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A comparison of metal-enclosed load interrupter (ME) switchgear and metal-clad (MC) switchgear

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Definitions

Metal-enclosed load interrupter switchgear type ME

Metal-enclosed switchgear is defined in ANSI C37.20.3-1987, in part, as metal-enclosed power switchgear including interrupter switches, power fuses (current limiting or non-current limiting), bare bus and connections; instrument transformers and control wiring and accessory devices. This essentially describes non-compartmentalized metal-enclosed single or multiple fused or non-fused load interrupters such as Eaton's type WLI.

ANSI C37.20.3, C37.20.4, and C37.22 are the standards for the load interrupter switch component. Previously, the standards for that device as a component were those for high-voltage air switches. (Reference C37.30, C37.32, C37.33, and C37.34.)

While most of these standards discuss temperature rise limits, ratings, service conditions, tests, and construction, they also specify current ratings including rated momentary currents and rated short time currents. Typically, these values are referred back to the power component switching device standard.

Metal-enclosed load interrupter switchgear type ME

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Metal-clad switchgear type MC

Metal-clad switchgear is defined in ANSI C37.20.2-1987 as metal-enclosed power switchgear characterized by the following required features (paraphrased):

- Removable (drawout) type switching and interrupting devices capable of moving between a connect and disconnect position with self-alignment and self-coupling
- Major parts of the switchgear to be completely enclosed by grounded metal barriers for compartmentalization
- Automatic shutters that cover primary stabs or studs when the removable element is in the disconnected, test, or removed position
- All primary bus conductors and connections covered with insulation material throughout

The features above describe metal-clad Eaton type VacClad-W switchgear including Eaton type VCP-W drawout vacuum circuit breakers and protective relays.

Metal-clad switchgear type MC

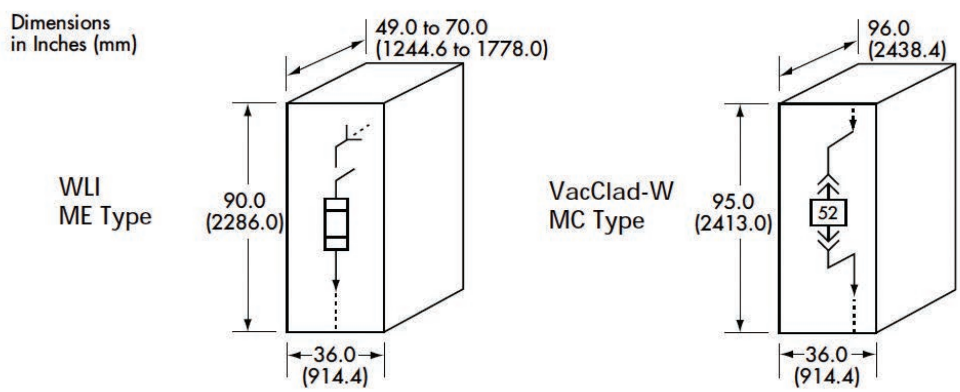

Figure 1. Typical one-lines and elevations for single indoor structures

Figure 1 shows typical one-lines and elevations for a single structure.

Table 1 shows a descriptive summary of some of the major differences between metal-enclosed and metal-clad types of equipment.

Table 1. Key differences between metal-enclosed and metal-clad types of equipment

Parameter ①		Metal-enclosed type WLI			Metal-clad type VacClad-W		
Voltage range		4.76 – 38 kV			4.76 – 38 kV		
BIL (Basic Impulse Level)		5 kV – 60 kV; 15 kV – 95 kV; 25.8 kV – 125 kV; 38 kV – 150 kV			5 kV – 60 kV; 8.25 kV – 95 kV; 15 kV – 95 kV; 27 kV – 125 kV; 38 kV – 170 kV ②		
Standards—switchgear		C37.20.3 – 1987			C37.20.2 – 1987		
Switch or breaker—device		C37.20.4 and C37.22			C37.04 –.11		
		Width	Depth	Height	Width	Depth	Height
Size/structure ③	Inches (mm)	36.0 (914.4)	55.3–70.0 (1404.6–1778.0)	90.4 (2296.2)	36.0 (914.4)	96.3 (2446.0)	95.0 (2413.0)
Weight	lb (kg)	1800 (816.5)			2650 (1202.0)		
Cost/switch/breaker		$12,000 – $14,000			$22,000 – $25,000		
ANSI minimum ④ electrical duty cycle		30			1000		
Protective device		Power fuse			Protective relays/breaker		
Operation		Manual operation (electrical operation is optional)			Electrically operated only		
Compartmentalization		Open			Barriered		

① Some data is typical and represents close estimates.

