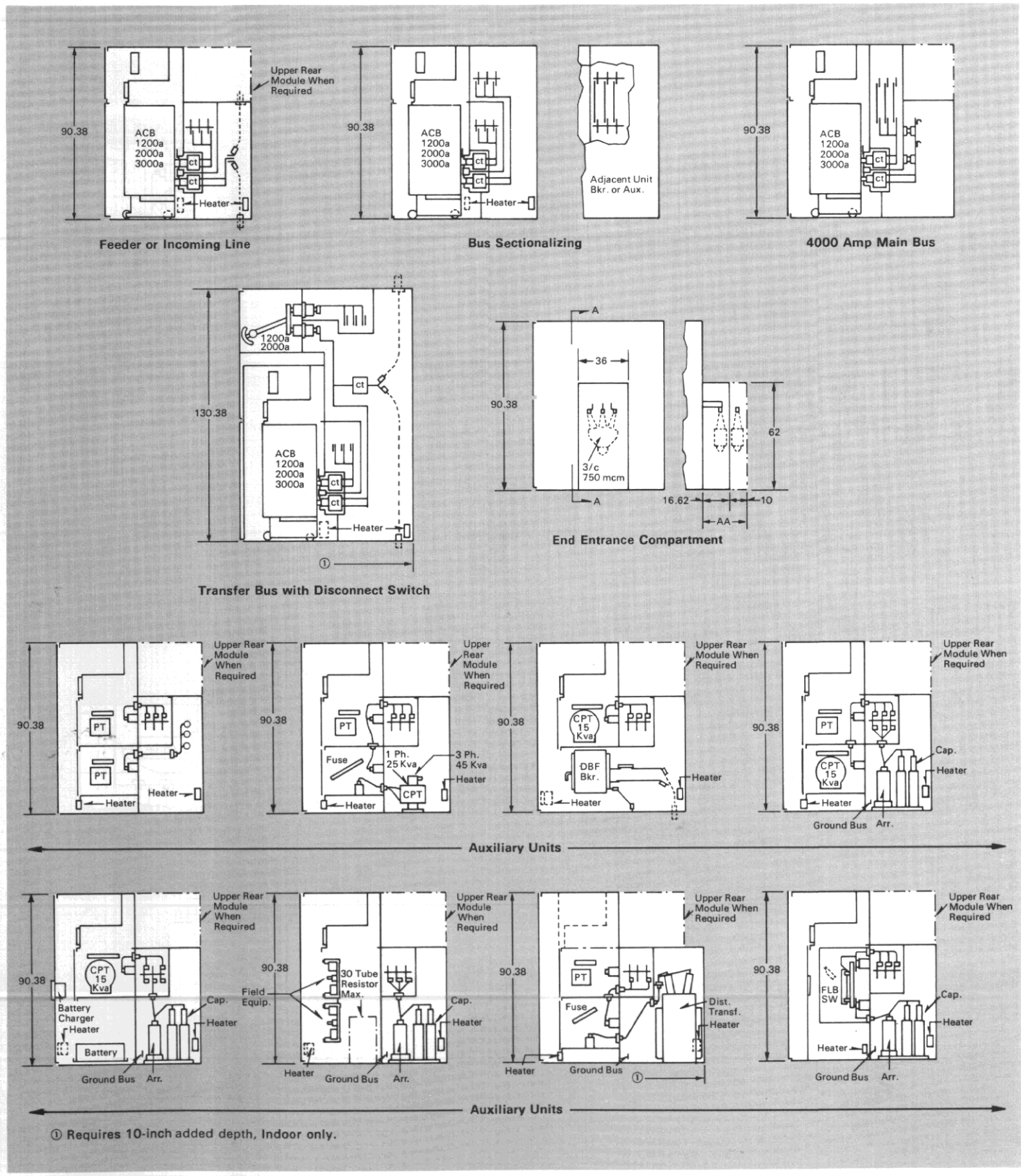
End Entrance Compartment





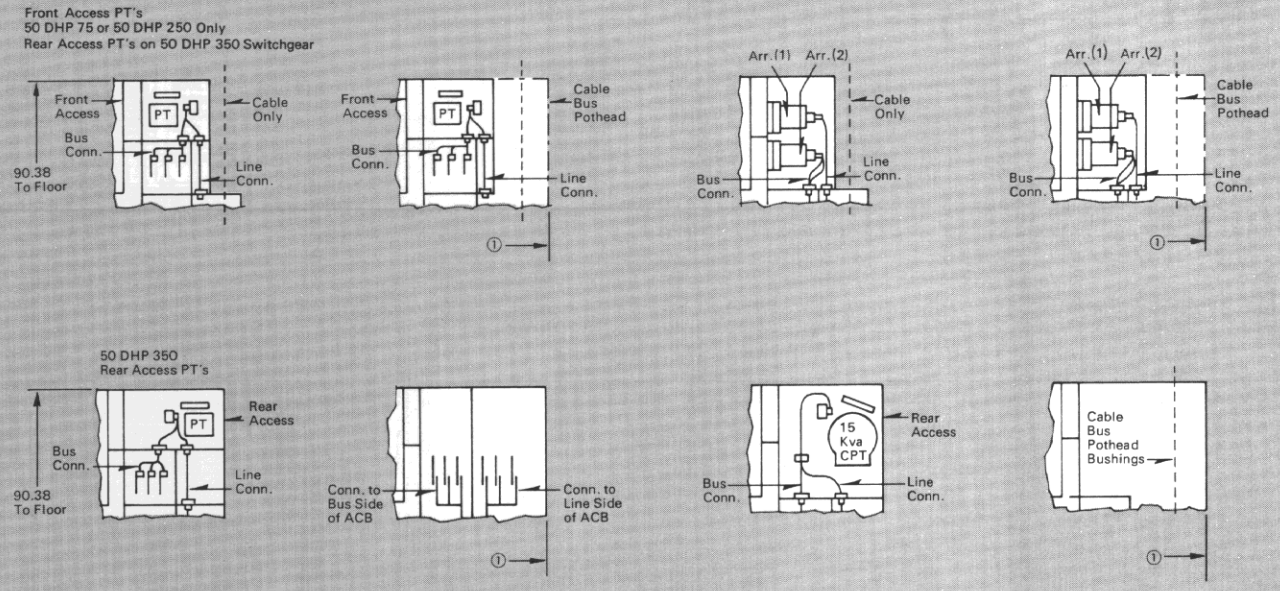
① Requires 8-inch added depth, Indoor only.

Standard Sections: 7.5 and 15 Kv



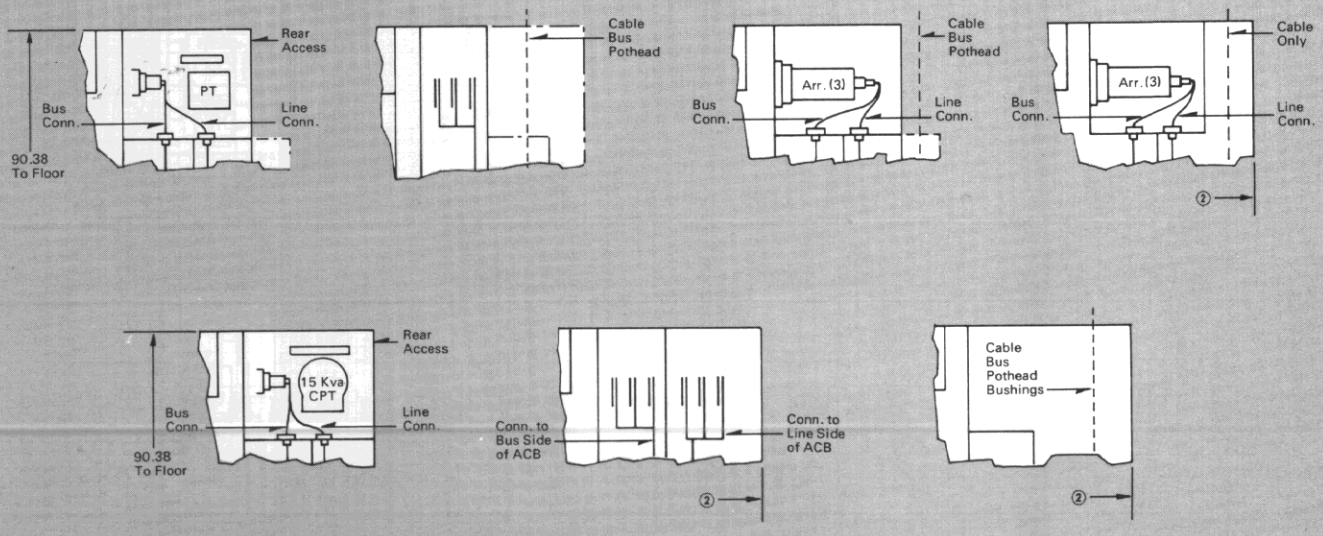
Standard Upper Rear Modules

5 Kv



① Requires 8-inch added depth, Indoor only.

7.5 and 15 Kv



② Requires 10-inch added depth, Indoor only.

Industry Standards
The following industry standards apply for the application, design, manufacture, and test of Westinghouse porcel-line medium voltage metal-clad switchgear.

ANSI Standard	American National Standards Institute
C37.010	Application guide for ac high-voltage circuit breakers rated on a symmetrical current basis
C37.100	Definitions for power switchgear
C37.04	Rating structure for ac high-voltage circuit breakers
C37.06	Preferred ratings for ac high-voltage circuit breakers rated on a symmetrical current basis
C37.07	Factors for reclosing service
C37.09	Test Procedure for ac high voltage circuit breakers
C37.11	Power circuit breaker control
C37.20	Switchgear assemblies including metal-enclosed bus
C37.24	Guide for evaluating the effect of solar radiation
NEMA Standard	National Electrical Manufacturers Association
SG-4	Power Circuit Breakers
SG-5	Power Switchgear Assemblies

Service Conditions
Usual service conditions for operation of metal clad switchgear at the nameplate rating are as follows:

Altitude does not exceed 3300 feet (1000 meters)

Ambient temperature within the limits of minus 30°C and plus 40°C (Minus 22°F and plus 104°F)

System frequency is 60 Hz.

