POWELL

Switchgear & Instrumentation



Type 298

Medium Voltage IEC Switchgear and Motor Control Centres

incorporating PowlVac$^{100}_{TM}$ Vacuum Circuit Breakers

Powered by Safety®

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Powered by Safety®

INTRODUCTION

From strategic locations across the world, Powell aims to lead the market in innovative switchgear system design and manufacture.

Focused to deliver superior value to its customers through a full range of differentiated IEC and ANSI products and services, it is Powell's mission to satisfy the ever more discerning requirements of the global market, in all industry sectors:

- Oil & Gas
- Petrochemicals
- Power Generation & Distribution
- Pharmaceuticals
- Paper & Pulp
- Food & Beverages
- Mining & Metals
- Utilities
- Transportation
- Building Services

IEC operations are centred at Switchgear & Instrumentation Ltd., Bradford, UK, whose customer-focused approach to the design and manufacture of Medium and Low Voltage IEC Switchboards and Motor Control Centres (MCCs) continues to deliver unparalleled sales growth.

Developed from Powell's extensive knowledge of design, engineering and state of the art manufacturing technology, and with a commitment to providing the highest levels of operational safety and reliability, the Type 298 range of Medium Voltage Switchgear and Motor Control Centres brings to market PowlVac™100, the latest in the PowlVac® series of vacuum circuit breakers, designed and manufactured by Powell.

All Type 298 MV Switchgear design and manufacturing activities are backed both by the Company's ISO 9001 : 2008 accreditation and an unrivalled programme of type testing and certification by the independent, international test and certification bodies, ASTA and KEMA.

The electrical power industry is amongst the most safety-conscious groups in the world. Powell's core philosophy, to be ***Powered by Safety***® ensures all products and services are designed to develop and reinforce this position by bringing safety-related features to our customers, making switchgear safer to own and operate.

OVERVIEW

DESIGN STANDARDS

Powell's commitment to ensuring the highest levels of operational safety and reliability is evident in all aspects of the Type 298 | PowlVac$^{100}_{TM}$ switchgear design.

Type 298 | PowlVac$^{100}_{TM}$ has been designed and fully certified to the following standards:

■ IEC 62271-100	High Voltage AC Circuit Breakers
■ IEC 62271-200	AC Metal Enclosed Switchgear & Controlgear for Voltages 1kV to 52kV
■ IEC 60470	High Voltage AC Contactors & Contactor Based Motor Starters
■ IEC 60694/ 62271-1	Common specifications for High Voltage Switchgear & Controlgear Standards

DESIGN FEATURES

- One circuit breaker, or one fused contactor, per cubicle
- Modular LSC2B-PM construction to IEC 62271-200
- Rated up to 15kV and 4000A
- Busbar ratings certified up to 63kA 3 secs
- Arc Fault Containment tested to IEC 62271-200 Annex A, IAC up to
  - 50kA 1 sec AFLR
  - 50kA 0.1 sec BFLR*
  - 63kA 0.1 sec AFLR*
- Basic Impulse Level (BIL) up to 95kV
- Power Frequency Withstand up to 36kV 1 min
- Fully interlocked closed-door operation
- Circuit breakers and contactors tested in Type 298 cubicle arrangements
- Up to IP42 external degree of protection
- IP4X inter-compartmental degree of protection
- No busbar adaptation required between circuit breaker and contactor cubicles
- Peak make currents up to 158kA
- Asymmetrical switching DC components up to 100%

* For completion 2010

CONSTRUCTION

The Type 298 MV switchgear metal-enclosed design is modular and categorised as LSC2B-PM by IEC 62271-200, providing maximum safety and flexibility in operation.

In accordance with Annex C Clauses C.2 and C.3 of IEC 62271-200, switchgear formerly referred to as "metal-clad" within IEC and ANSI standards is now defined as LSC2B-PM.

The Loss of Service Continuity (LSC) describes the extent to which other compartments of an assembly may remain energised when a main circuit compartment is opened. Type 298's LSC2B design allows maximum continuity of service during access to compartments, including the provision for maintenance of a main switching device while the corresponding cable connection remains energised.

The PM designation refers to the Partition Class of the switchgear and requires continuous earthed metallic partitions and shutters to be provided between open accessible compartments and any live parts.

The Type 298 assembly consists of five distinct accessible compartments:

- **Busbar compartment**
- **Circuit breaker/ contactor compartment**
- **Cable compartment**
- **Voltage transformer compartment**
- **Low voltage compartment**

Operator safety is ensured in all cases when compartments are accessed for operation or maintenance. The main circuit switching device compartments are designated as 'interlock-controlled accessible compartments' while the remainder are arranged for either 'tool-based' or 'procedure-based' accessibility.

Fastening Circuit Breaker Compartment Door

Circuit Breaker Compartment Door Construction

ARC FAULT CONTAINMENT

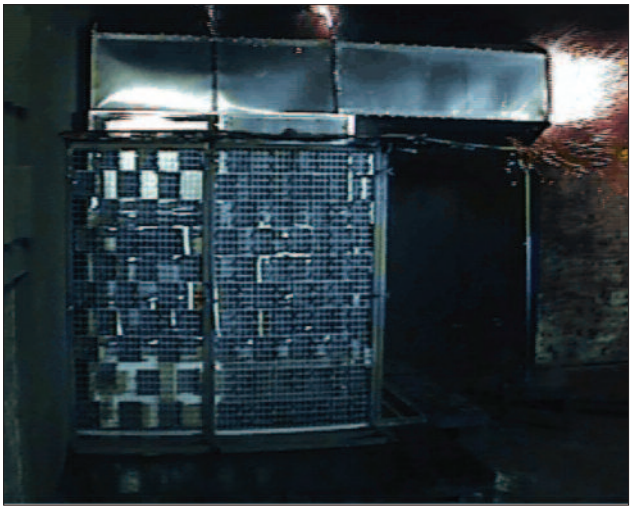
Internal arcing faults in switchgear assemblies are generally recognised as being the most destructive, and therefore potentially the most dangerous, to personnel in the vicinity of the equipment.

Only those switchgear assemblies with an IAC (Internal Arc Classification) as defined by IEC 62271-200 Annex A are internationally recognised as being sufficiently robust in design and construction to contain the effects of an internal arc occurring during normal operation, thereby protecting personnel in the vicinity from potentially fatal injury and plant adjacent to the affected compartment from catastrophic blast damage.

The classification 'IAC' is intended to offer a tested level of protection to persons in the vicinity of the equipment in normal operating conditions, and with the switchgear and controlgear in the normal service position, in the event of an internal arc.