② ANSI standards at 38 kV require 150 kV BIL.

③ Data based on 5–15 kV class equipment. Feeder breakers may be stacked two-high.

④ Metal-enclosed data is for 15 kV, 600 A switches. Metal-clad data is for 1200–2000 A breakers.

Factors affecting selection

There are significant differences (first cost included) to consider when selecting metal-enclosed or metal-clad switchgear. The following paragraphs explain some of these differences in terms of owner and engineering value.

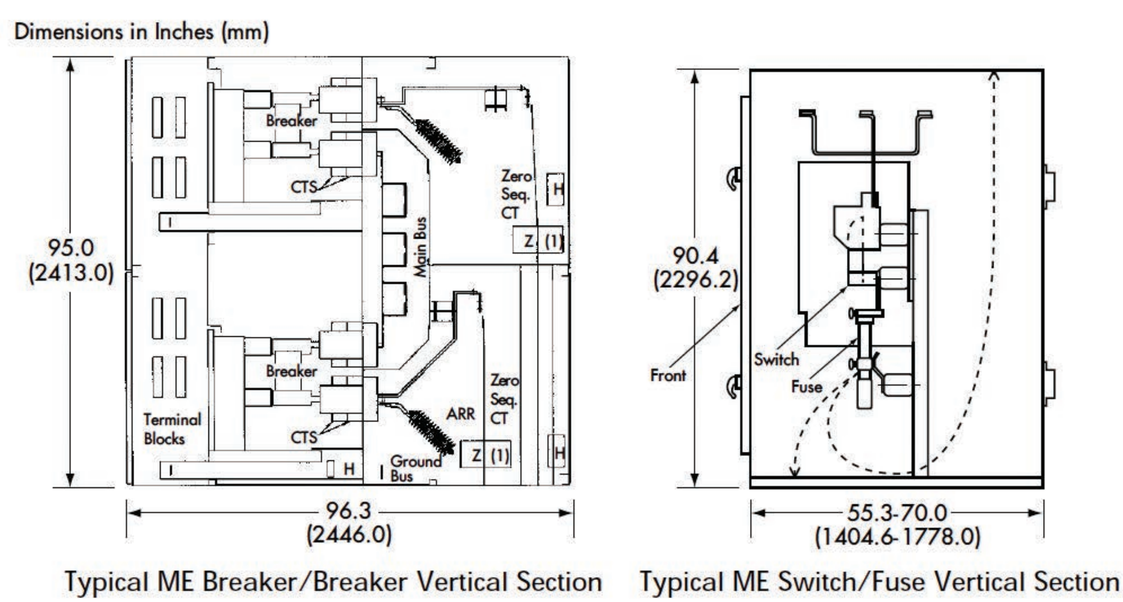

Figure 2. Section views of typical feeder devices

Construction

The first selection factor, construction (see **Figure 2**), is related to continuity of service and its negative financial impact due to an extended shutdown.

For switchgear lineups, the metal-clad construction offers superior fault isolation from compartment-to-compartment because the grounded sheet metal barriers surround all major components and devices. In metal-enclosed construction, however, because of its more open and non-compartmentalized construction, an internal fault, while rare, could propagate throughout the switchgear.

The probability of and total cost of extended downtime needs to be addressed in the selection process as well as the additional first cost for metal-clad construction. (For single vertical section application, barriering offers much less value.)

Metal-clad switchgear, such as type VacClad-W, incorporates only insulated bus with sufficient air clearances in between phase bussing. However, insulated bus joints are more difficult to check and maintain. While some metal-enclosed load interrupter equipment may insulate bus, standards permit open uncovered bussing. Insulation of the bus provides additional safety against faults occurring due to unattached equipment or tools left on bus bars.

The drawout feature in metal-clad switchgear is very important, especially for lineups, for continuity of service because the entire lineup does not have to be shut down to remove a single element for maintenance and/or repair. For a single load interrupter switch on a secondary unit substation, the drawout feature does not offer as significant a benefit.

In radial systems with one primary upstream load interrupter feeding one or more unit substations with primary metal-enclosed switches, unnecessary power outage, although unlikely, may occur if the feeder switch had to be removed from service (see **Figure 3** for example). If the secondaries of these unit substations are double ended with a second primary source, the importance of this feature is considerably reduced in terms of continuity of service.