Applications of metal clad switchgear at other than standard altitude, ambient temperature or 60 Hz frequency require special consideration. Other unusual service conditions that may affect design and application include:

Exposure to salt air, hot or humid climate, excessive dust, dripping water, falling dirt, or other similar conditions.

Unusual transportation or storage conditions.

Switchgear assemblies when used as the service disconnecting means.

Installations accessible to the general public.

Seismic Application
The switchgear Division has done extensive seismic testing to demonstrate the seismic capability of metal-clad switchgear for the nuclear industry. Nuclear Class 1E switchgear must be capable of withstanding the force resulting from earthquakes and continue to function.

Earthquake motion is filtered and amplified by the foundation, building or other structures. Therefore, it is recommended that critical equipment be located on the lower floors where the amplification is lower. Floor response spectra based upon a 5% equipment damping factor must be furnished for the metal-clad switchgear location as a part of the user's requirement to permit evaluation of the application.

Seismic requirements are also being specified for other than nuclear applications, although continuity of function is usually not a requirement in these cases. Floor response spectra may also be needed in order to properly evaluate these applications.

Drawings furnished for a switchgear order for seismic application will specify location and strength or rigidity required where necessary to permit user to complete design of foundations, floor steel, anchoring, supports for bus run, etc.

Surge Protection

Surge equipment is an excellent investment for the protection provided, since its cost is low, life expectancy long, and maintenance requirements minimal. Although lightning storms are the primary source of voltage surges in a power system, voltage surges can be caused by other system conditions, such as, the switching of capacitor banks, either isolated or back-to-back; the switching of shunt reactors or long cables; and the switching of unloaded transformers by means of a vacuum breaker. Many such applications may require special consideration.

Lightning arresters are given a maximum rms voltage rating which must not be exceeded. The arrester must both discharge a surge current and interrupt the power follow current to function properly. If the system voltage across the arrester terminals is above the arrester rating, interruption following a surge discharge might not occur, resulting in possible failure of the arrester. Therefore, caution must be used in selecting the proper arrester rating, to be sure that the system line-ground voltage during all system conditions will not exceed the arrester maximum rms voltage rating.

The typical lightning arrester application table included applies only to the most common type of systems and operating voltages. The manufacturers' catalog sections for the various types of available lightning arresters will give complete information for other voltages and types of systems.

If the supply transformer to a system is protected by arresters and the low voltage secondary system does not have lightning exposure, the secondary system will not require arresters. An isolated system where there is no exposure to lightning also will not require arresters.

Adequate surge protection for metal-clad switchgear and associated system equipment will, as a minimum, require:

1—Surge capacitors and lightning arresters be located at the terminals of all rotating ac machines to provide surge protection for the turn-to-turn and conductor-to-ground insulation.

2—When switching a unloaded transformer with a vacuum circuit breaker, the application of surge capacitors on the transformer terminals or the added capacitance of a length of cable between the switch and transformer to minimize overvoltages.

3—Ventilated dry type transformers be provided with lightning arresters in the transformer case. These are generally provided as standard.

4—Lightning arresters must be provided at the junction of cables connected to lines exposed to lightning.

5—Coordination of arrester location with apparatus insulation level.

Typical Lightning Arrester Application

Operating Voltage Kv	Impedance Grounded or Ungrounded System	Solidly Grounded System
2.4	3 Kv	3 Kv
4.16	6 or 4.5 Kv	3 Kv
6.9	9 or 7.5 Kv	6 Kv
12.0	15 Kv	9 Kv
13.8	15 Kv	12 Kv

The location of arresters at the junction of cables connected to exposed line may also protect equpiment. The following table shows typical maximum cable lengths which can be protected by riser pole arresters, based on typical assumed system parameters and on the full range of known arrester types and makes. Where cable length to equipment exceeds the maximum listed, it is recommended that arresters also be located at the equipment.

Suggested maximum cable length, in feet, between riser pole arresters and protected equipment:

Lightning Arrester Rating	Station Type Arrester	Intermediate Type	Distribution Type
To 60 Kv BIL Metal-Clad Switchgear			
3 Kv	NL	NL	NL
4.5 Kv	NL	NL	X
6 Kv	NL	NL	70
To 95 Kv BIL Metal-Clad Switchgear			
6 Kv	NL	NL	NL
7.5 Kv	NL	NL	X
9 Kv	NL	NL	160
12 Kv	NL	240	70
15 Kv	110	80	S
To 60 Kv BIL Liquid or Gas-Filled Transformer			
3 Kv	NL	NL	NL
4.5 Kv	NL	NL	X
6 Kv	NL	NL	NL
To 75 Kv BIL Lquid or Gas-Filled Transformer			
3 Kv	NL	NL	NL
6 Kv	NL	NL	NL
7.5 Kv	NL	NL	X
9 Kv	NL	NL	90
To 95 Kv BIL Liquid or Gas-Filled Transformer			
9 Kv	NL	NL	NL
12 Kv	NL	NL	120
15 Kv	NL	130	70

NL means no limit to cable length

X means not applicable

S means cable length too short to consider

Circuit Breaker Control

The DHP circuit breaker has a motor charged spring type stored energy closing mechanism. Closing the breaker charges accelerating springs. Protective relays or the control switch will energize a shunt trip coil to release the accelerating springs and open the breaker. This requires a reliable source of control power for the breaker to function as a protective device.

For ac control, a capacitor trip device is used with each circuit breaker shunt trip and each WL-2 lockout relay to insure that energy will be available for tripping during fault conditions. A control power transformer is required on the source side of each incoming line breaker for closing and bus tie or bus sectionalizing breakers will require automatic transfer of control power. This control power transformer may also supply other Ac auxiliary power requirements for the switchgear.

Dc control would require a dc control battery, battery charger and an ac auxiliary power source for the battery charger. The battery provides a very reliable dc control source, since it is isolated from the ac power system by the battery charger. However the battery will require periodic routine maintenance and battery capacity is reduced by low ambient temperature.

Any economic comparison of ac and dc control for switchgear should consider that the ac capacitor trip is a static device with negligible maintenance and long life, while the dc battery will require maintenance and replacement at some time in the future.

Space Heaters

Outdoor bus runs and each unit of outdoor metal clad switchgear are provided with space heaters to control condensation. Manual control is standard but optional thermostatic control is available where conservation of energy is desired. Space heaters are recommended for indoor switchgear installed in an unheated room or building and will be provided where specified.

Tubular type heaters are operated at half-voltage for long life. 500 volt or 250 volt rated heaters are used for 250 volt or 125 volt service as follows:

Space heater watts at half-voltage

375 watts/8 ft length bus run
500 watts/26 inch wide 5 Kv unit
750 watts/36 inch wide 7.5 Kv or 15 Kv unit

DHP or DVP Breaker Stored Energy Mechanism Control Power Requirements

Rated Control Voltage	Spring Charge Motor Run Amperes 5 Kv	15 Kv	Time Sec.	Close or Trip Amperes	Voltage Range Close	Trip	Ind. Light Amperes
48 V Dc	13.0	13.0	5	10	40-50	28-60	.035
125 V Dc	5.0	5.0	5	5	90-130	70-140	.035
250 V Dc	2.6	2.6	5	2	180-260	140-280	.035
115 V Ac	6.0	6.0	5	17	95-125	95-125	.035
230 V Ac	3.0	3.0	5	7	190-250	190-250	.035

Control Power Transformers • Disconnect Type • 1 Phase • 60 Hertz

Primary Volts ① Taps +7½%	Rated	−7½%	Secondary Volts	Kva	Kv Class
2580	2400	2220	240/120	5, 10, 15	5
4470	4160	3850	240/120	5, 10, 15	5
5160	4800	4400	240/120	5, 10, 15	5
7740	7200	6680	240/120	5, 10, 15	15
12900	12000	11100	240/120	5, 10, 15	15
14300	13300	12300	240/120	5, 10, 15	15

① If connected line to ground, system neutral must be solidly grounded.

Instrument Transformers

Instrument transformers are used to protect personnel and secondary devices from high voltage and permit use of reasonable insulation levels and current carrying capacity in relays, meters and instruments. The secondaries of standard instrument transformers are rated at 5 amperes and/or 120 volt, 60 Hertz.

Potential Transformers

Selection of the ratio for potential transformers is seldom a question since the primary rating should be equal to or higher than the system line to line voltage to 120 volts. The number of potential transformers per set and their connection is determined by the type of system and the relaying and metering required.

The 3 phase, 3 wire system with 2 element watthour meters would require a set of two line to line potential transformers. If line to ground potential is also required for a directional ground relay, then a set of three line to ground potential transformers could be used to provide both line to line potential for the 2 element watthour meter and line to ground potential for the ground relay.

Ground detection lights or relay for the ungrounded system requires three line to ground potential transformers and a separate set is usually recommended for this purpose.

The 3 phase, 4 wire, solidly grounded system usually requires three line to ground potential transformers.

Where synchronizing of generators or systems is involved, it is recommended that only line to line potential be used.

Current Transformers

The current transformer ratio is generally selected so that the maximum load current will read about 70 percent full scale on a standard 5 ampere coil ammeter. Therefore, the current transformer primary rating should be 140 to 150 percent of the maximum load current.

Maximum system fault current can sometimes influence the current transformer ratio selection since the connected secondary devices have published one second ratings.

The BYZ zero-sequence current transformer is used for sensitive ground fault relaying or self-balancing primary current type machine differential protection. The BYZ zero-sequence current transformer is available with nominal ratios of 50-5 or 100-5 and available opening sizes for power cables of 4.75 or 7.5 inches.

The minimum number of current transformers for circuit relaying and instruments is three current transformers, one for each phase or two phase connected current transformers and one BYZ zero-sequence current transformer. Separate sets of current transformers are required for differential relays.

The minimum pickup of a ground relay in the residual of three phase connected current transformers is primarily determined by the current transformer ratio. The relay pickup can be reduced by adding one residual connected auxiliary current transformer. This connection is very desirable on main incoming and tie circuits of low resistance grounded circuits.