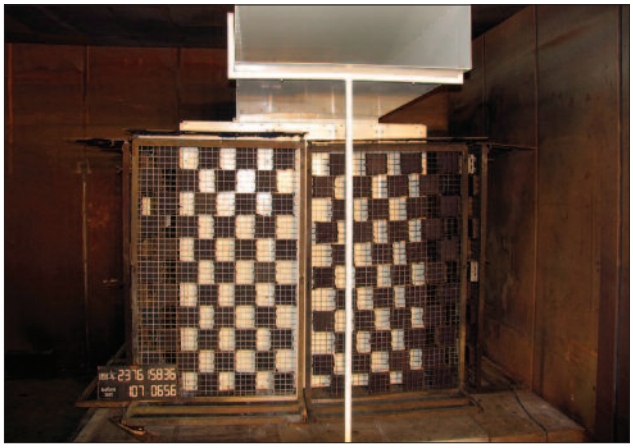
Test Acceptance Criteria:

- Doors and covers do not open
- No fragmentation of the enclosure
- Arcing does not cause holes in the accessible sides up to a height of 2m
- Indicators do not ignite due to the effect of hot gases
- The enclosure remains connected to earth



Early stage testing to ensure final design achieves all 5 criteria of Annex A IEC 62271-200

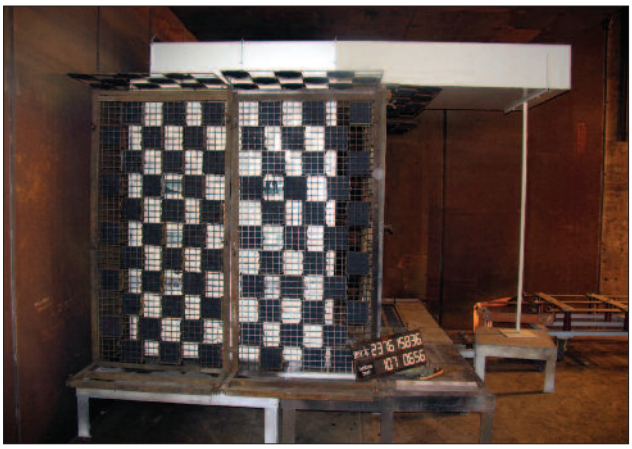
With overriding commitment to the safety of our customers' personnel and processes, Powell has particularly considered the detail and implications of a number of key clauses of IEC 62271-200 in the design and construction of Type 298 MV switchgear.

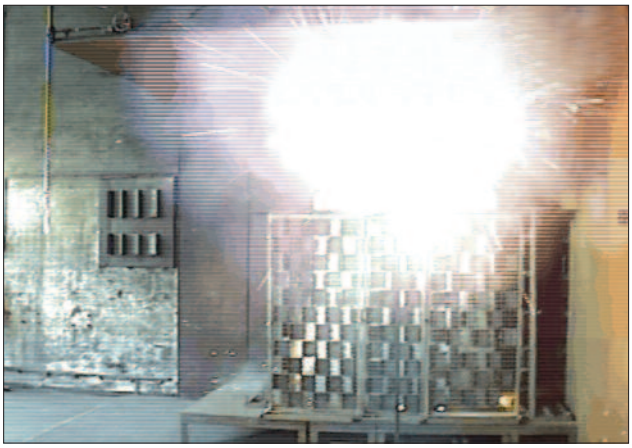


3.132 Internal Arc Classified Switchgear and Controlgear
Metal-enclosed switchgear and controlgear for which prescribed criteria for protection of persons are met in the event of internal arc as demonstrated by the appropriate tests.

5.101 Internal Fault
If the switchgear and controlgear is installed, operated and maintained following the instructions of the manufacturer, there should be little probability that an internal arc occurs during its entire service life, but it cannot be completely disregarded. Failure within the enclosure of metal-enclosed switchgear and controlgear due either to a defect or an exceptional service condition or maloperation ***may initiate an internal arc, which constitutes a hazard, if persons are present.***

The effectiveness of the design, at providing the prescribed level of protection of persons in case of an internal arc, can be verified by testing according to Annex A. ***Designs which have been successfully tested qualify as IAC classified.***



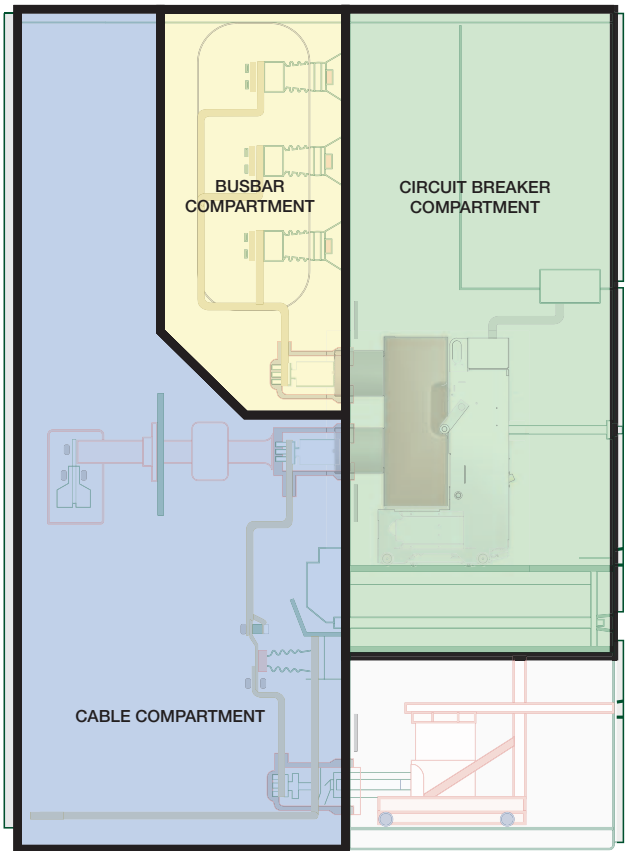


Arcing products safely ducted away during successful test

ARC FAULT CONTAINMENT

6.106 Internal Arcing Test

This test is applicable to metal-enclosed switchgear and controlgear, ***intended to be qualified as IAC classified with respect to personnel protection*** in the event of an internal arc. The test shall be performed according to Annex A, ***in every compartment containing main circuit parts*** of representative functional units. This test covers the case of a fault resulting in an arc occurring in air, or in another insulating fluid (liquid or gas) within the enclosure or within components having housings which form part of the enclosure ***when the doors and covers are in the position required for normal operating conditions.***



Circuit breaker cubicle cross-section showing three IAC - tested compartments

8.3 Internal Arc Classification

When selecting a metal-enclosed switchgear and controlgear, ***the possibility of the occurrence of internal faults should be properly addressed, with the aim of providing an acceptable protection level*** for operators and, where applicable, for the general public.

8.3 Internal Arc Classification

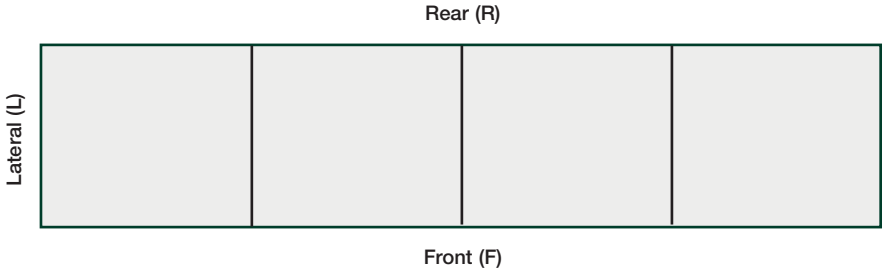
As a guide for the selection of the adequate switchgear and controlgear with respect to internal arcs, the following criteria may be used:

- Where the risk is considered negligible, metal-enclosed switchgear and controlgear IAC classified is not necessary;
- ***Where the risk is considered to be relevant, only metal-enclosed switchgear and controlgear IAC classified should be used;***

For the second case, ***the selection should be made by taking into account the foreseesable maximum level of current and duration of the fault, in comparison with the rated values of the tested equipment.*** In addition, the installation instructions of the manufacturer should be followed. In particular, ***the location of personnel during an internal arc event is important. The manufacturer should indicate which sides of the switchgear and controlgear are accessible, according to the testing arrangement and the user should follow the instruction carefully. Allowing personnel to enter an area not designated as accessible may lead to personnel injury.***

Classification IAC gives a tested level of protection of persons under normal operating conditions as defined in Clause A.1. It is concerned with personnel protection under these conditions; it is not concerned with personnel protection under maintenance conditions nor with service continuity.