One additional advantage is when a spare vacuum breaker is available for minimizing a particular feeder's downtime. In lineups of load interrupter equipment, this would be impractical.

Estimates and analysis of the importance of continuity of service and prospective downtime need to be reviewed to make these evaluations.

In addition, the protective sensing devices used for metal-clad switchgear are typically protective relays such as induction disk or microprocessor-based protective relays, such as Eaton's Digitrip 3000 overcurrent protective relay, which can be tested and removed while keeping the circuit energized.

Another construction feature concerns resettability, i.e., re-energizing primary circuits and/or transformers after an overload trip. In the case of metal-enclosed fusible devices, fuses obviously must be replaced; whereas with protective relays, the protective relay may be reset and a resumption of service can be made in a significantly shorter time frame.

Replacement costs of fuses can be thousands of dollars.

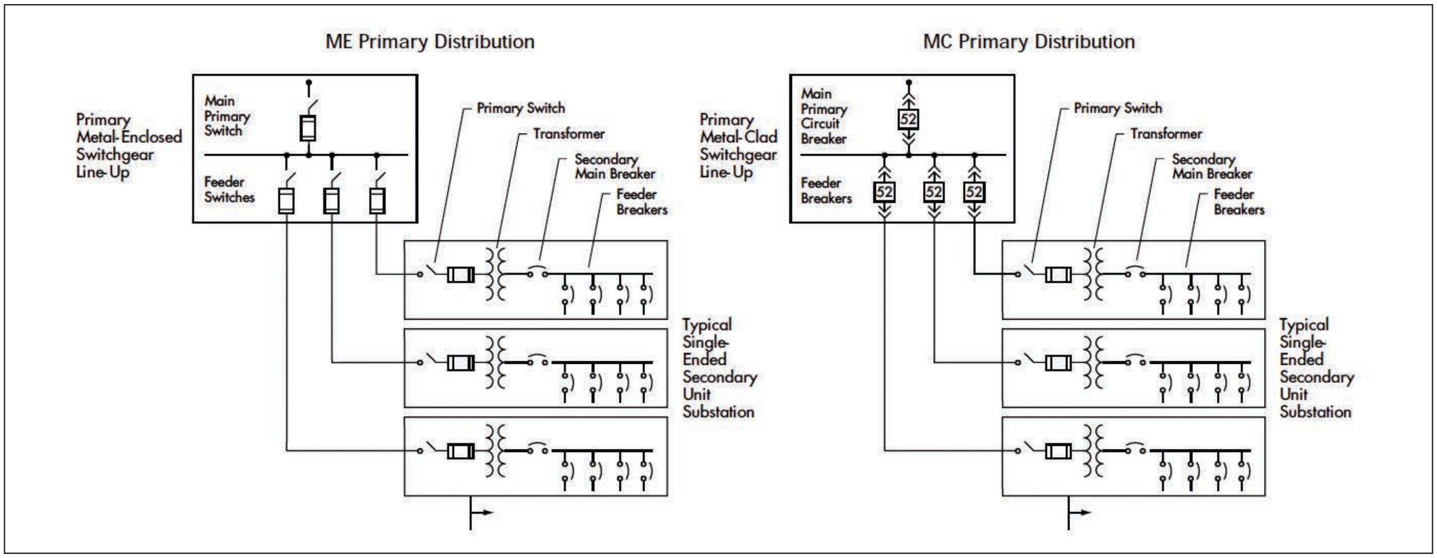

Figure 3. Radial systems

Size

Figure 1 shows size differences per structure. For lineups of primary protective devices, size advantage in terms of length may reside with metal-clad vacuum circuit breakers, stemming from the ability to stack feeder breakers two-high. (See **Figure 6** for a typical dual source lineup with two main devices, a tie device, and feeder devices.) In essence, this allows two 15 kV feeder devices in a single 36-inch (914.4 mm) wide section. In terms of depth, load interrupter switchgear provides significant size reductions of 25 to 32 inches (635.0 to 812.8 mm) for lineups.