Standard accuracy current transformers are normally more than adequate for most standard applications.

Standard Potential Transformers • 60 Hertz

Rating	2400-120,	4200-120,	4800-120,	7200-120,	8400-120,	12000-120,	14400-120
Ratio	20	35	40	60	70	100	120

Switchgear			Potential Transformers 120 Volt Secondary						
Kv Class	Kv BIL	Unit Width	Max. Number Per Set and Connection	Standard Ratio's	ANSI Accuracy Class 120 Volts at Burden W, X, Y	Z	69.3 Volts at Burden W, X	Y	Thermal Rating 55°C Conn.	Volt-amp
5	60	26	2LL or 3LG	20,① 35, 40	0.3	1.2	0.3	..	LL LG LG②	700 400 700
7.5 & 15	95	36	2LL or 3LG	35, 40, 60, 70, 100, 120	0.3	0.3	0.3	0.3	LL LG LG②	1000 550 1000

① For solidly grounded 4160 volt system only or any type 2400 volt system.
② For solidly grounded system only.

LL Line to Line connection
LG Line to Ground connection

Standard Current Transformers • Type RCT • 55°C Ambient

Current Ratings Amperes	Metering Accuracy Classification 60 Hz Standard Burden B 0.1	B 0.5	B 2.0	ANSI Relaying Accuracy
Single Ratio				
① 50-5	1.2	2.4	—	C 10
75-5, 100-5, 150-5, 200-5	0.6	2.4	—	C 20
300-5	0.6	2.4	2.4	C 20
400-5, 500-5	0.6	1.2	2.4	C 50
600-5	0.3	0.3	2.4	C 50
800-5	0.3	0.3	1.2	C 50
1000-5, 1200-5, 1500-5	0.3	0.3	0.3	C 100
2000-5, 2500-5, 3000-5	0.3	0.3	0.3	C 100
4000-5, 5000-5	0.3	0.3	0.3	C 100
Multi-Ratio				
600-5, 1200-5, 2000-5	0.3	0.3	0.3	C 200

① Two 100-5 RCT Current Transformers with Secondaries in Parallel.
② For Technical Data See Westinghouse TD 44-060.

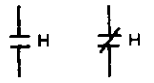
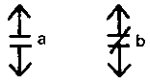
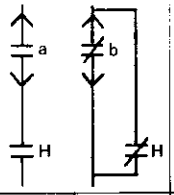
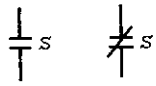
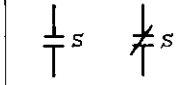
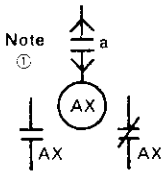
Auxiliary Switches

Optional circuit breaker and cell auxiliary switches are available where needed for interlocking or control of auxiliary devices. Typical applications and operation are described in the following table.

Auxiliary switch contacts from the circuit breaker mechanism are limited in number by the breaker control requirements usually to one 'a' and two 'b' contacts for ac control or two 'a' and two 'b' contacts for dc control.

When additional auxiliary contacts are needed, the optional auxiliary relay or mechanism operated cell (MOC) switch is used. The MOC switch may be applied for operation in the operating position only, or operating and test position of the breaker as determined by the application.

The optional truck operated cell (TOC) switch operates when the circuit breaker is levered into or out of the operating position.

Typical Applications		Permissive Local Control		General Auxiliary Switch applications, Indicating lights, Alarm, Supv. Control Indicator, Field application, etc.									
		Start-run Breaker Interlocking		Capacitor Trip Recloser		Interlocking to prevent Parallel Operation of Breakers Motor Space Heaters				Start-run Breaker Interlocking			
Type Auxiliary Switch or Device (supplied only when required.)		TOC Switch Shown for Breaker in Test Position 		Breaker Auxiliary Switch Shown for Breaker in Open Position 		TOC and Auxiliary Switch 		MOC Switch Operating Position Shown for Breaker in Open Position 		MOC Switch Operating and Test Position Shown for Breaker in Open Position 		SG or MG6 Auxiliary Relay Note ① 	
Breaker Condition													
Operating Position	Close	X		X		X		X		X		X	
	Open	X			X		X		X		X		X
Test Position	Close		X	X			X		X	X		X	
	Open		X		X		X		X		X		X
Withdrawn			X				X		X		X		X

① MOC Switch preferred unless scheme is fail safe on coil failure.
X Indicates switch contact or circuit closed.

Auxiliary switch contacts are primarily used to provide interlocking in control circuits, switch indicating lights, auxiliary relays or other small loads. Suitability for switching remote auxiliary devices, such as motor heaters or solenoids, may be checked with the interrupting capacity listed in the following table. Where higher interrupting capacities are required, an interposing contactor should be specified.

Interrupting Capacity Auxiliary Switch Contacts

Type Auxiliary Switch	Continuous Current Amperes	Control Circuit Voltage 115 Ac	230 Ac	48 Dc	125 Dc	250 Dc
		Non-inductive circuit interrupting capacity in amperes				
Breaker Auxiliary Switch	15	75	25	20	11	2
TOC Auxiliary Switch	15	75	25	20	11	2
MOC Auxiliary Switch	20	60	30	20	8	1.8
		Inductive circuit interrupting capacity in amperes				
Breaker Auxiliary Switch	15	25	5	8	6.25	1.75
TOC Auxiliary Switch	15	25	5	8	6.25	1.75
MOC Auxiliary Switch	20	30	20	5	2.4	1.1

Application Quick Check Table

For application of circuit breakers in a radial system supplied from a single source transformer. Short-circuit duty was determined using E/X amperes and 1.0 multiplying factor for X/R ratio of 15 or less and 1.25 multiplying factor for X/R ratios in the range of 15 to 40.

Source Transformer MVA Rating		Kv Operating Voltage				
Motor Load						
100%	0%	2.4	4.16	6.6	12	13.8
1 1.5 2	1.5 2 2.5	50 DHP 75 12 Ka	50 DHP 75 10.1 Ka	150 DHP 500 150 DVP 500 23 Ka	150 DHP 500 150 DVP 500 22.5 Ka	150 DHP 500 150 DVP 500 19.6 Ka
2.5 3	3 3.75					
3.75 5	5 7.5	50 DHP 250 36 Ka	50 DHP 250 33.2 Ka			
7.5 10①	10 10	50 DHP 350 49 Ka				
10	12①					
12	15		50 DHP 350 46.9 Ka	75 DHP 500 41.3 Ka		
15	20					
20①	20	Breaker Type and Sym. Interrupting Capacity at the Operating Voltage			150 DHP 750 150 DVP 750 35 Ka	150 DHP 750 150 DVP 750 30.4 Ka
	25 30					
	50①				150 DHP 1000 46.3 Ka	150 DHP 1000 40.2 Ka

① Transformer Impedance 6.5% or more, all other Transformer Impedances are 5.5% or more.

Load Current Switching

The following table of number of operations is a guide to normal maintenance for circuit breakers operated under usual service conditions for most repetitive duty applications including isolated capacitor bank switching and shunt reactor switching, but not for arc furnace switching.

Servicing shall consist of adjusting, cleaning, lubricating, tightening, etc., as recommended by the circuit breaker instruction book.

Fault operation indicates the breaker is expected to open its rated interrupting capability once. If a fault operation occurs before the completion of the number of operations listed, the circuit breaker should be inspected and maintained, if necessary.

Nonfault duty is a special application where the circuit breaker is not required to interrupt fault currents.

Circuit Breaker Type	Continuous Current Rating Amperes	Number of Operations					
		Max. No. Operations Between Servicing	No Load Mechanical Duty	Full Load	Inrush	Full Load	Inrush
				Fault Operation		Nonfault Duty	
All DHP Air Circuit Breakers Ratings Except 50DHP350 & 150DHP1000	1200	2000	10,000	1000	750	5000	3000
	2000	2000	10,000	1000	750	3000	2000
50DHP350, 150DHP1000 & All 3000A Ratings	1200 2000 3000	1000	5,000	500	400	2500	1500
All DVP Vacuum Breakers	1200	2000	10,000	1000	750	5000	3000
	2000	2000	10,000	1000	750	3000	2000

Table 1: Application: Available Breaker Types Rated on Symmetrical Current Rating Basis

Identification			Rated Values								Related Required Capabilities③			
	Nominal Voltage Class	Nominal 3-Phase MVA Class	Voltage		Insulation Level		Current		Rated Interrupting Time	Rated Permissible Tripping Delay	Rated Max. Voltage Divided By K	Current Values		
			Rated Maximum Voltage	Rated Voltage Range Factor	Rated Withstand Test Voltage		Rated Continuous Current at 60 Hz	Rated Short Circuit Current (at rated Max. Kv)				Maximum Sym. Interrupting Capability	3 Sec. Short-Time Current Carrying Capability	Closing and Latching Capability (Momentary)
				②	Low Frequency	Impulse		②		④		K Times Rated Short-Circuit Current②		1.6 K Times Rated Short-Circuit Current
Circuit Breaker Type	Kv Class	MVA Class	E	K				I		Y	E/K	KI		
			Kv rms		Kv rms	Kv Crest	Amperes	KA rms	Cycles	Sec.	Kv rms	KA rms	KA rms	KA rms
DHP Air Circuit Breaker														
50 DHP 75	4.16	75	4.76	1.36	19	60	1200	8.8	5	2	3.5	12	12	19
50 DHP 250		250		1.24			1200 2000	29			3.85	36	36	58
H 50 DHP 250①							1200 2000							78①
50 DHP 350		350		1.19			1200 2000 3000	41			4.0	49	49	78
75 DHP 500	7.2	500	8.25	1.25	36	95	1200 2000 3000	33	5	2	6.6	41	41	66
150 DHP 500	13.8	500	15	1.30	36	95	1200 2000 3000	18	5	2	11.5	23	23	37
H 150 DHP 500①							1200 2000 3000							58①
150 DHP 750		750					1200 2000 3000	28				36	36	58
H 150 DHP 750①							1200 2000 3000							77①
150 DHP 1000		1000					1200 2000 3000	37				48	48	77
DVP Vacuum Circuit Breaker														
150 DVP 500	13.8	500	15	1.30	36	95	1200 2000	18	3	2	11.5	23	23	37
150 DVP 750		750					1200 2000	28				36	36	58

① Non-Standard Breaker with High Momentary Rating available for Special Applications.