The metal-enclosed switchgear and controlgear may have different types of accessibility on the various sides of its enclosure, identified as F(front), L (lateral), R (rear).



Annex A

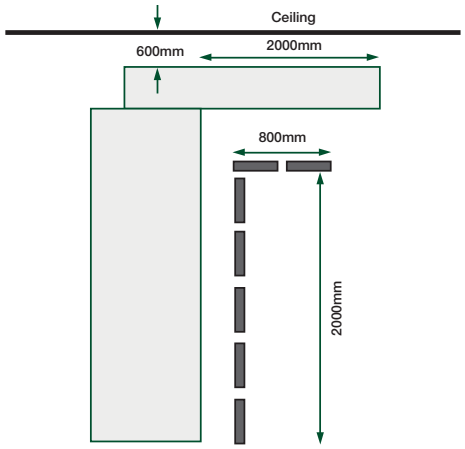
Internal Fault - Method for testing the metal-enclosed switchgear and controlgear under conditions of arcing due to an internal fault.

The Internal Arc Classification IAC ***makes allowance for internal overpressure acting on covers, doors, inspection windows, ventilation openings, etc.*** It also takes into consideration the ***thermal effects of the arc or its roots on the enclosure and of ejected hot gases and glowing particles,*** but not damage to internal partition and shutters not being accessible in normal operating conditions.

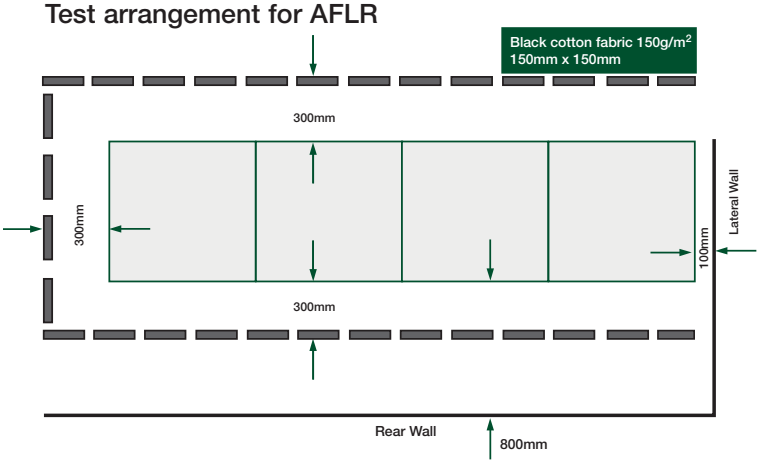
A distinction is made between two types of accessibility to the metal-enclosed switchgear and controlgear which are possible in the site of installation:

Accessiblity Type A: restricted to authorized personnel only

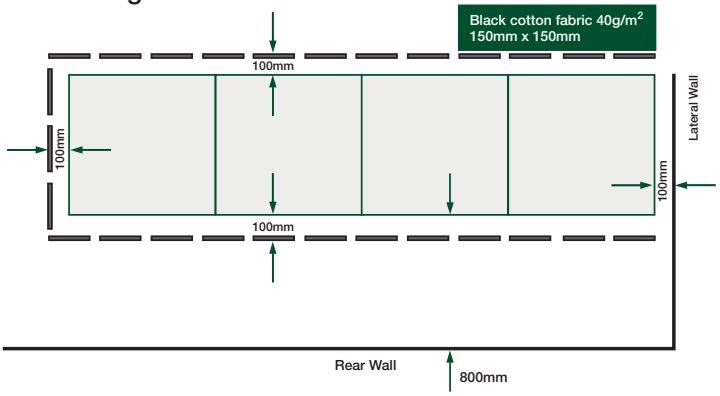
Accessibility Type B: unrestricted accessibility, including that of the general public



Test arrangement for AFLR



Test arrangement for BFLR



A.3.2 Special case, use of exhausting ducts

If the manufacturer claims that the design requires that exhausting ducts need to be used to evacuate gases generated during the internal arc, their minimum cross-section dimensions, location and output features (flaps or grid, with their characteristics) shall be stated by the manufacturer. ***The test shall be carried out with simulation of such exhausting ducts. The output end of the exhausting ducts shall be at least 2m away from the switchgear and controlgear tested.***

NOTE: The possible effects of hot gases outside of the room containing the switchgear and controlgear are not covered by this standard.

To permit the most appropriate selection of equipment to match system fault levels and protection characteristics, Type 298 switchgear is offered at a variety of ratings with varying prospective fault currents and test durations. Ratings already available and those planned for availability during 2010 are indicated on Page 10.

TYPE TEST CERTIFICATION DATA

SHORT CIRCUIT MAKING AND BREAKING TESTS / SHORT TIME CURRENT TESTS TO IEC 62271-100

FRAME	RATING	CERTIFYING AUTHORITY
40kA 700mm	12kV, 40kA,100kApk, 3secs	KEMA
50kA 700mm	15kV, 50kA,125kApk, 3secs	KEMA
50kA 1000mm	15kV, 50kA,125kApk, 3secs	KEMA
63kA 1000mm	15kV, 63kA,158kApk, 3secs	KEMA

CIRCUIT BREAKER ASYMMETRICAL TEST DUTIES TO IEC 62271-100

FRAME	RATING	CERTIFYING AUTHORITY
40kA 700mm	12kV, 40 kA, 45% DC	KEMA
50kA 700mm	15kV, 50 kA, 45% DC	KEMA
50kA 1000mm	15kV, 50 kA, 41% DC	KEMA
63kA 1000mm	15kV, 63 kA, 46% DC	KEMA
63kA 1000mm	15kV, 50 kA, 100% DC	KEMA

MAIN BUSBAR SHORT TIME CURRENT TESTS TO IEC 62271-200

FRAME	RATING	CERTIFYING AUTHORITY
700mm/1000mm	40kA, 100kApk, 3secs	KEMA
700mm/1000mm	50kA, 125kApk, 3secs	KEMA
1000mm	63kA, 158kApk, 3secs	KEMA

TEMPERATURE RISE TESTS TO IEC 62271-200

FRAME	RATING	CERTIFYING AUTHORITY
40kA 700mm	Thermal Rating 1600A VCB	KEMA
50kA 700mm	Thermal Rating 2000A VCB	KEMA
50kA 1000mm	Thermal Rating 3150A VCB	KEMA
50kA 1000mm	Thermal Rating 4000A VCB FC	KEMA
63kA 1000mm	Thermal Rating 3150A VCB	KEMA
63kA 1000mm	Thermal Rating 4000A VCB FC	KEMA
400mm VCU	Thermal Rating 400A VCU	KEMA

DIELECTRIC TESTS TO IEC 62271-200

FRAME	RATING	CERTIFYING AUTHORITY
40kA 700mm	75kV BIL/28kV 1min	KEMA
50kA 700mm	75kV BIL/28kV 1min	KEMA
50kA 700mm	95kV BIL/36kV 1 min	KEMA
50kA 1000mm	75kV BIL/28kV 1min	KEMA
50kA 1000mm	95kV BIL/36kV 1 min	KEMA
63kA 1000mm	75kV BIL/28kV 1min	KEMA
63kA 1000mm	95kV BIL/36kV 1 min	KEMA
400mm VCU	60kV BIL/20kV 1 min	KEMA

VACUUM CONTACTOR TYPE C CO-ORDINATION TO IEC 60470

FRAME	RATING	CERTIFYING AUTHORITY
400mm VCU	50kA at 3.6kV	KEMA
400mm VCU	50kA at 7.2kV	ASTA

