Information on Short Circuit Current Interruption

Medium Voltage Switching Devices
Selection for application and purpose

Medium Voltage

Switchgear and switchgear installations for high voltage up to and including 52 kV are commonly referred to as “medium voltage”.

Applications – General

Which one is better, Vacuum or SF_6 circuit breakers for medium voltage applications?

In the past there was a concern with Vacuum Circuit Breakers, however with materials and technologies utilised today should there be reason for concern?

CRITERIA	SF6 CIRCUIT BREAKER	VACUUM CIRCUIT BREAKER
Summated cumulative breaking current	To 50 times rated short circuit breaking current; to 10,000 times continuous rated current	To 100 times rated short circuit breaking current; 10,000 to 20,000 times continuous rated current
Number of operations between servicing referred to operating mechanism	5,000 to 20,000 C–O operations	10,000 to 20,000 C–O operations
Service life of interrupter	5,000 to 20,000 C–O operations (between overhauls)	20,000 to 30,000 C–O operations
Service interval	Lubrication of operating mechanism after 5 to 10 years (if limiting number of operations not reached)	Lubrication of operating mechanism after 10 years (if limiting number of operations not reached)
Expenditure on overhaul of interrupter	Overhaul involves complete dismantling of interrupter. Labour costs high, material cost low	Test used to check vacuum level. If necessary, replace interrupter. Low labour costs, high material costs
Suitability for single and multishot auto–reclose cycles	Very well suited	Very well suited
Switching of transformers	Very well suited. Overvoltages when switching unloaded transformers generally below 3 pu. Surge arresters not normally necessary	Very well suited. Overvoltages when switching unloaded transformers generally below 3 pu. in special cases use of surge arresters recommended (eg. for furnace transformers)
Switching of overhead and cable feeders	Very well suited. Restrike–free	Very well suited. Restrike–free
Switching of capacitors	Very well suited. Restrike–free	Very well suited up to 25kV. Restrike–free
Switching of capacitors back–to–back	Very well suited. In special cases, reactors may be necessary to limit inrush current	Well suited up to 25kV. In special cases, reactors may be necessary to limit inrush current.
Switching of shunt reactors	Well suited. Overvoltages generally under 2.5 pu. Normally no action necessary to limit overvoltages	Well suited. Under certain circumstances steps to limit overvoltages may be necessary, because of possibility of virtual current chopping
Switching of motors	Very well suited. Overvoltages generally under 2.5 pu. Normally no action necessary to limit overvoltages	Well suited. Under certain circumstances steps may be necessary to limit overvoltages because of possibility of virtual current chopping
Switching of arc furnaces	Only suitable in applications with comparatively low number of operations per day	Suitable also for applications with very high number of operations (over 100 C–O per day)
Traction application (16 2/3 Hz)	Suitable in principle	Very well suited
Dielectric withstand strength of contact gap	High	Very high but subject to wider fluctuations than in SF_6 due to influence of condition of contact surfaces
Supervision of circuit breaker condition	Supervision of SF_6 gas pressure possible (pressure gauge with contacts for remote signalling)	Supervision of vacuum level not necessary (sealed for life)
Behaviour in event of fault	Rupture of interrupter housing, free–burning arc will lead to three–phase short circuit	Destruction of interrupter, free–burning arc will lead to three–phase short circuit

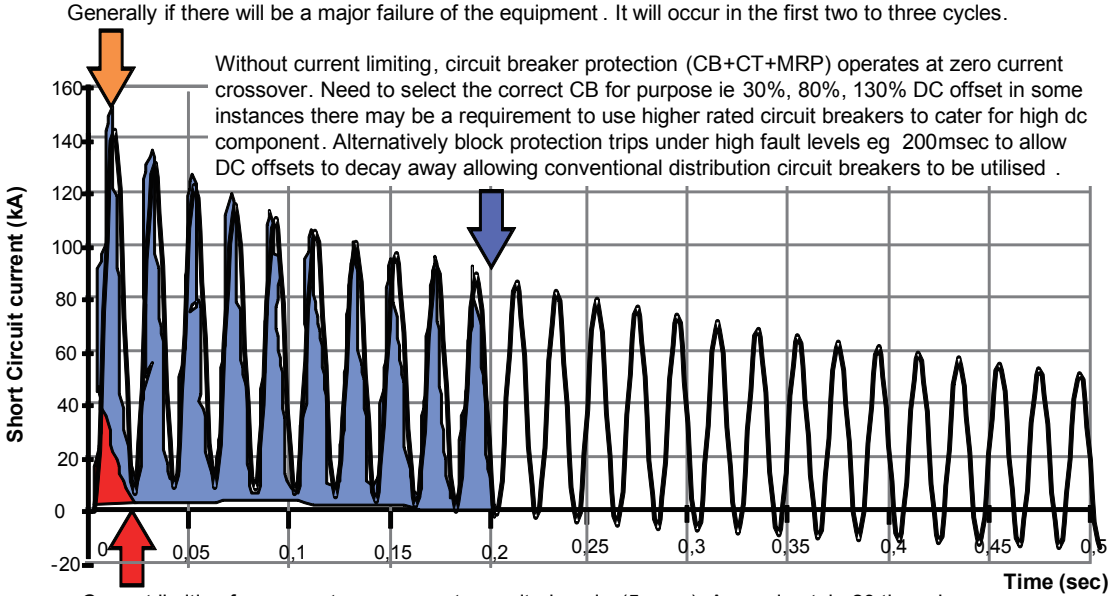
Summary of circuit breaker comparison

Vacuum or SF_6 – the choice is yours!