② For 3 phase and line to line faults, the sym. interrupting capability at a Kv operating voltage

$$= \frac{E}{Kv} \text{(Rated Short-Circuit Current)}$$

But not to exceed KI.
Single line to ground fault capability at a Kv operating voltage

$$= 1.15 \frac{E}{Kv} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.
The above apply on predominately inductive or resistive 3-phase circuits with normal-frequency line to line recovery voltage equal to the operating voltage.

③ For Reclosing Service, the Sym. Interrupting Capability and other related capabilities are modified by the reclosing capability factor obtained from the following formula:

$$R\,(\%) = 100 - \frac{C}{6}\left[(n-2) + \frac{15-T_1}{15} + \frac{15-T_2}{15} + \ldots\right]$$

Where C = KA Sym. Interrupting Capability at the Operating Voltage but not less than 18
n = Total No. of Openings
T_1, T_2, etc. = Time interval in seconds except use 15 for time intervals longer than 15 sec.

Note: Reclosing Service with the standard duty cycle 0+15s+CO Does not require breaker Capabilities modified since the reclosing capability factor R = 100%.

④ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:
T (seconds) =

$$Y\left[\frac{KI\ (K \text{ Times Rated Short-Circuit Current})}{\text{Short-Circuit Current Through Breaker}}\right]^2$$

The aggregate tripping delay on all operations within any 30 minute period must not exceed the time obtained from the above formula.

Application on Symmetrical Current Rating Basis

Application Considerations

Westinghouse medium voltage metal-clad switchgear provides control and protection for generators, motors, transformers and all types of feeder circuits. In the usual application the selection of the circuit breaker for the operating voltage, to carry the load current and provide for the interruption of the available short-circuit is of primary importance. The purpose of this application data is to aid in this selection.

It should be noted that for a particular application there may be other items of technical importance that require careful consideration. Also requirements for special applications or unusual service conditions should be referred to the nearest Westinghouse Sales Office with details and a request for recommendations.

Rated Maximum Voltage

The Kv operating voltage should not exceed the rated maximum voltage, E in Table 1, since this is the upper limit for operation.

Rated Continuous Current

The continuous current rating of a circuit breaker is a maximum rating. The circuit breaker rating should always be in excess of the utilization equipment rating to provide for short time overload capability.

Transformer main breakers should be rated in excess of 125% of transformer full load amperes. Always consider forced cooled rating, possible future forced cooling and 12% additional capacity for 65°C. rise rating when used.

Induction motor and synchronous motor starting breakers should be rated in excess of 125% of motor full load amperes.

Generator breakers should be in excess of 125% of generator full load current. Other factors such as increased capacity at 1.0 power factor, reduced voltage or low ambient temperature rating may have to be considered.

Capacitor bank feeder breakers should have a rating in excess of 135% of the bank full load current. This is due to a 0 to +15% manufacturing tolerance in capacitors, KVAR due to harmonic currents and possibility of up to 10% over-voltage. Capacitor switching is generally limited to 1200 ampere breakers since larger size banks are switched in steps and other factors such as limiting transient voltages and momentary duty from switching capacitors back to back or other limitations due to the type of breaker may have to be considered

Interrupting Capability

Table 1 lists rated short-circuit current at rated voltage for the various available circuit breaker types which is adjusted for the operating voltage to obtain the 3 phase symmetrical interrupting capability. This value is multiplied by 1.15 to obtain the single line to ground capability. Note that the 3 phase or single line to ground capabilities may not exceed KI, the maximum symmetrical interrupting capability.

Although these capabilities are expressed in sym. kilo-amperes, the circuit breaker shall be able to interrupt all values of asymmetrical as well as symmetrical short-circuit current from a system having an X/R ratio of 15 or less.

Short-Circuit Duty

To check the breaker application from an interrupting standpoint, compare the interrupting capability at the operating voltage with the short-circuit duty determined for the point of application in the power system.

Table 2 lists multiplying factors depending upon the system X/R ratio and the breaker rated interrupting time to obtain the maximum short-circuit duty. If the maximum multiplying factor for the source of short-circuit current is used, it is not necessary to calculate the system X/R ratio. If the system X/R ratio is 15 or less, the multiplying factor is 1.0.

Short-Circuit Duty=E/X amperes (Max. Mult. Factor)

A closer check of the application requires calculation of the system X/R ratio. It is sufficiently accurate (on the conservative side) to neglect the resistance component when calculating the system reactance X and neglect the reactance component when calculating the system resistance R. Use actual equipment data for important electrical devices wherever possible.

Typical data for various system components is included in Table 3 for estimating purposes.

System X/R ratio $= \frac{X_1}{R_1}$ for 3 phase faults

and $= \frac{2X_1 + X_0}{2R_1 + R_0}$ for single line to ground faults where X_1 and X_0 are positive and zero sequence reactances, R_1 and R_0 are positive and zero sequence resistances.

System X/R ratio so determined is used to obtain the E/X ampere multiplying factor from Table 2.

Short-Circuit Duty=E/X amperes (Mult. Factor Table 2)

E/X Amperes Calculations

Short circuit calculations usually consist of simple E/X computations:

3 phase fault	single line to ground fault
$I_{3\phi} = \frac{E}{X}$	$I_{LG} = \frac{3E}{2X_1 + X_0}$

where E is line to neutral operating voltage, and reactances are ohms, per phase, line to neutral.

Computations are simplified by selection of a common base and using the per unit system of calculations:

3 phase fault	single line to ground fault
$I_{3\phi} = \frac{I_B}{X}$	$I_{LG} = \frac{3I_B}{2X_1 + X_0}$

Where I_B is the base current in kilo-amperes and reactances are in per-unit of the common base. Convenient per-unit system formulas:

$$I_B = \frac{\text{MVA Base}}{\sqrt{3}\,\text{Kv}} \qquad \text{Base ohms} = \frac{KV^2}{MVA}$$

$$\text{per unit } X = \frac{X}{MVA}\ \text{MVA base}$$

$$\text{or} = \frac{X}{I} I_B$$

$$\text{or} = \frac{X\ \text{ohms}}{\text{base ohms}}$$

$$\text{or} = \frac{X\ \text{percent}}{100}$$

Where system is impedance grounded to limit the single line to ground fault to the 3 phase fault value or lower, only the 3 phase fault calculations are necessary.

Table 3 lists reactances quantity to be used for X for the various system components. Use actual data for important electrical devices wherever possible. Table 4 lists typical X/R ratio ranges and is included for estimating purposes.

The E/X amperes determined are in rms symmetrical kilo-ampere.

Momentary Duty

When there is motor contribution to the total short circuit, an additional calculation should be made to determine the momentary duty using the reactance quantities for momentary duty from Table 3.

Momentary Duty=1.6 E/X Amperes

Compare momentary duty with close and latch capability or momentary rating listed in Table 1.

Table 2: Multiplying Factor for E/X Amperes

Source of Short Circuit

Local

Application of breakers at generator voltage is local source. Also local sources are considered to be where short circuit is fed predominantly from generators through:

a) Not more than one transformation, or

b) a per-unit reactance external to the generator which is less than 1.5 times the generator per-unit subtransient reactance on a common system MVA base.

① Max. Multiplying Factor 1.25 3ϕ Fault
1.43 LG Fault

Remote

Most applications including station service auxiliaries are remote source. Remote sources are considered to be where the short circuit is fed predominantly from generators through:

a) two or more transformations, or

b) a per-unit reactance external to the generator that is equal to or exceeds 1.5 times the generator per-unit subtransient reactance on a common system MVA base.

① Max. Multiplying Factor 1.43 3ϕ or LG

System X/R Ratio	Type DHP Air Circuit Breaker Rated Interrupting Time, 5 Cycle			Type DVP Vacuum Circuit Breaker Rated Interrupting Time, 3 Cycle		
	Type of Fault			Type of Fault		
	3ϕ	LG	3ϕ & LG	3ϕ	LG	3ϕ & LG
	Source of Short Circuit			Source of Short Circuit		
	Local		Remote	Local		Remote
1	1.00	1.00	1.00	1.00	1.00	1.00
15②	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.02	1.05	1.00	1.01	1.05
25	1.00	1.06	1.10	1.04	1.06	1.10
30	1.04	1.10	1.13	1.06	1.10	1.15
35	1.06	1.14	1.17	1.10	1.14	1.18
40	1.08	1.16	1.22	1.12	1.16	1.21
45	1.12	1.19	1.25	1.13	1.18	1.23
50	1.13	1.22	1.27	1.14	1.21	1.25
55	1.14	1.25	1.30	1.15	1.22	1.26
60	1.16	1.26	1.32	1.16	1.23	1.27
65	1.17	1.28	1.33	1.17	1.25	1.29
70	1.19	1.29	1.35	1.18	1.26	1.30
75	1.20	1.30	1.36			
80	1.21	1.31	1.37	1.19	1.27	1.31
85			1.38			
90	1.22	1.32	1.39	1.20	1.28	1.32
95			1.40			
100	1.23	1.33	1.41	1.20	1.29	1.33
110	1.24	1.34	1.42	1.21	1.30	1.34
120	1.24	1.35	1.43	1.22		
130	1.24	1.35	1.43	1.22	1.30	1.35

① Not necessary to calculate the system X/R ratio when Max. Multiplying Factor is used.

② Where system X/R ratio is 15 or less, the Multiplying Factor is 1.0.