For single devices, in a unit substation configuration, the metal-enclosed type WLI sizing offers a clear advantage. The 96.30-inch (2446.0 mm) minimum depth of metal-clad drawout vacuum circuit breakers presents a more significant dimensional constraint than the typical 62-inch (1574.8 mm) or 70-inch (1778.0 mm) deep load interrupter switch. Note that most dry-type transformers and 480 V secondary switchgear are rarely in excess of 72 inches (1828.8 mm) deep. In addition, metal-clad switchgear requires certain minimum aisles in the front for circuit breaker withdrawal as well as to enable lift trucks to remove these breaker elements from the lineup. Required aisle space in front of metal-clad switchgear is typically 5 ft (1524.0 mm) to 6 ft (1828.8 mm). Rear accessibility and working space is required for metal-clad construction. Metal-enclosed switchgear can be either front or rear accessible depending upon options and cable entry/exit requirements.

For primary selective applications (two sources of primary power), metal-enclosed types offer two options: A duplex configuration (see **Figure 4**) and a selector configuration (see **Figure 5**). Costs would be dramatically higher for metal-clad duplex equivalent arrangements because two vacuum breakers would be required. No equivalent exists in a metal-clad type for the selector configuration.

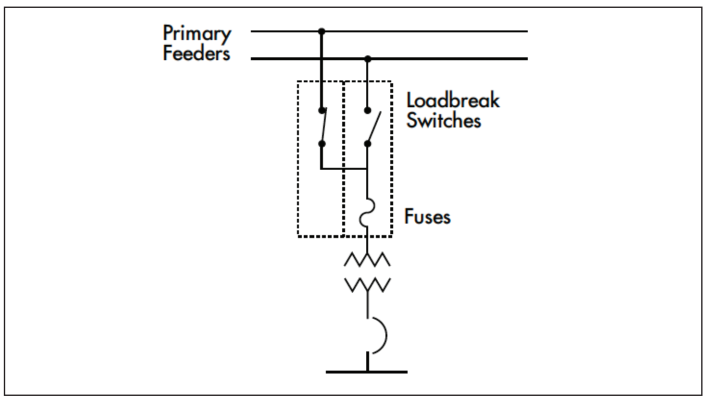

Figure 4. Duplex fused switch in two structures

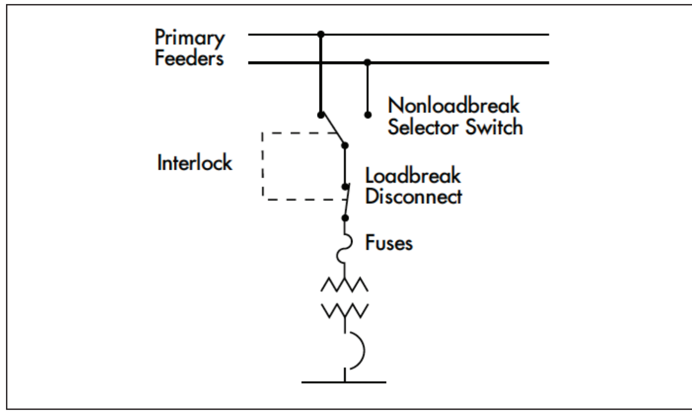

Figure 5. Fused selector switch in one structure

Operation

Method of operation—Most load interrupter switchgear (such as type WLI) is manually operated while all metal-clad vacuum circuit breaker switchgear is inherently electrically operated either from a dc or an ac source. For single section metal-enclosed equipment, feeding a single transformer such as a unit substation, presents no adverse problems; and in fact, the simplicity of a manually operated switch may lend itself to many of these installations.

For lineups (see **Figure 6**) with automatic throw-over with load interrupter equipment, the mains and ties would have to be equipped with motor operators, which typically require auxiliary structures and are add-on devices at increased cost. (Type WLI is available with integral motor operators, requiring no additional space.) In metal-clad construction, with automatic throw-over schemes, the inherent motor operation of vacuum breakers can be more meaningful to the designer in addition to the obvious benefits of convenient operation. The speed required in a transfer will also affect selection (breakers operate in several cycles).

Duty cycle—**Table 2** depicts duty cycle differences, which in essence defines their useful life. In this regard, there is a stark difference between metal-enclosed load interrupter switches and metal-clad vacuum circuit breakers. Obviously, the application must take duty cycle into account when selecting different types of equipment such as automatic throw-over schemes and especially ones that are exercised on a scheduled basis.

Table 2. Duty cycle differences

Device (per ANSI) ①	Number of load current switching operations	Number of mechanical operations
Metal-enclosed interrupter switches	30	500
Metal-clad breakers	1000	10,000

① Data is for 600 A, 15 kV switches and 1200 A, 15 kV breakers.