BUSBAR, CIRCUIT BREAKER / CONTACTOR AND CABLE TERMINATION COMPARTMENTS ARC CONTAINMENT TESTS TO IEC 62271-200

FRAME	RATING	CERTIFYING AUTHORITY
700mm VCB	25kA 1 sec AFLR	IPH
700mm VCB	31.5kA 1 sec AFLR	IPH
700mm VCB	50kA 0.1 sec AFLR	IPH
700mm VCB	50kA 1 sec AFLR	IPH
1000mm VCB	25kA 1 sec AFLR	IPH
1000mm VCB	31.5kA 1 sec AFLR	IPH
1000mm VCB	50kA 0.1 sec AFLR	IPH
1000mm VCB	50kA 0.1 sec BFLR	IPH
1000mm VCB	50kA 1 sec AFLR	IPH
1000mm VCB	63 kA 0.1 sec AFLR	IPH
400mm VCU	25kA 1 sec AFLR *	IPH
400mm VCU	31.5kA 1 sec AFLR *	IPH
400mm VCU	50 kA 0.1 sec AFLR *	IPH

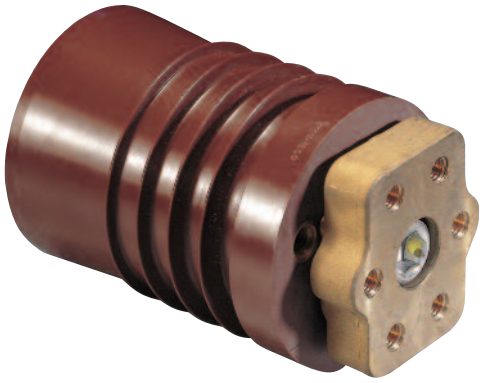
* Note, the VCU section cable chamber is always fuse protected therefore the test was carried out at a prospective fault level of 50kA.

To be completed during 2010

BUSBAR SYSTEM

The busbar system is housed in a totally segregated chamber within the cubicle assembly and all components are fully insulated. The busbar system is fully tested and independently certified, for all current ratings, up to 63kA for 3 seconds. Normal current ratings up to 4000A are available.

Horizontal busbars and droppers are manufactured from 5mm thick, silver plated HDHC copper laminations and insulated with 0.8mm thick epoxy resin applied in the Company's state of the art epoxy dip coating plant.

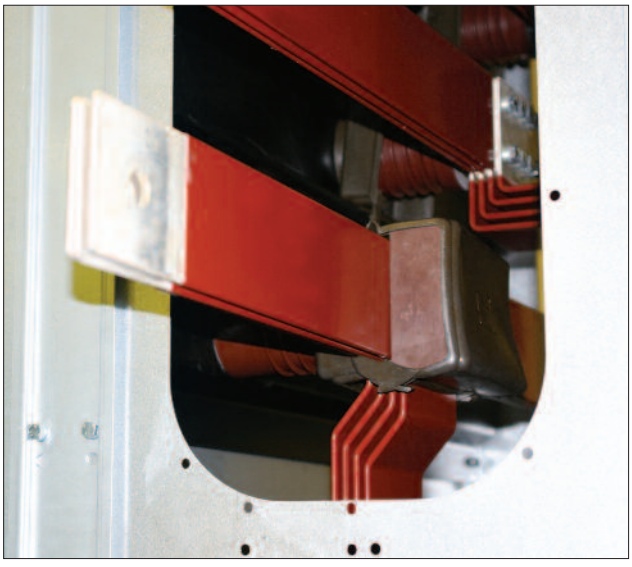


Busbar Insulator and Joint Casting

Busbars and droppers are braced and supported on epoxy stand off insulators and terminated onto the uniquely designed joint casting. Droppers are terminated at moulded epoxy resin spouts sealed with EPDM (synthetic rubber compound).

Horizontal busbars are fitted at site during installation of the switchgear; the joint castings obviate the need for fish-plates and greatly reduce installation times.

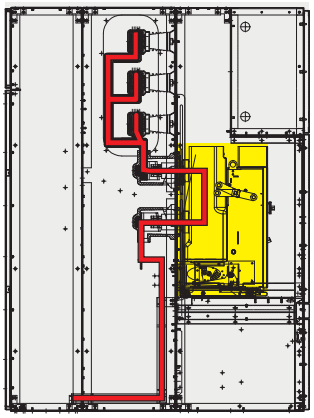
Moulded, insulating joint boxes for protection against ingress of dust and enhanced dielectric properties are fitted at each busbar joint.



BUSBAR EARTHING

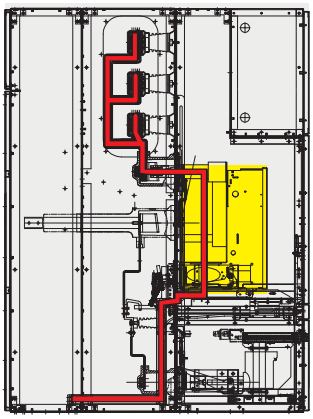
Busbar earthing is provided by one of the following methods:

1. Earth Copperwork in Cubicle in conjunction with Incomer Circuit Breaker



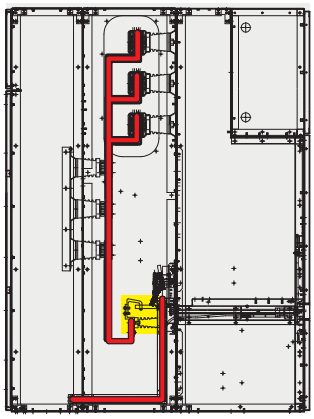
Each section of busbar is provided with an earthing facility either by the provision of a dedicated earthing cubicle or by utilising a bus-transition cubicle complete with earthing copperwork. To apply an earth to the required section of busbar, an incomer circuit breaker is moved to the earthing cubicle. Trapped-key interlocks are provided to prevent the racking of this circuit breaker to the 'service' position unless all sources of supply are isolated from that busbar. The circuit breaker is racked into position and closed onto an earthed shorting-bar provided in this cubicle. This process is then reversed with the incomer circuit breaker being returned to its original cubicle and the trapped-key interlock released to permit the incomer breaker to be returned to service and the busbar safely re-energised.

2. Earthing Switch with Integral Copperwork in conjunction with Incomer/Feeder Cubicle



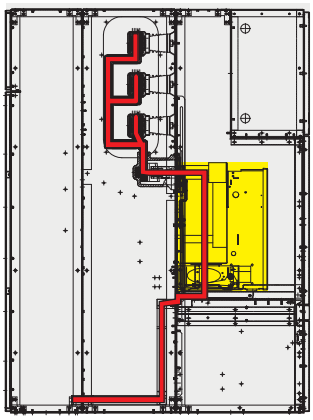
Earthing is achieved by the provision of an earthing switch, fitted with integral earthing copperwork, which is inserted in to an incomer/feeder compartment after withdrawal of the incomer or feeder circuit breaker. A trapped-key interlock is provided on the earthing switch which is only released when all sources of supply have been removed from the busbar. This releases interlock plates on the earthing switch which otherwise prevent this switch from being inserted in to the incomer or feeder compartment. Once inserted, the earthing switch can be racked to the service position and closed to apply the earth. The process is then reversed with the earthing switch being removed from the cubicle allowing the trapped-key to be released thus permitting the busbar to be safely re-energised.