Table 3: Reactance X for E/X Amperes

System Component	Reactance X Used for		Typical Values & Range on Component Base	
	Short-Circuit Duty	Momentary Duty	% Reactance	X/R Ratio
2 Pole Turbo Generator	X	X	9 7 - 14	80 40 - 120
4 Pole Turbo Generator	X	X	14 12 - 17	80 40 - 120
Hydro Gen. with Damper Wdgs. and Syn. Condensers	X	X	20 13 - 32	30 10 - 60
Hydro Gen. without Damper Windings	.75 X	.75 X	30 20 - 50	30 10 - 60
All Synchronous Motors	1.5 X	1.0 X	24 13 - 35	30 10 - 60
Ind. Motors above 1000 HP, 1800 RPM and above 250 HP, 3600 RPM	1.5 X	1.0 X	25 15 - 25	30 15 - 40
All Other Induction Motors 50 HP and Above	3.0 X	1.2 X	25 15 - 25	15 5 - 20
Ind. Motors Below 50 HP and all Single Phase Motors	Neglect	Neglect	.....	.....
Distribution System from Remote Transformers	X	X	as Specified or Calculated	15 5 - 15
Current Limiting Reactors	X	X	as Specified or Calculated	80 40 - 120
Transformers				
OA to 10 MVA, 69 Kv	X	X	5.5 5 - 7	10 6 - 12
OA to 10 MVA, above 69 Kv	X	X	7.5 7 - 11	12 8 - 15
FOA 12 to 30 MVA	X	X	10 8 - 24	20 10 - 30
FOA 40 to 100 MVA	X	X	15 8 - 35	30 20 - 40

Use transient reactance X'd for X for hydro generator without damper windings.

For other machines use subtransient reactance X"d for X.

For other system components use positive sequence reactance X_1 for X.

Table 4: Typical System X/R Ratio Range (for estimating purposes)

Type of circuit	X/R Range
Remote generation thru other types of circuits, such as:: transformers rated 10 MVA or smaller for each three-phase bank, transmission lines, distribution feeders, etc.	15 or less
Remote generation connected thru transformers rated 10 MVA to 100 MVA for each three-phase bank, where the transformers provide 90 percent or more of the total equivalent impedance to the fault point	15-40
Remote generation connected thru transformers rated 100 MVA or larger for each three-phase bank, where the transformers provide 90 percent or more of the total equivalent impedance to the fault point	30-50
Synchronous machines connected thru transformers rated 25 to 100 MVA for each three-phase bank	30-50
Synchronous machines connected thru transformers rated 100 MVA and larger	40-60
Synchronous machines connected directly to the bus or thru reactors	40-120

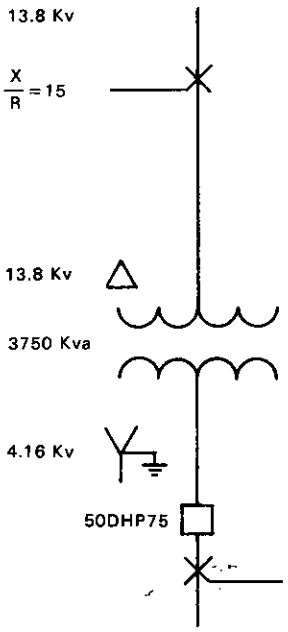
Application on Symmetrical Current Rating Basis

Example 1—Fault Calculations

Type Breaker	E Max.	3φ Sym. Interrupting Capability @ E. Max.	Max. Ki	@ 4.16 Kv Oper. Voltage	Close & Latch or Momentary
50DHP75	4.76	8.8 Ka	12 Ka	$\frac{4.76}{4.16}(8.8)=10.1$ Ka ②	19 Ka ①
		LG Sym. Interrupting Capability			
			12 Ka	1.15 (10.1) = 11.6 Ka ③	

Note: Interrupting capabilities ② and ③ at operating voltage do not exceed max. sym. interrupting capability Ki.

Check capabilities ① ② and ③ on the following utility system where there is no motor contribution to short circuit.



On 13.8 Kv System, 3.75 Mva Base

$$Z=\frac{3.75\text{ Mva}}{375\text{ Mva}}=.01\text{ pu or }1\%$$

$$Z^2=X^2+R^2=R^2\left(\frac{X^2}{R^2}+1\right)$$

$$R=\frac{Z}{\sqrt{\frac{X^2}{R^2}+1}}=\frac{1}{\sqrt{226}}=\frac{1}{15.03}=.066\%$$

$$X=\frac{X}{R}(R)=15\ (.066)=.99\%$$

Transformer Standard 5.5% Impedance has a ± 7.5% Manufacturing Tolerance

$$\text{Transformer } Z=\frac{5.50\text{ Standard Impedance}}{-.41\ (-7.5\%\text{ Tolerance})}{5.09\%}$$

From transformer losses R is calculated

31,000 Watts Full Load
−6,800 Watts No Load
24,200 Watts Load Losses

$$R=\frac{24.2\text{ Kw}}{3750\text{ Kva}}=.0065\text{ pu or }.65\%$$

$$\text{Transformer } X=\sqrt{Z^2-R^2}=\sqrt{(5.09)^2-(.65)^2}=\sqrt{25.91-.42}=\sqrt{25.48}$$

$X=5.05\%$

	X	R	X/R
13.8 Kv System	.99%	.066%	15
Transformer	5.05	.65	8
System Total	6.04%	.716%	9
or	.0604 pu	.00716 pu	

For 3 Phase Fault

$I_{3\phi}=\frac{E}{X}$ where X is ohms per phase and E is line to neutral voltage

or $I_{3\phi}=\frac{I_B}{X}$ where X is per unit reactance and I_B is base current.

$$\text{Base current } I_B=\frac{3.75\text{ Mva}}{\sqrt{3}\ 4.16\text{ Kv}}=.52\text{ Ka}$$

$$I_{3\phi}=\frac{I_B}{X}=\frac{.52}{.0604}=8.6\text{ Ka Sym.}$$

$$\text{System } \frac{X}{R}=9\text{ (is less than 15) would use}$$

1.0 mult. factor for short-circuit duty, therefore, short-circuit duty is 8.6 Ka sym. for 3φ fault ② and momentary duty is 8.6 x 1.6=13.7 Ka ①

For Line to Ground Fault

$$I_{LG}=\frac{3E}{2X_1+X_0}\text{ or}=\frac{3I_B}{2X_1+X_0}$$

For this system, X_0 is the zero sequence reactance of the transformer which is equal to the transformer positive sequence reactance and X_1 is the positive sequence reactance of the system.

Therefore,

$$I_{LG}=\frac{3(.52)}{2(.0604)+.0505}=9.1\text{ Ka Sym.}$$

Using 1.0 mult. factor, short-circuit duty= 9.1 Ka Sym. LG ③

The 50DHP75 breaker capabilities exceed the duty requirements and may be applied.

With this application, short cuts could have been taken for a quicker check of the application. If we assume unlimited short circuit available at 13.8 Kv and that Trans. Z=X

$$\text{Then } I_{3\phi}=I_{LG}=\frac{I_B}{X}=\frac{.52}{.055}=9.5\text{ Ka Sym.}$$

X/R ratio 15 or less mult. factor is 1.0 for short-circuit duty

The short-circuit duty is then 9.5 Ka Sym. ② ③ and momentary duty is 9.5 x 1.6 Ka= 15.2 Ka ①

Example 2—Fault Calculations

All calculations on per unit basis, 7.5 Mva Base

Base Current $I_B = \frac{7.5 \text{ Mva}}{\sqrt{3}\ 6.9 \text{ Kv}} = .628$ Ka

	X	R	X/R
13.8 Kv System $X = \frac{.628}{21}\frac{(6.9)}{(13.8)} = .015$	.015	.001	15
Transformer	.055	.0055	10
Total Source Transf.	.070 pu	.0065 pu	11

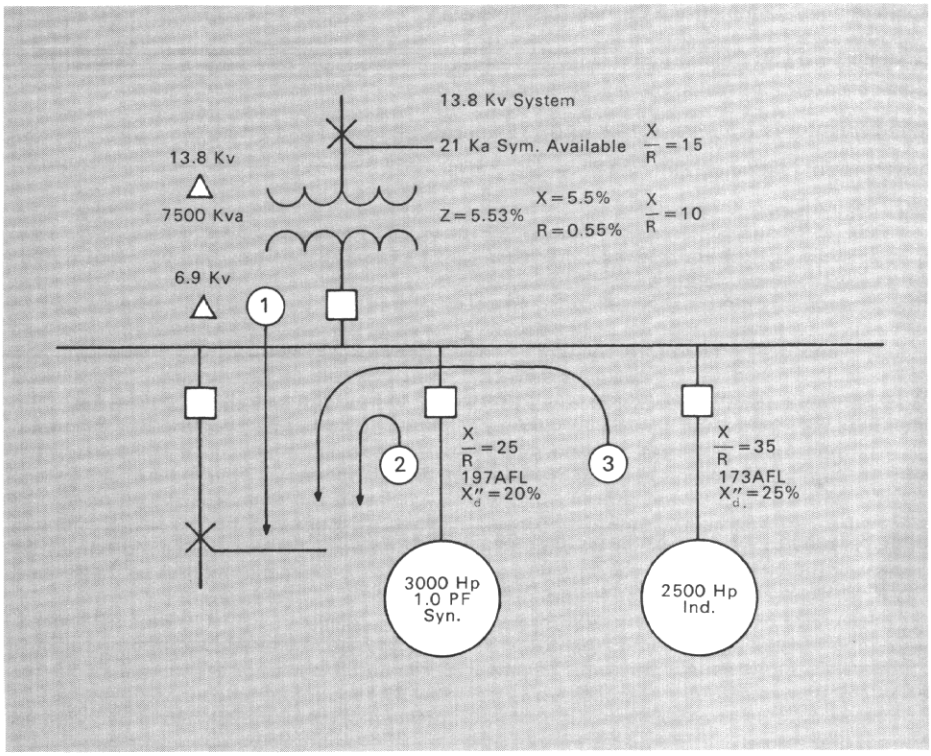
3000 Hp Syn. motor

$X = .20\frac{(.628)}{.197} = .638$ pu at 7.5 Mva base

2500 Hp Ind. Motor

$X = .25\frac{(.628)}{(.173)} = .908$ pu at 7.5 Mva base

$I_{3\phi} = \frac{E}{X}$ or $= \frac{I_B}{X}$ where X on per unit base



Source of Short Circuit Current	Interrupting E/X Amperes	Momentary E/X Amperes	X/R	X(1)/R(X) = 1/R
① Source Transf.	$\frac{.628}{.070} = 8.971$	$\frac{.628}{.070} = 8.971$	11	$\frac{11}{.070} = 157$
② 3000 HP Syn. Motor	$\frac{.628}{(1.5)\ .638} = .656$	$\frac{.628}{.638} = .984$	25	$\frac{25}{.638} = 39$
③ 2500 HP Ind. Motor	$\frac{.628}{(1.5)\ .908} = .461$	$\frac{.628}{.908} = .691$	35	$\frac{35}{.908} = 39$
	$I_{3F} = \frac{1}{\text{or}}\ \frac{10.088}{10.1 \text{ Ka}}$	$\frac{10.647}{\times 1.6}$ 17.0 Ka Momentary Duty		Total $1/R = \overline{235}$

Total $X = \frac{I_B}{I_{3F}} = \frac{.628}{10.1} = .062$

System $\frac{X}{R} = .062\ (235) = 14.5$ is Mult. Factor 1.0 from Table 3.