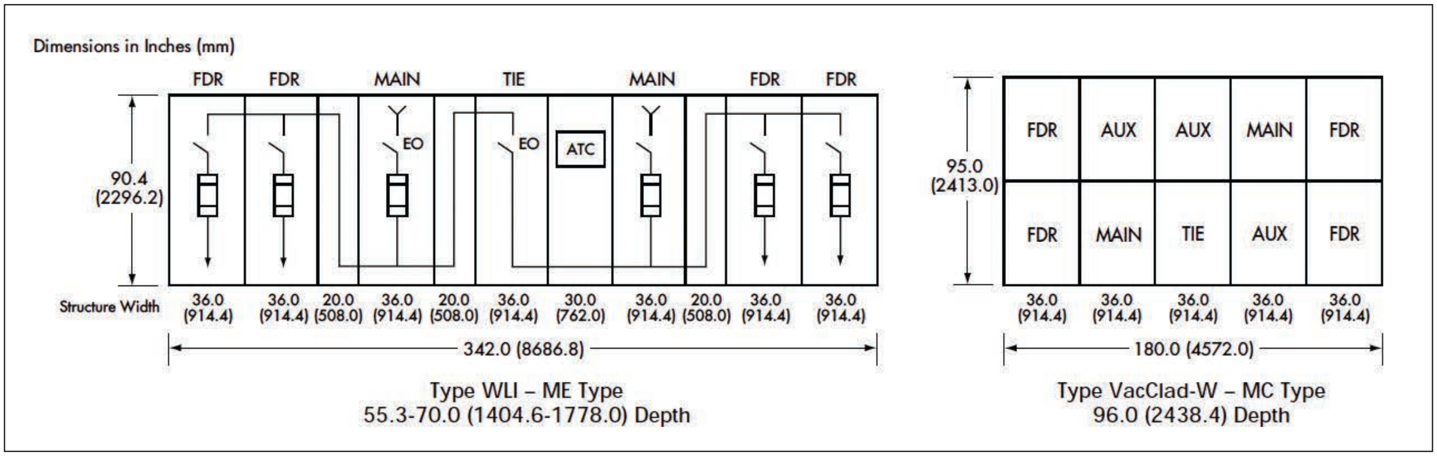

Figure 6. Lineups with automatic throw-over

Protection

Protection is one of the major differentiations and selections between metal-enclosed and metal-clad switchgear (see **Table 3** and also Section 5.4 in the IEEE® Grey Book "Electric Power System in Commercial Buildings").

Table 3. Protection summary

Features	Fuses	Relays
Overload protection	No	Yes
Medium and high short circuits	Yes	Yes
May cause single-phasing of circuit	Yes	No
Adjustable time current curves	No	Yes
Maintainable	No	Yes
Additional protective functions	No	Yes
Replaced when operated	Yes	No
Ground fault protection	No	Yes
Coordination	Good	Excellent

Metal-enclosed typically relies on fuses for protection, which in general provides safe and cost-effective means for medium and high fault clearing. The following are application comments:

- In some cases, switches have been specified on 5 kV low resistance grounded systems where ground faults are limited to values below the switch rating, typically 600 A. Basically, external relays are called upon to signal the load interrupter to open. Because this occurs while a fault is in progress, it's possible the fault will escalate into a higher phase-to-phase fault just as the switch is relied on to open. Because of this, a vacuum circuit breaker should be used; it can interrupt up to 1000 MVA. Eaton does not recommend that a switch be used on a ground fault application. (See **Figure 7** for a low resistance ground scheme using breakers.)
- Medium-voltage fuses provide poor ground fault protection because the magnitude of the ground fault may be well below the current rating of the fuse.
- Care should also be taken to prevent single-phasing of fusible load interrupter metal-enclosed equipment. (Reference Section 13.3.15 of the IEEE Buff Book.) It can be shown that as low as a 3-1/2% voltage unbalance can produce upward of 20% overheating in induction motors. Single-phase and/or blown fuse protection is optionally available for metal-enclosed switchgear.
- Possible voltage spikes/transients produced by fuses during significant current limitation should also be factored into the selection process and should be coordinated with surge protection.
- References for medium-voltage fuses and load interrupter equipment and their recommended usage can be found in Sections 5.3, 9.2, and 9.3 in the IEEE Red Book "Electric Power Distribution for Industrial Plants;" Sections 5.3 and 5.4 in the Grey Book "Electric Power Systems in Commercial Buildings;" and also Sections 5.12 through 5.17 in the Buff Book "Protection and Coordination of Industrial and Commercial Power Systems." It can be seen that load interrupter fused switches are commonly applied for many applications, especially for transformer protection.