3. Fixed Earthing-Switch in Dedicated Cubicle



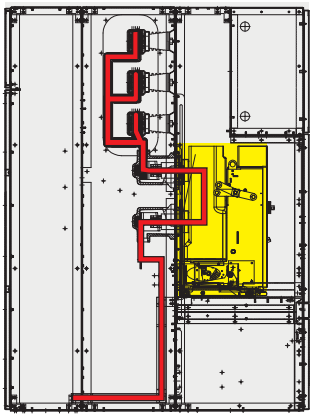
Each section of busbar is provided with a fixed earthing-switch located in either a dedicated earthing cubicle or in a bus-transition/bus-section circuit breaker cubicle. A trapped-key interlock is provided which is only released when all sources of supply are removed from the busbar. This key allows movement of the operating handle access plate thus permitting insertion of the operating handle and therefore closure of the earthing switch. This operation is performed from the front of the cubicle and utilises the same handle as that used for the circuit-earth switch. Once the earth-switch is reopened, the key is released thus permitting the busbar to be safely re-energised.

4. Earthing Switch with Integral Copperwork in conjunction with Dedicated Cubicle



Each section of busbar is provided with a dedicated earthing cubicle complete with an earthing switch fitted with integral earthing copperwork. Trapped-key interlocks prevent this switch being racked to the service position unless all sources of supply are isolated from the busbar. The switch is racked to the service position and closed to apply the earth. The process is reversed with the switch being opened, then racked to the disconnected position thus releasing the trapped key interlock and thereby permitting the busbar to be safely re-energised. This option provides a switchboard cubicle which could, after adaptation, be utilised as a feeder/incomer circuit as the earthing copperwork is installed on the switch rather than in the cubicle.

5. Earth Copperwork in Cubicle in conjunction with Dedicated Circuit Breaker



Each section of busbar is provided with an earthing facility either by the provision of a dedicated earthing cubicle or by utilising a bus-transition cubicle complete with earthing copperwork. To apply an earth to the required section of busbar, a dedicated circuit breaker is racked into the earthing cubicle. Trapped-key interlocks are provided to prevent the racking of this circuit breaker to the 'service' position unless all sources of supply are isolated from that busbar. The circuit breaker is racked into position and closed onto an earthed shorting-bar provided in this cubicle.In contrast to option 4 above, this option provides a circuit breaker which could be utilised in a feeder/incomer circuit as the earthing copperwork is installed in the cubicle rather than on the circuit breaker.

Cubicle Width	Fault Rating	Type
700mm	25kA	Switch/Breaker
700mm	31.5kA	Switch/Breaker
700mm	40kA	Switch/Breaker
700mm	50kA	Breaker
1000mm	50kA	Switch/Breaker
1000mm	63kA	Breaker

PowlVac™ 100 VACUUM CIRCUIT BREAKERS

Powell's expertise in the sphere of vacuum circuit breaker engineering is internationally recognised, with a portfolio of products and services drawn from 30 years' experience of breaker design and first-class manufacturing technology.

Combined with Powell's global presence in both the IEC and ANSI switchgear markets and with a commitment to providing the highest levels of operational safety and reliability, we now bring to market PowlVac™ 100, the latest addition to the PowlVac® series of vacuum circuit breakers designed and manufactured by Powell, incorporated within our Type 298 range of Medium Voltage IEC Switchgear and Motor Control Centres.

1000mm, 15kV 63kA

700mm, 12kV 40kA or 15kV 50kA

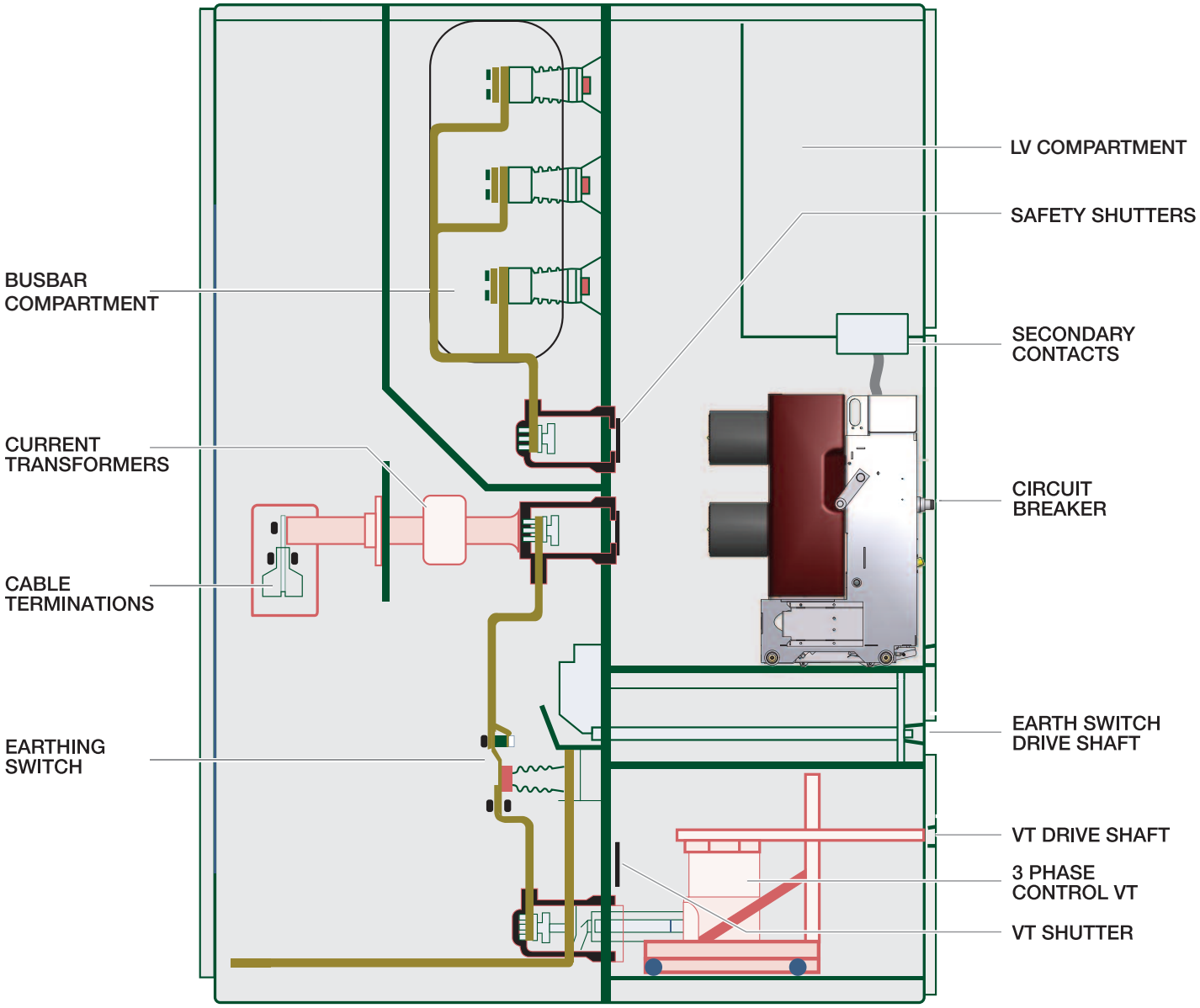
1000mm, 15kV 50kA

CIRCUIT BREAKER CUBICLES

An extensive programme of type testing and certification at internationally recognised, independent testing laboratories has now matched Powell's Type 298 MV Switchgear cubicle and busbar system design with the group's world-renowned circuit breaker technology.