Short circuit duty = 10.1 Ka

Type Breaker	E Max.	3φ Sym. Interrupting Capability @ E. Max.	Max. Ki	@ 6.9 Kv Oper. Voltage	Close & Latch or Momentary
75DHP500	8.25	33 Ka	41 Ka	$\frac{8.25}{6.9}(33) = 39.5$ Ka	66 Ka
150DHP500	15	18 Ka	23 Ka	$\frac{15\ (18)}{6.9} = (39.1) = 23$ Ka (But not to exceed Ki)	37 Ka

Either breaker could be properly applied, but price will make the type 150DHP500 the more economical selection.

Application on Symmetrical Current Rating Basis

Example 3—Fault Calculations

Check breaker application on generator bus where

Each generator is 7.5 Mva, 4.16 Kv 1040 amperes full load, $1_B = 1.04$ Ka

Sub transient reactance Xd'' = 11% or, X = .11 pu

Gen $\frac{X}{R}$ ratio is 30

$$\frac{1}{X_S} = \frac{1}{X} + \frac{1}{X} + \frac{1}{X} = \frac{3}{X} \text{ and } \frac{1}{R_S} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$$

or $X_S = \frac{X}{3}$ and $R_S = \frac{R}{3}$ Therefore, System $\frac{X_S}{R_S} = \frac{X}{R} = \text{Gen}\frac{X}{R} = 30$

Since generator neutral grounding reactors are used to limit the I_{LG} to $I_{3\phi}$ or below, we need only check the $I_{3\phi}$ short-circuit duty.

$$I_{3\phi} = \frac{I_B}{X} + \frac{I_B}{X} + \frac{I_B}{X} = \frac{3I_B}{X} = \frac{3(1.04)}{.11} = 28.4 \text{ Ka Sym. E/X amperes}$$

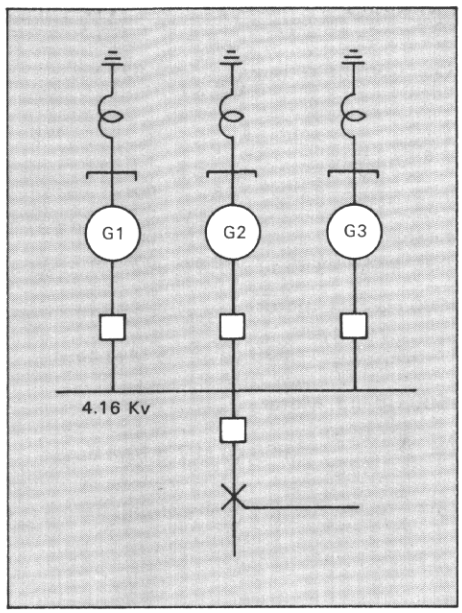
Table 3 System $\frac{X}{R}$ of 30 is Mult. factor 1.04

Short-circuit duty is 28.4 (1.04) = 29.5 Ka Symmetrical.

Type Breaker	E Max.	3φ Sym. Interrupting Capability @ E Max.	Max. Ki	@ 4.16 Kv Oper. Voltage
50DHP250	4.76	29 Ka	36 Ka	$\frac{4.76}{4.16}(29) = 33.2$ Ka
50DHP350	4.76	41 Ka	49 Ka	$\frac{4.76}{4.16}(41) = 46.9$ Ka

The 50DHP250 breaker could be applied. However, the 50DHP350 breaker would permit addition of a future duplicate generator.

Future Short-circuit Duty = $\frac{4(1.04)}{.11}$ (1.04) = 39.3 Ka Sym.



Type DHP Porcel-line® Metal-Clad Switchgear

Typical Specifications

General
The type DHP metal-clad switchgear described in this specification will be an assembly of breaker housings, auxiliary housings, and horizontal drawout circuit breakers arranged to suit the specific requirements of the purchaser. The switchgear will be designed, manufactured and tested in accordance with the latest standards of ANSI and NEMA.

The breaker housings and auxiliary housings will be bolted to each other to form a rigid metal enclosed switchgear assembly. Each housing will consist of functional components or modules. They will be the breaker/bus, control, and line modules (and, if required, an upper rear module). Metal side pans will provide a double thickness of steel between adjacent housings and metal barriers will isolate the primary major sections of each circuit. Removable metal barriers will provide access to the primary major sections of each circuit. Rear covers will be bolted-on sheets.

Weatherproofing: Aisle-less
Each shipping group will be mounted upon an integral base frame. A weatherproof enclosure will be assembled onto the complete metal enclosed switchgear assembly. A weatherproof door will be provided on the breaker drawout side of each housing.

Weatherproofing: Shelterfor-M
Each shipping group will be mounted upon an integral base frame. A weatherproof enclosure will be assembled onto the complete metal enclosed switchgear assembly. The weatherproof enclosure will extend on the breaker drawout side of the complete assembly to form an operating and/or maintenance aisle large enough to permit interchange of circuit breakers. A weatherproof door with an inside quick-release latch mechanism will be located at each end of the aisle to permit opening door even when locked from outside.

Panels: Indoor and Shelterfor-M
A formed hinged panel for control devices, relays, meters and instruments will enclose the upper front of each housing.

All units will have front panels that can be closed for any position of the breaker element to form a continuous line.

Panels: Aisle-less
A full-height formed hinged panel will be located on the breaker drawout side behind the outer weatherproof door and will be used for control devices, relays, meters, and instruments.

Breaker/Bus Module
The main bus will have flame retardant insulation. Porcelain main bus supports will cover the bus opening between housings to provide a non-combustible fire wall. Bus joints shall be provided in each unit. All bus joints will be silver-plated, bolted, and insulated with boots. The stationary primary contacts will be silver-plated and recessed within procelain supports. An automatic shutter will cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the housing with full air clearance to live parts. The stationary secondary contacts will be silver-plated multiple sockets.A stationary guide rail, levering-in screw, and safety interlocks will be provided to function with the circuit breaker. A ground contact will ground the breaker between and including the operating and test positions. Breaker/bus modules of the same rating will be interchangeable and will house any circuit breaker of the same rating.

Control Module
One set of terminal blocks will be provided for secondary connections to external circuits. One control circuit cutout device will be provided in each circuit breaker housing. Switchgear secondary wire will be #14AWG minimum.

Line Module
The ground bus will extend the length of the switchgear assembly. The ground bus joints will be silver-plated and will be bolted to each housing and to each breaker ground contact. A clamp-type terminal will be furnished for terminating a ground cable. Clamp-type terminals, one/phase, will be furnished for terminating power cables unless other terminations are specified.

Instrument Transformers
Ring-type current transformers will be furnished as indicated in the detail specification. Their thermal and mechanical rating will be coordinated with the circuit breakers. Their accuracy rating will be at least equal to ANSI Standard requirements.

The standard location for at least one ring type current transformer per phase on the bus side and line side of breaker units will be front accessible to permit adding or changing current transformers without removing high voltage insulated connections. Potential transformers or control power transformers up to 15 Kva single phase are trunion mounted with current limiting fuses in enclosed compartments. They are disconnected, grounded and isolated from high voltage when the access door is open.

A mechanical interlock is provided for control power transformers to require the secondary breaker to be open before the access door can be opened to disconnect the primary fuses.

Finish
Steel will be cleaned and phosphatized. The final indoor finish will be light grey ASA #61. The final outdoor finish will be dark grey ASA #24, applied over a coat of light grey paint. An undercoating compound will be applied to outdoor switchgear.

Circuit Breaker
The circuit breakers will be horizontal drawout type. The breakers will be operated by a motor-charged spring stored energy mechanism. The stored energy mechanism will be charged normally by a universal electric motor and in an emergency by a manual handle. The primary contacts will be silver-plated and supported on porcelain insulators. The primary disconnecting fingers will be silver-plated and retained to the primary contacts with leaf springs. Hinged tilting arc chutes with center coil blowout magnets will be provided in "Limitrak" enclosures. A vertical metal barrier in front of the arc chutes will form a shield from primary parts.

The secondary disconnecting contacts will be silver-plated multiple plugs of the train-line coupler type. The plugs will automatically engage the housing sockets in the breaker operating position. They can be manually engaged in the breaker test position. A guide channel will provide lateral alignment with the housing guide rail. Horizontal levering will be provided by rotating and engaging a shaft and nut assembly onto the housing screw. The levering mechanism shall spin-free to prevent over tightening when breaker is levered into the operating position. Interlocks will be provided to prevent levering of a closed breaker to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker will be secured positively in the housing between and including the operating and test positions. Circuit breakers of the same rating will be interchangeable and will fit any housing of the same rating.

Guide Specifications
The following guide specifications are based upon minimum equipment essential for the various typical units listed. A choice of alternates is indicated by (dc-ac) and ( ) is used to indicate where additional specific information is required. A few optional items are listed for consideration. Additional information or assistance needed for a specific application may be obtained from the nearest Westinghouse Sales Office.