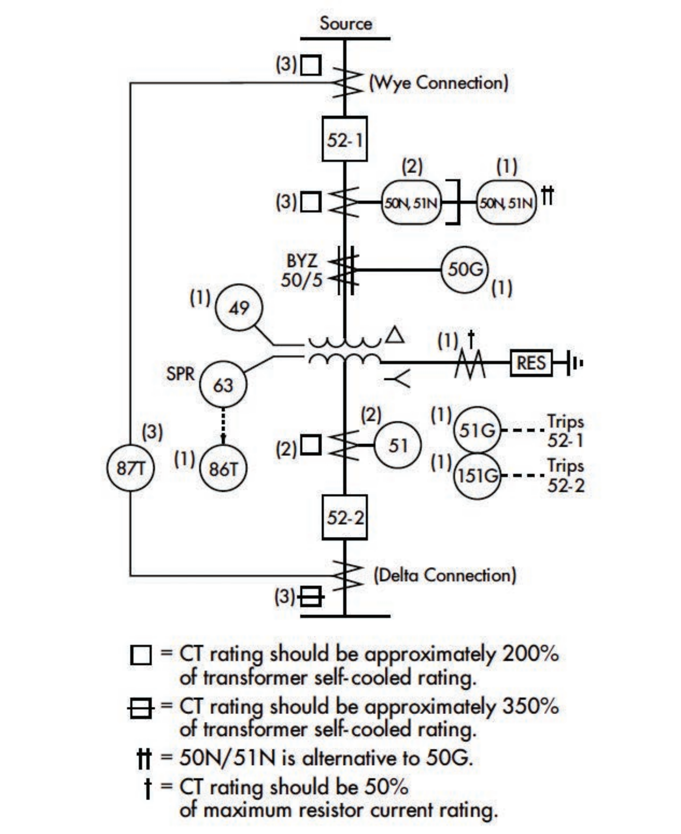

Figure 7. Lineups with automatic throw-over

Protective relays and associated current transformers on the other hand, are the means for fault sensing used in metal-clad switchgear. The following are application comments:

- Relays can provide very sensitive ground fault protection under any condition since the vacuum breaker is a fully rated interrupting device and can be called upon to interrupt under those conditions. References include Section 5.5, 9.2, and 9.3 in the Red Book; 5.5 in the Grey Book; and Chapter 4 in the Buff Book on relays
- Relays offer close overload protection. Power fuses do not provide overload protection and can rarely provide good backup protection for secondary main devices during overload conditions
- Other types of protection such as differential protection can be provided using protective relays
- Another important difference is curve shaping. Projects likely to have expansions and/or changing loads may benefit from relays and metal-clad switchgear
- Fuses cannot be tested whereas protective relays can be calibrated and tested. For hospitals, waste treatment plants, and industrial plants, this may provide extended life and reduced downtime. For commercial buildings with lesser trained maintenance personnel, the maintenance aspect of protective relays and metal-clad switchgear may actually detract from their selection
- Fair to good coordination is available with fuses depending on the shape of the upstream and downstream overcurrent protection devices. Relays generally can be set to "nest" better and provide shorter "wait" time in tripping. Because damage is proportional to I2t, for each additional cycle the fault flows, significantly more damage occurs. (See Chapter 7 on ground fault protection and Chapters 9 and 10 on equipment selection in the IEEE Buff Book.)

Maintenance

Recommended maintenance information can be found in the IEEE Buff Book maintenance section.

Another main reference source is the Westinghouse Electric "Electrical Maintenance Hints" publication, Chapters 6, 7, and 40.

Summary

The engineering selection process for medium-voltage switchgear should include evaluations of the following:

- Building life and reliability needs
- Maintenance
- Operating personnel
- First cost
- Size and room configurations
- Protection of circuits
- Continuity of service
- Available ratings
- Single unit or lineup arrangements

For single transformer protection 2500 kVA and below, metal-enclosed equipment offers good economic protection when taking the cost of the transformers into account. Protective relays and vacuum breakers should be carefully considered for many applications where the highest degree of continuity of service, safety, and protection is determined to be cost-effective.

Reference publications

- ANSI publications C37
- IEEE Grey Book Standard, 241-1990
- IEEE Buff Book Standard, 242-1986
- IEEE Red Book Standard, 141-1993
- Westinghouse Electric "Electrical Maintenance Hints"

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