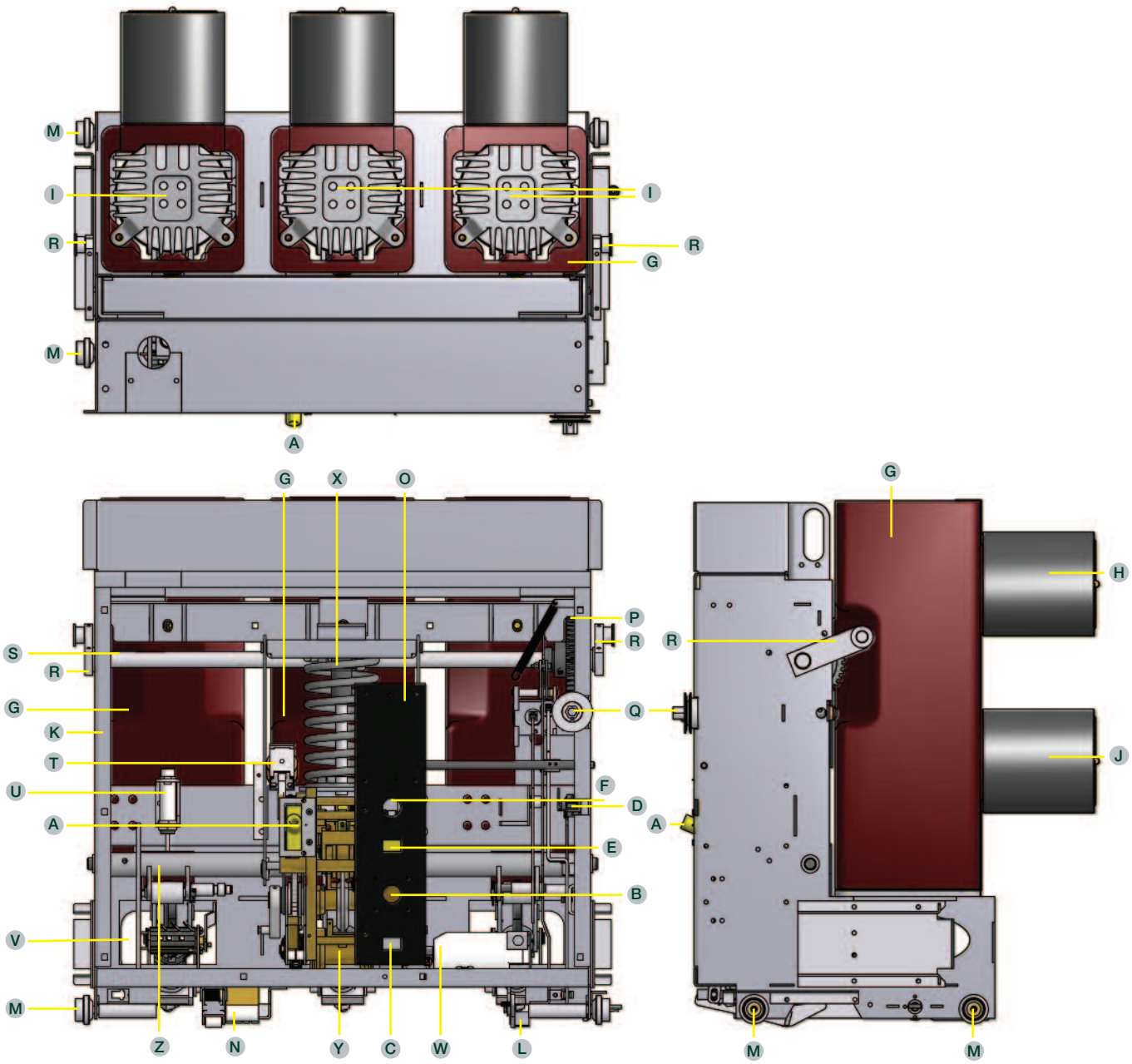
Circuit breaker ratings up to 4000A can be accommodated and have been tested within Type 298 cubicles to confirm their switching and short time withstand performance to Test Duties T10, T30, T60, T100s and T100a of IEC 62271-100.

Operational safety is the fundamental requirement of the Type 298 design and the circuit breaker section design is for operation behind a closed door.



Cross-section of Circuit Breaker Cubicle with Breaker in 'Test/Disconnected' position and VT in 'Service' position

PowlVac$^{100}_{TM}$ CONSTRUCTION



A	Manual Charging Crank
B	Manual Close Operator
C	Spring Charge Indicator
D	Operations Counter
E	Circuit Breaker Open/Closed Indicator
F	Manual Trip Operator
G	Pole Moulding
H	Upper Primary Disconnecting Device
I	Vacuum Interrupter
J	Lower Primary Disconnecting Device
K	Frame
L	Anti-Rollout Latch
M	Wheel
N	Earth Connection
O	Serial Number/Rating Plate Location
P	Worm Gear
Q	Racking Drive Shaft Extension
R	Racking Crank Arm
S	Anti-Pump Relay Location
T	Primary Shunt Trip Coil
U	Shock Absorber
V	Auxiliary Switch
W	Charging Motor
X	Main Closing Spring
Y	Closing Coil
Z	Jackshaft

QUALITIES OF VACUUM INTERRUPTERS

Improvements in vacuum-interrupter technology over recent years have enabled vacuum circuit breakers to assume a dominant position in medium voltage switchgear design up to 15kV. This is based on the efficacy of vacuum technology in the three areas of operating life, environmental benefits and switching performance.

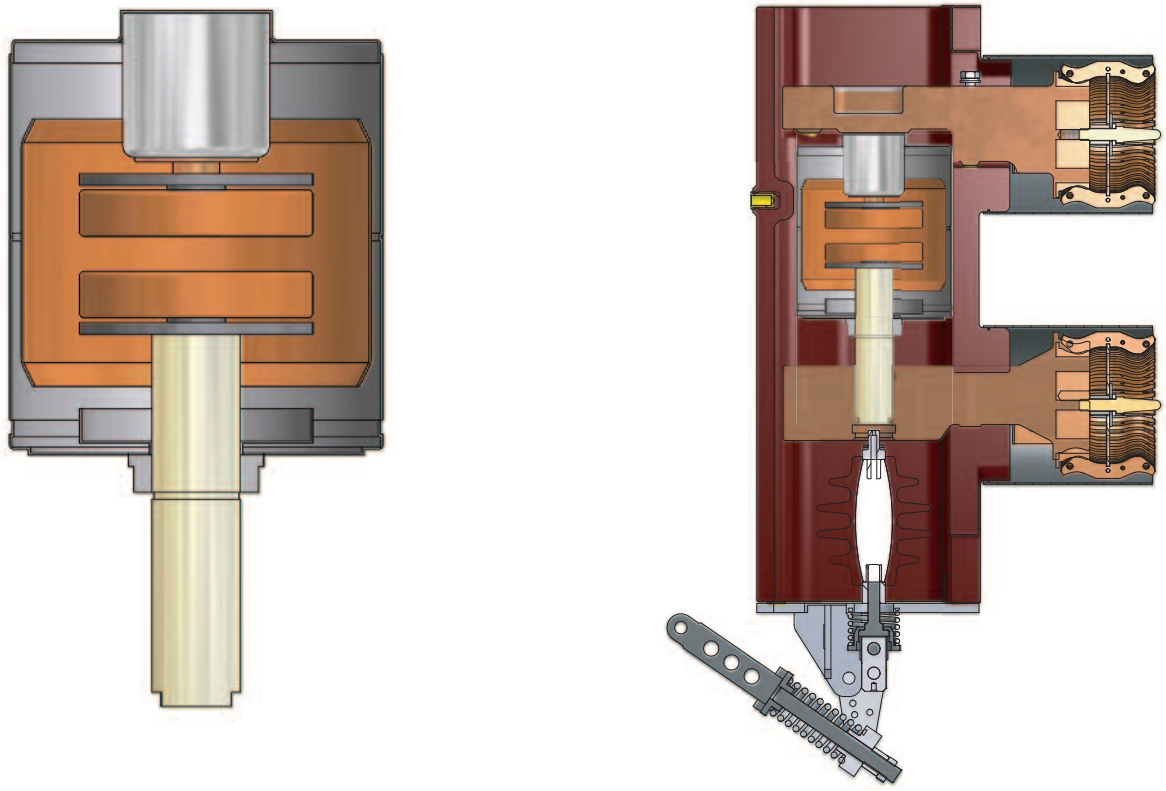
Improvements in manufacturing techniques have reached the point where the electrical life of the vacuum interrupter exceeds the mechanical life of the circuit breaker. Please see page 19 for further detail on electrical switching life.