- Switching devices with today's technologies are basically equal for medium voltage application.
- SF_6 now being phased out within many organisations due to environmental concerns, and under arcing SF_6 by-products found to be of concern, special handling disposal requirements.
- Vacuum does have slight advantage with respect to life and maintenance due to the lower energy requirement mechanisms, as less force and less contact separation required.
- SF_6 and Vacuum for typical distribution systems with standard distribution class circuit breakers can be supplied with up to 30% DC offset. This is generally acceptable where there are small generators connected to the system.
- For medium and larger sized generation applications, Generator type Vacuum of SF_6 Circuit breakers can be supplied with up to 130% DC offset.

Short Circuit Current Interruption – Comparison between Circuit Breaker and Fused Contactor

The short circuit peak current causes the mechanical stress on an installation due to magnetic forces . Generally if there will be a major failure of the equipment . It will occur in the first two to three cycles.



Current limiting fuse operates on current magnitude only (5msec). Approximately 20 times less energy fed into a fault situation compare to circuit breaker. Minimal mechanical and thermal damage as peak short circuit currents never reached . DC offsets catered for by the fuse.

Applications – Motor Starter

Which one is better, Fused Contactor or Circuit Breakers for medium voltage motor starter applications?

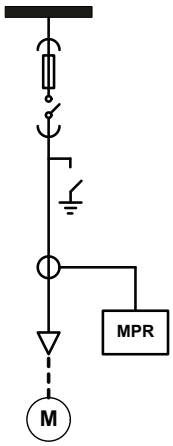
In the recent past, circuit breaker was standardised for all short circuit fault switching applications. This trend is changing to favour fused contactor technology.

Lessons Learned

Most faults on MV motors occur in the motor terminal boxes due to moisture ingress. Many industrial organisations such as SHELL and others have moved away from circuit breaker protection and returned to fused contactor technology. This being due to experience when these faults where CB protected, generally the motor were destroyed; where fused contactor was used only re-termination of MV cables required.

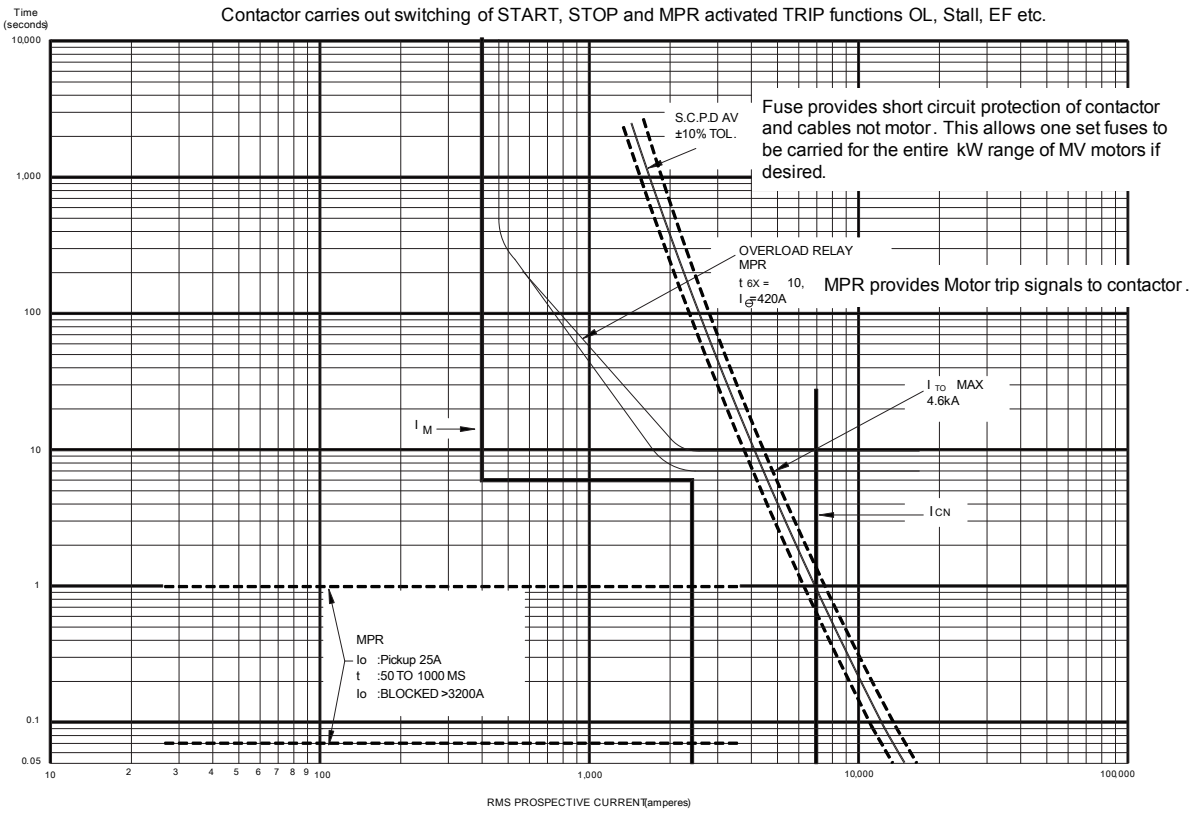
CRITERIA	FUSED CONTACTOR	CIRCUIT BREAKER
Operation Health and Safety	Reduce arc flash hazard. Fast and reliable arc quenching throughout the entire current range.	Higher arc flash hazard. Slow clearing of fault currents; breaks at first zero crossing in many cases beyond 200msec.
Current limitation	Fault current limitation due to HRC fuses. Reduced fault current let–through 6kA.	No fault current limiting capability.
Let through energy	Reduced 20x. Allows power cables to be size smaller. Significant cost savings on cables.	Full fault energy exposure. Power cables to be sized to maximum system short circuit level.
Thermal Stress	Very low due to limited let–through fault current. Longer life expectancy on motor insulation.	Very high on motor, consistent with short circuit level. Degradation of insulation expected.
Service life of interrupter	1,000,000 C–O operations	20,000 to 30,000 C–O operations
Maintenance	Extremely low contact erosion. Maintenance free throughout service life.	Required planned maintenance.
Footprint	Very small 0.365 m^2. Significant cost savings on E–House.	Average 1 m^2. Large area to house switchgear.