General
The (indoor-outdoor Aisle-less—outdoor shelterfor-M—outdoor common aisle shelterfor-M) metal-clad switchgear described in this specification will be designed for operation on a (2400-4160-4800-6900-12000-12470-13800) volt 3-phase (3-4) wire (solidly grounded—impedance grounded—ungrounded) 60 hertz system:

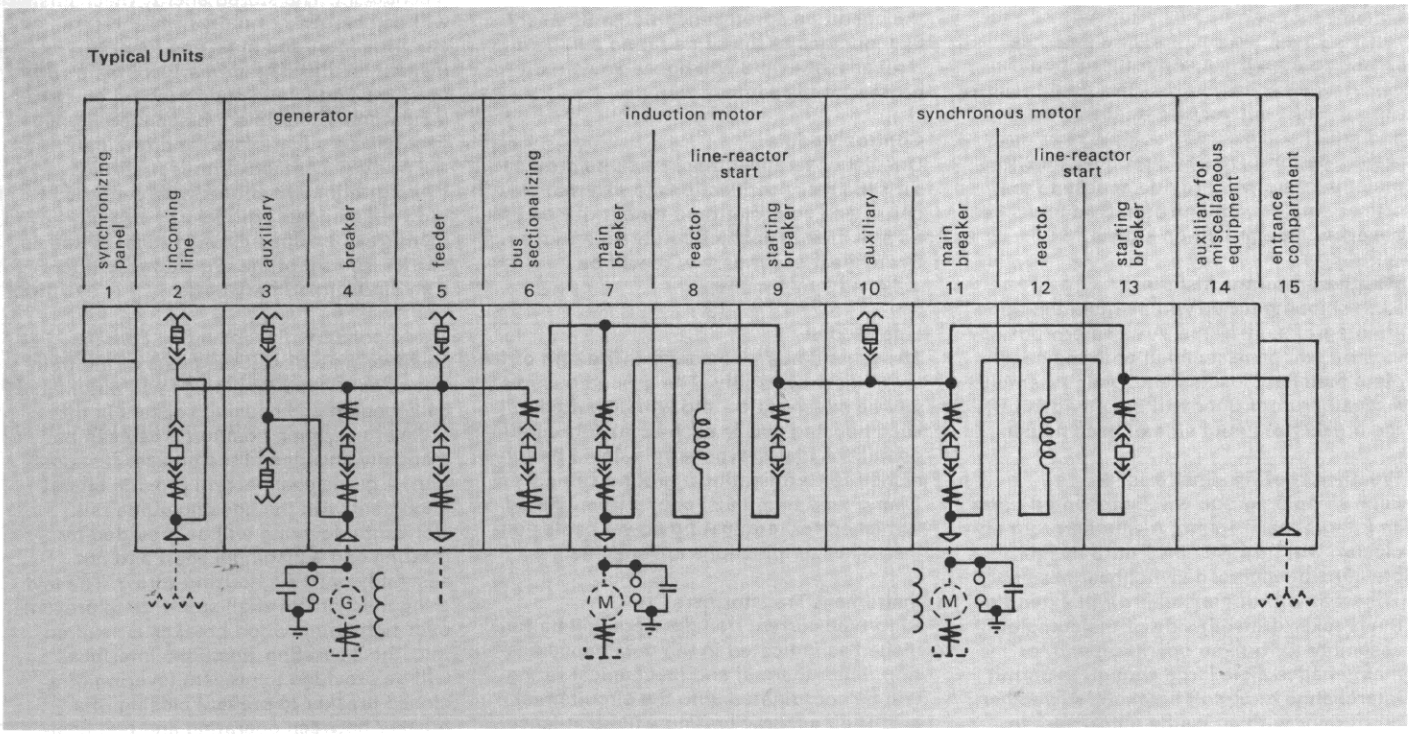
A set of (1200-2000-3000-4000) ampere (aluminum-copper) conductor insulated main bus will be provided with provisions for addition of future units to (either-the left-the right) end.

A bare ground bus bolted to each housing and breaker ground contact shall be included. (In addition a (bare-insulated) (600-1200) ampere system neutral bus is required).

The removable circuit breakers shall be (4.16-7.2-13.8) Kv (75-250-350-500-750-1000) Mva interrupting class, 3 phase, 60 hertz, (standard-high) momentary type (50DHP75-50DHP250-H50DHP250-50DHP350-75DHP500-150DHP500-H150DHP500-150DHP750-H150DHP750-150DHP1000) electrically operated by an (dc-ac) motor-charged spring stored energy mechanism. Control shall be (48dc-125dc-250dc-230ac-115ac) close and (48dc-125dc-250dc-ac capacitor) trip.

The metal-clad switchgear units will be numbered left to right and arranged as shown on the attached (drawing-one line diagram—sketch).

Standard DHP Assemblies: Indoor and Outdoor



Typical Units

Unit 1 Synchronizing Panel

1—Swinging instrument panel

2—KA-221 ac voltmeter

1—KI-241 synchroscope with two lamps

Optional Item
1—KR3-221 Frequency meter

Unit 2 Incoming line

The metal-clad switchgear for control incoming line will include:

1—Breaker base unit ( ) ampere

1—( ) ampere main bus

1—Set of cable lugs

3—Current transformers, ( )-5 ratio

1—W-2 breaker control switch with red & green lights

1—W-2 ammeter switch

1—KA-221 ac ammeter 0-( ) scale

3—CO phase overcurrent relays

Optional Items
1—Two line to line potential transformers

1—Three line to ground potential transformers

1—W-2 synchronizing switch

1—W-2 voltmeter switch

1—KA-221 ac voltmeter

1—KY-221 wattmeter, 0-( ) scale

1—D4B-2F watthour meter, 2 element

Units 3 and 4 Generator

The metal-clad switchgear for control of a generator will consist of one auxiliary unit and one breaker unit as follows:

Unit 3 The generator auxiliary unit will include:

1—( ) ampere main bus

1—(Two line to line) (Three line to ground) potential transformers for generator metering

1—(one) (two) line to line potential transformer for generator regulator

1—DBF field breaker, electrically operated

1—Provision for field discharge resistor

1—Provision for exciter field rheostat control either (a) handwheel only for maximum of two 15 inch diameter plates or (b) W-2 control switch for remote electrically operated rheostat mechanism

1—W-2 regulator transfer switch

1—Provisions for voltage regulator

1—KX-221 dc ammeter and shunt, 0-( ) scale

Optional Items
1—TRA ( ) voltage regulator

1—KX-221 dc voltmeter, 0-( ) scale

1—KX221 temperature meter equipment and switch

1—CRN-1 generator anti-motoring relay

3—CA generator differential relay

1—WL-2 lockout auxiliary relay, hand reset

Unit 4 The generator breaker unit will include:

1—( ) ampere main bus

1—Breaker base unit ( ) ampere

1—Set of cable lugs

3—Current transformers ( )-5 ratio

1—Current transformer ( )-5 ratio for voltage regulator, if required for parallel operation

2—W-2 control switch with red and green lights for field breaker and generator breaker

1—W-2 ammeter switch

1—W-2 voltmeter switch

1—W-2 synchronizing switch

1—W-2 governor motor control switch

1—KA-221 dc ammeter, 0-( ) scale

1—KY-221 wattmeter, 0-( ) scale

1—KY-221 varmeter, 0-( ) scale

3—COV voltage controlled overcurrent relay

Optional Items
1—D4B-2F watthour meter, 2 element

3—Current transformers, ( )-5 ratio for generator differential relays

3—Current transformers, ( )-5 ratio for generator differential relays and connection in generator neutral, unmounted

1—Set of surge capacitors and lightning arresters for connection at generator terminals, unmounted

Unit 5 Feeder

The metal-clad switchgear for control of a feeder will include:

1—Breaker base unit ( ) ampere

1—( ) ampere main bus

1—Set of cable lugs

3—Current transformers, ( )-5 ratio

1—W-2 breaker control switch with red & green lights

1—W-2 ammeter switch

1—KA-221 ac ammeter, 0-( ) scale

3—CO phase overcurrent relays

Optional Items
1—D4B-2F watthour meter, 2 element

1—(one) (two) line to line potential transformers

1—Three line to ground potential transformers

Unit 6 Bus sectionalizing

The metal-clad switchgear for control of bus sectionalizing will include:

1—Breaker base unit ( ) ampere

1—( ) ampere bus transition

1—W-2 breaker control switch with red & green lights

Optional Items
3—Current transformers, ( )-5 ratio

1—W-2 ammeter switch

1—KA-221 ac ammeter, 0-( ) scale

3—CO phase overcurrent relays

Typical Units

Unit 7 Induction Motor, full voltage start

The metal-clad switchgear for control of induction motor will include:

1—Breaker base unit ( ) ampere

1—( ) ampere main bus

1—Set of cable lugs

3—Current transformers, ( )-5 ratio

1—W-2 breaker control switch with red & green lights

1—W-2 ammeter switch

1—KA-221 ac ammeter, 0-( ) scale

1—BL-1 temperature relay, 2 element

1—CO phase overcurrent relay

1—CV undervoltage relay

Optional Items

1—BYZ zero sequence current transformer 50-5 ratio

1—ITH ground inst. overcurrent relay, 1 element

1—CM phase current unbalance relay

3—CA motor differential relay

1—WL-2 lockout auxiliary relay, hand reset

3—Current transformers ( )-5 ratio for motor differential relays

3—Current transformers ( )-5 ratio for motor differential relays and connection in the motor neutral, unmounted

Units 7, 8 and 9 Induction Motor, Line-Reactor Start

The metal-clad switchgear will consist of two breaker units and one reactor unit as follows:

Unit 7 The main or running breaker unit will include:

1—Set of equipment identical to the equipment for 'unit 7 induction motor, full voltage start' plus

1—Transition bus ( ) ampere

1—MOC switch, auxiliary contacts

1—TOC switch, premissive control

1—Agastat time relay

Unit 8 The starting reactor unit will include:

1—( ) ampere main bus

1—Reactor housing and connections

1—Motor starting reactor

Note—Specify the percent starting voltage desired or limitation on starting current or starting Kva with minimum starting voltage of the drive.