Vacuum interrupters are constructed from environmentally friendly materials and when subjected to an electrical fault pose no health risk to plant operators, or to the general public on ultimate disposal.

A problem commonly encountered with early designs of vacuum interrupters was that of current chopping. This could result in high surge voltages across the network unless the circuit breaker was installed in conjunction with surge arrestors. The development of the copper chromium contacts used in PowlVac® circuit breakers has reduced chopping currents to the range of 3-5 Amps, which eliminates the problems of voltage surges due to current chopping.

Features of the vacuum interrupters utilised in PowlVac™100 circuit breakers include:

- **Transverse magnetic field contact design**
- **Cu-Cr contacts**
- **Condensate shield Cu-Cr-stainless steel**
- **Two-piece ceramic floating shield design**
- **Hydro-formed bellows**
- **Vacuum bottle is vacuum brazed**



Sections through PowlVac™100 vacuum interrupters and pole mouldings

PowlVac$^{100}_{TM}$ VACUUM CIRCUIT BREAKERS

PowlVac$^{100}_{TM}$ Vacuum Circuit Breaker Data					
RATED VOLTAGE		kV	12	12	12
				15	15
RATED FREQUENCY		Hz	50	50	50
RATED CURRENT	700mm	A	630	630	
	700mm	A	1250	1250	
	700mm	A	1600	1600	
	700mm	A		2000	
	1000mm	A		2500	2500
	1000mm	A		3150	3150
	1000mm FC	A		4000	4000
RATED SHORT CIRCUIT BREAKING CURRENT		kA	40	50	63
RATED SHORT CIRCUIT MAKING CURRENT		kA	100	125	158
RATED SHORT CIRCUIT DURATION		s	3	3	3
RATED POWER FREQUENCY		kV	28	28	28
WITHSTAND VOLTAGE				36	36
RATED LIGHTNING IMPULSE		kV	75	75	75
WITHSTAND VOLTAGE				95	95
OPENING TIME		ms	25	25	25
ARCING TIME		ms	15	15	15
TOTAL OPENING TIME		ms	40	40	40
CLOSING TIME		ms	40	40	40
SIMULTANEITY OF POLES	OPENING AT 50Hz	ms	<3.3	<3.3	<3.3
	CLOSING AT 50Hz	ms	<5	<5	<5
CONTROL CIRCUIT SUPPLY VOLTAGE LV (U)		Vdc	48	48	48
			110	110	110
			125	125	125
			240	240	240
		Vac	120	120	120
			240	240	240
VOLTAGE RANGE			70% - 110% U		
CONTROL CIRCUIT LOAD	TRIP COIL	VA	400	400	400
	CLOSE COIL	VA	400	400	400
	MOTOR CHARGE	VA	150	150	150
MOTOR CHARGE TIME		s	15	15	15
MINIMUM OPENING COMMAND DURATION		ms	70	70	70
MINIMUM CLOSING COMMAND DURATION		ms	95	95	95

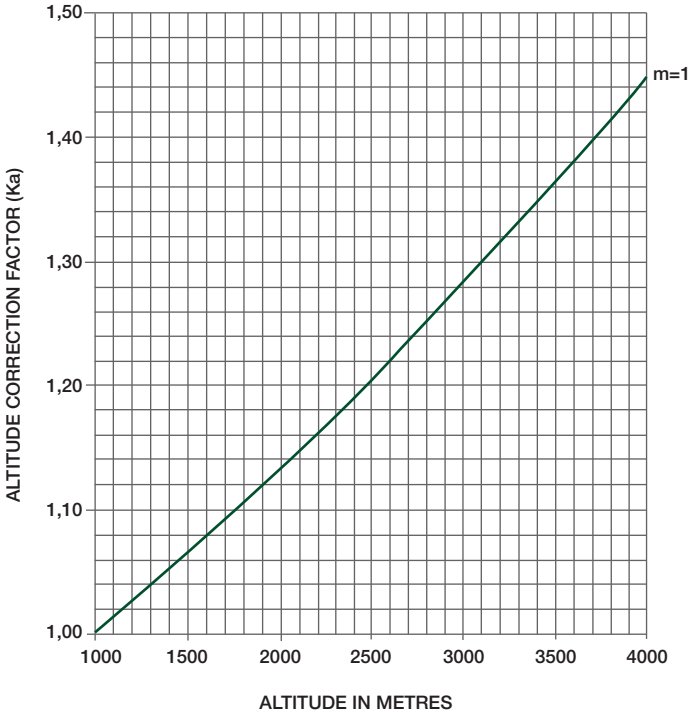
ALTITUDE

For installations at an altitude higher than 1000 metres, the withstand level of external insulation at the service location is determined by multiplying the rated insulation levels (power frequency withstand voltage and lightning impulse withstand voltage) by a factor Ka as indicated in the chart opposite.

To illustrate the impact of an altitude of 2000 metres on a 12kV rated application:

- Power frequency withstand voltage = 28kV x 1.135
  = 31.78kV
- Lightning impulse withstand voltage = 75kV x 1.135
  = 85.125kV

Therefore a 15kV rated system would be required (i.e. with power frequency withstand of 36kV and BIL of 95kV).

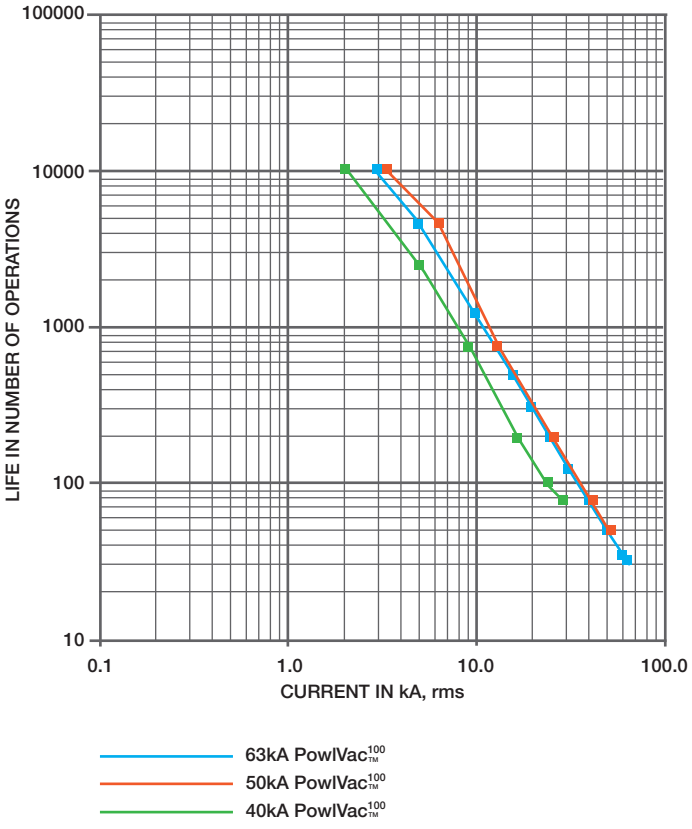


ELECTRICAL SWITCHING LIFE

The electrical switching life of PowlVac™100 is shown as a function of the rms breaking current.