Fused Contactor Configuration



Basic Components	Functions
HRC Fuses	Short circuit protection of contactor and power cables
Contactor	Switching, Starting and clearing of motor faults, i.e. overload, stall
Current Transformer	Provide MPR with data for trips
Motor Protection Relay	Protect Motor

Short Circuit Protection Device Coordination – Fused Contactor



MOTOR I FULL LOAD 400A, I START 2400A t START 6sec FUSE 2xK81SDX315 ~550amp

For selection of fuses starting current, time and starts per hour need to be considered

Summary of fused contactor comparison

Fused Contactor or Circuit Breaker – the choice is yours!

- As fuse provides full short protection, the contactor mechanisms do not require such extreme energy and force, therefore greatly improved mechanical and electrical endurance. Ideal for high switching duty applications such as pumps, compressors fans, etc.
- As fuse provides current limitation, downstream equipment has higher degree of protection than over a circuit breaker solution. Ideal for high short circuit installations or where high DC offsets may exist on installations.
- Reduced risk of fire and damage, higher availability with minimal downtime under fault restoration.
- Fuses act as a backup protection to MPR in the event of a failure of DC or Protection systems.

TYPICAL POWER CABLE COST COMPARISON

Motor FLC (A)	31.5kA				50kA			
	Fused Contactor		Circuit Breaker		Fused Contactor		Circuit Breaker	
	Cable csa sq mm	Cable Cost 100m	Cable csa sq mm	Cable Cost [1] 100m	Cable csa sq mm	Cable Cost 100m	Cable csa sq mm	Cable Cost [1] 100m
45	35	€ 1,600	185	€ 4,800	35	€ 1,600	300	€ 7,500
60	35	€ 1,600	185	€ 4,800	50	€ 2,000	300	€ 7,500
75	35	€ 1,600	185	€ 4,800	50	€ 2,000	300	€ 7,500
90	50	€ 2,000	185	€ 4,800	50	€ 2,000	300	€ 7,500
120	50	€ 2,000	185	€ 4,800	70	€ 2,900	300	€ 7,500
150	50	€ 2,000	185	€ 4,800	70	€ 2,900	300	€ 7,500
165	50	€ 2,000	185	€ 4,800	70	€ 2,900	300	€ 7,500
185	50	€ 2,000	185	€ 4,800	70	€ 2,900	300	€ 7,500
225	70	€ 3,800	185	€ 4,800	95	€ 3,800	300	€ 7,500

TYPICAL FLOOR SPACE COMPARISON

Typical Dimensions, W x D (mm)	Typical Switching Device	Typical Footprint Area (sq m)	Building Construction cost [2]
325 x 1300	Fused Contactor	0.42	€ 1,268
400 x 1300	Fused Contactor	0.52	€ 1,560
500 x 1300	Circuit Breaker	0.65	€ 1,950
600 x 1300	Circuit Breaker	0.78	€ 2,340
700 x 1300	Circuit Breaker	0.91	€ 2,730
800 x 1300	Circuit Breaker	1.04	€ 3,120
900 x 1300	Circuit Breaker	1.17	€ 3,510
1000 x 1300	Circuit Breaker	1.30	€ 3,900
1200 x 1300	Circuit Breaker	1.56	€ 4,680

[1] Cable cost in yr. 2008.

[2] Building construction cost in yr. 2008.

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