Advise complete motor data including locked rotor amperes, starting power factor, starting torque and starting time at 100% volts.

Advise system short-circuit Kva available at the motor terminals for starting.

Unit 9 The starting breaker unit will include:

1—Breaker base unit ( ) ampere

1—( ) ampere main bus

1—Set of connection to reactor

1—TOC switch, permissive control

3—Current transformers ( )-5 ratio

1—W-2 breaker control switch with red & green lights

Optional Items

3—Current transformers ( )-5 ratio for motor differential relays

Note—Metal-clad switchgear for neutral reactor start would include a set of equipment same for line reactor start except delete current transformers from the starting breaker unit and delete the transition bus from the main or running breaker unit.

Units 10 and 11 Synchronous motor, full voltage start.

The metal-clad switchgear will consist of one auxiliary unit and one breaker unit as follows:

Unit 10 The auxiliary unit will include:

1—( ) ampere main bus

1—ASR synchronous motor field application control with field failure relay

1—Field discharge resistor

1—Field contactor or electrically operated type DBF field breaker for field currents over 240 amperes

1—Exciter field control either (a) hand-wheel only for maximum of two 15 inch diameter plates or (b) W-2 control switch for remote electrically operated rheostat mechanism

1—SG auxiliary relay for excitation check

1—Agastat time relay for sequence check

1—KX-221 dc ammeter and shunt

Unit 11 The breaker unit will include:

1—Breaker base unit ( ) ampere

1—( ) ampere main bus

1—Set of cable lugs

3—Current transformers, ( )-5 ratio

1—W-2 breaker control switch with red & green lights

1—W-2 ammeter switch

1—KA-221 ac ammeter, 0-( ) scale

1—KY-221 varmeter, 0-( ) scale

1—BL-1 temperature relay, 2 element

1—CO phase overcurrent relay

1—CV undervoltage relay

Optional Items

1—BYZ zero sequence current transformer 50-5 ratio
1—ITH ground inst. overcurrent relay, 1 element
1—CM phase current unbalance relay
3—CA motor differential relay
1—WL-2 lockout auxiliary relay, hand reset
3—Current transformers ( )-5 ratio for motor differential relays
3—Current transformers ( )-5 ratio for motor differential relays and connection in the motor neutral, unmounted

Units 10, 11, 12 and 13 Synchronous motor, line reactor start

The metal-clad switchgear will consist of one auxiliary unit, two breaker units and one reactor unit as follows:

Unit 10 The auxiliary unit will include

1—Set of equipment identical to the equipment for 'unit 10 synchronous motor, full voltage start'

Unit 11 The breaker unit will include

1—Set of equipment identical to the equipment for 'unit 11 synchronous motor, full voltage start'
plus

1—Transition bus ( ) ampere

1—MOC switch, auxiliary contacts

1—MOC switch, permissive control

1—Agastat time relay

Unit 12 The synchronous motor reactor unit will include:

1—Set of equipment identical to the equipment for 'unit 8 starting reactor unit'

Unit 13 The synchronous motor starting breaker unit will include:

1—Set of equipment identical to the equipment for 'unit 9 starting breaker unit'

Unit 14 Auxiliary unit

The metal-clad switchgear for auxiliary unit will include:
1—( ) ampere main bus

1—Set of equipment such as potential transformers, control power transformer, surge protection equipment, etc.

Unit 15 Entrance compartment
The metal-clad switchgear for one entrance compartment will include

1—( ) ampere main bus

1—Set of cable lugs

Bus Run—Refer to page 3 for guide specification and ordering information.

Accessories: Standard
One set of accessories for test, inspection, maintenance, and operation, including:

1—Maintenance handle for manually closing circuit breaker when not in housing and manually charging

1—Levering crank for moving circuit breaker between test and connected positions

1—Spanner nut wrench for removing, replacing, or checking tightness of main disconnect contacts when de-energized

1—Set of test plugs for use with Flexitest relays and meters

1—Arc chute lifter to assist in tilting of arc chutes. For 50DHP350 breakers and all 7.5 and 15 Kv circuit breakers

1—Transport truck for handling circuit breaker outside housing. For Aisle-less gear

1—Turning dolly for handling circuit breaker outside housing. For indoor and Shelterfor-M gear

1—Test cable for electrically operating circuit breaker outside housing

1—(Optional) Test cabinet for testing electrically operated breakers outside housing

Optional Equipment
125 Volt Control Battery
The control battery will provide power for electrical operating mechanisms and may be used for indicating lamps, alarm circuits, and control relays:

1—60-cell storage battery, lead-acid type, in sealed plastic jars. Discharge rate will not be less than . . . . amperes for one minute, or . . . . amperes for 8 hours to 1.75 volts per cell. There will also be furnished electrolyte, interconnectors, rack, cell numbers, portable hydrometer, and vent hole thermometer.

48 Volt Tripping Battery
The tripping battery will provide power for the shunt trip coils:

1—24-cell storage battery, lead-acid type, in sealed plastic jars. Discharge rate will not be less than . . . . amperes for one minute or . . . . amperes for 8 hours to 1.75 volts per cell. There will also be furnished electrolyte and interconnectors.

Battery Chargers
Non-automatic:

1—Static battery charger, ... volt, 60 cycles, ac and . . . . amperes to . . . . amperes dc, with dial switch, ammeter, and voltmeter

Self-regulating:

1—Self-regulating battery charger, ... volts, 60 cycles, ac, and . . . . amperes to . . . . amperes dc, with indicating and control devices

Ac Closing
The stored energy circuit breaker is available for ac closing. In lieu of a reliable external ac source, one . . . . -240/120 volt operating transformer may be required on the line side for each incoming line, generator unit, and bus section.

Ac Tripping
In lieu of battery tripping, specify a capacitor trip device for each circuit breaker and lockout relay. In addition, a potential transformer may be required on the line side of each incoming line, generator unit, and bus section.

Surge and Lightning Protection
Where there are exposed lines, it is recommended that the purchaser provide adequate surge and lightning protection. If desired, this protective equipment can be supplied in the metal-clad gear.

When ordering, specify:

1. Single-line diagram showing main connections and sketch showing desired order of assembly units.

2. Item details such as current transformer ratios, relay types, characteristics, ranges, etc.

3. Name of manufacturer and complete nameplate rating of all equipment to be controlled by the switchgear. Generator information should include the field rheostat, field discharge resistor, governor motor information and exciter rating. Synchronous motor information should include exciter rating.

4. The control voltages for operating the closing mechanism and shunt trip coil.

5. Type of cable, number and size of conductors and diameter over lead or braid for each power circuit and where they are to enter (top or bottom).

6. How power cables are to terminate (clamp-type terminals or potheads).

7. Where control cables are to enter (top or bottom).

8. Maximum overall dimensions of shipping section which can be handled and installed at destination.

9. Complete wording for each circuit identification nameplate.

Drawings and Instruction Books

Every Porcel-line type DHP order includes a set of general assembly and floor plan drawings, a series of installation and field assembly drawings, and a job instruction book. This information provides complete details for layout planning. This information also provides detailed instructions as to the shipping and receiving, handling, storing, and installation of the metal-clad switchgear. No field operations should be attempted without first consulting the drawings and instruction books.

Shipping and Receiving

Porcel-line metal-clad switchgear is shipped in groups of one or more units. Each group is ruggedly designed and braced to withstand shipment by truck, rail, or ship. Indoor groups are bolted to skids and enclosed in a protective covering. Because of their structural base outdoor groups do not need skids. For single-row Shelterfor-M the aisle wall is positioned across the front of the shipping group. For double-row Shelterfor-M a protective covering is located across the front of each shipping group. Aisle-less gear is protected by its own weatherproof enclosure. DHP circuit breakers, aisle parts, accessories, and installation materials are packed and crated separately. Appendages such as bus runs and synchronizing panels and large internal equipment such as oil-filled transformers may also be packed and crated separately. When received the purchaser should check the material against the shipping list. If loss or damage is discovered, file claims with the transportation company and notify the nearest Westinghouse representative.

Handling

Porcel-line metal-clad switchgear is equipped for handling by crane. In addition, it is provided with shipping braces and jack supports. It is recommended that the groups be lifted into position by crane. However, if no crane is available they may be skidded into place on rollers using jacks to raise and lower the group.

Porcel-line type DHP breakers are crated so as to be handled by crane or industrial "fork" truck. After uncrating but before installing arc chutes, breakers may be lifted by crane. On smooth floors they may be rolled easily on their own wheels.

Storing

Porcel-line switchgear which cannot be installed and put into service immediately must be stored so as to maintain the equipment in a clean and dry condition. Storage in a heated building is recommended. If stored outdoors, special precautions must be taken: indoor switchgear must be covered and temporary heating equipment installed, outdoor switchgear must be supplied with temporary power for operation of the space heaters. During storage the shipping groups should be placed on a level surface to prevent unnecessary strain.

Installation and Field Assembly

Westinghouse Porcel-line switchgear is factory-tested and factory-assembled from accurately tooled parts upon true and level bedplates. A minimum of installation and field assembly time will be required if the procedures described on the drawings and in the instructions are adhered to.

Careful preparation of the foundation will simplify erection and will assure good switchgear performance and reliability. The foundation must have sufficient strength to withstand the weight of the structure and breakers plus the impact resulting from breaker operation.

The foundation for indoor switchgear should consist of rugged steel channels imbedded in a concrete floor. The steel channels must be flat, level, and in a true plane with each other. The finished floor must be in a true plane with the steel channels and must not project above the level of the steel channels.

The foundation for outdoor switchgear may be a concrete pad, footers, or pillars. For any condition, the aisle-less switchgear requires a reasonably level and smooth pad for breaker drawout. The integral base furnished with outdoor switchgear should be supported in a level and true plane.

Field assembly of the Shelterfor-M aisle and of some weather-proofing is required. These parts are standardized and tool-made to simplify and expedite their assembly. The details of assembly are described in the job instruction book and associated drawings.

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Switchgear Division
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