PowlVac™100 meets the requirements of the following circuit breaker endurance classes as defined by IEC 62271-100:

- E1 – circuit breaker with basic electrical endurance
- S1 – circuit breaker intended to be used in a cable system (i.e. without direct connection to overhead lines)
- M1 – circuit breaker with normal mechanical endurance (type tested for 2000 operations)



LEAN, BEST-PRACTICE, MANUFACTURE

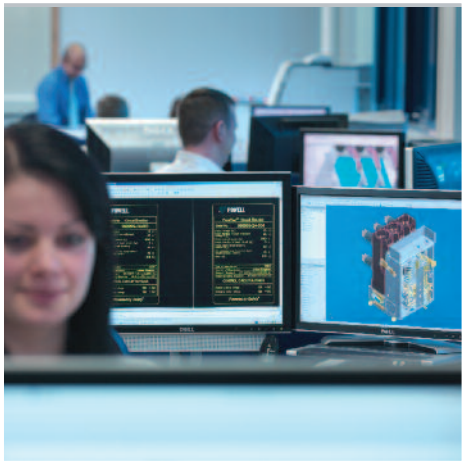
Powell's IEC operation, Bradford UK, is accredited to both ISO 9001:2008 and ISO 14001:2004. OHSAS 18001:2007 and TS29001 accreditation will be achieved during 2010.

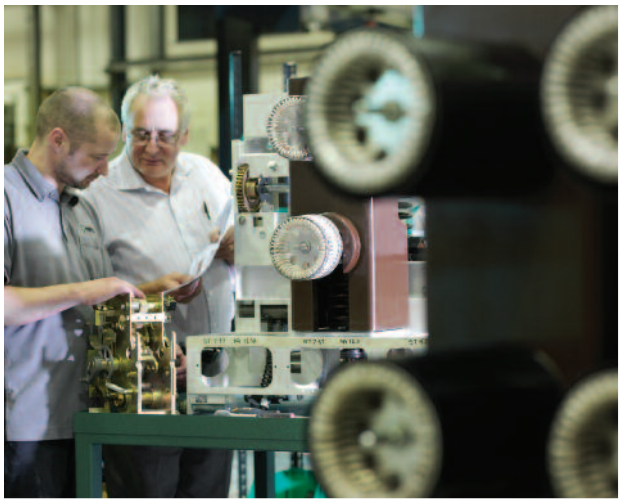
Electrical assembly and test operations are complemented by an in-house fabrication and paint capability that includes laser profiling and CNC punching and folding, providing agile and adaptable customer-focused engineering solutions.

Lean Sigma processes are in place to optimise performance to our SQDV (Safety, Quality, Delivery, Value) standards.

Manufacturing systems and Lean manufacturing processes are employed to achieve right-first-time execution and minimise waste in a make-to-order environment.

Ongoing training programmes reinforce Lean best-practice and ensure that transferrable skills are available to meet our business demands both now and in the future.





Our quality systems ensure that Standard Operating Procedures and Quality Control Plans are in place and regularly audited to guarantee conformance.

Test engineers prove the functionality and repeatability of all PowlVac™100 Vacuum Circuit Breakers after assembly and our traceability systems govern that each breaker is identifiable by a unique serial number (clearly visible on the front of the breaker), recorded on all FITRs (Final Inspection and Test Records).

Routine test procedures incorporate:

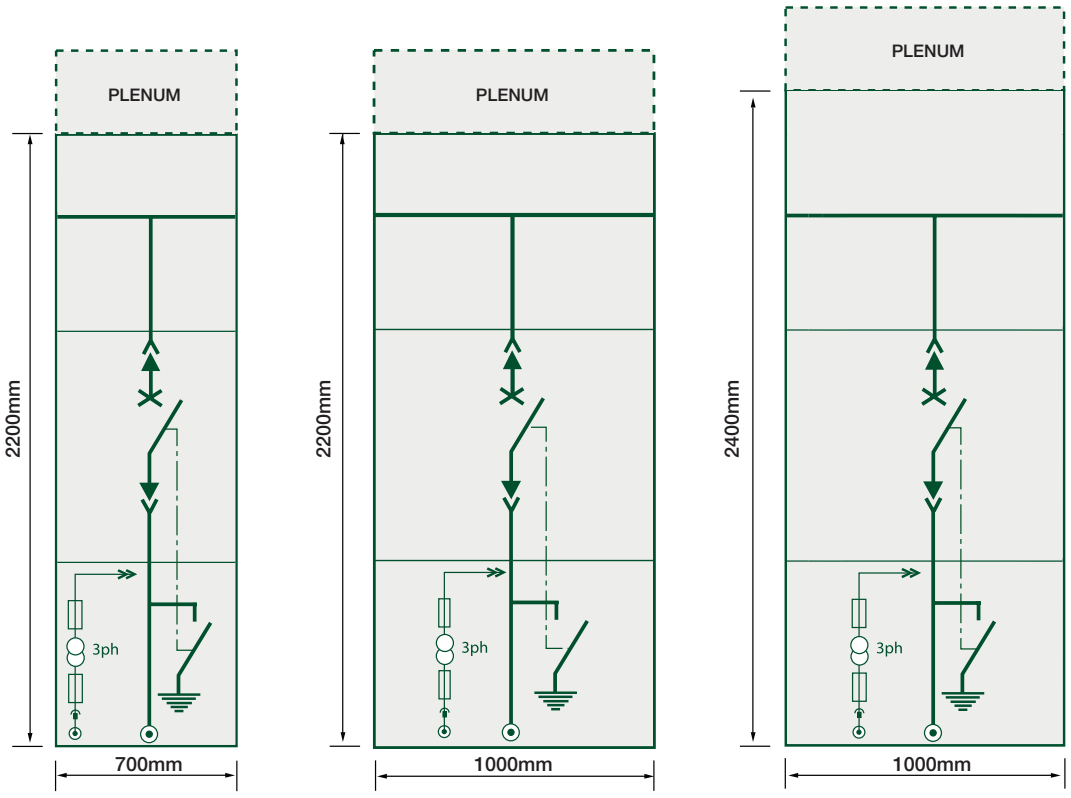
- **Setting of mechanisms and stroke measurement of all critical moving parts**
- **Functionality testing of electrical components**
- **Analysis and recording of all speed closure times and distance**
- **Dielectric**
- **Contact conductivity**
- **Testing of mechanical interlock systems**

CIRCUIT BREAKER SWITCHGEAR

Two cubicle widths are available to cover current ratings from 630A to 4000A.

The cubicles incorporate the guide and mounting systems for the circuit breakers, the primary contact spouts and safety shutters.

Operational safety is the fundamental requirement of the Type 298 design and both the circuit breaker section and PowlVac$^{100}_{TM}$ are designed for operation behind a closed door.



The plenum height is determined by the IAC rating as indicated below:

Cubicle Width	IAC Rating	Plenum Height mm
700mm/1000mm	<50kA 1 sec AFLR	434
700mm/1000mm	50kA 1 sec AFLR	634
1000mm	50kA 0.1 sec BFLR	634
1000mm	63kA 0.1 sec AFLR	634

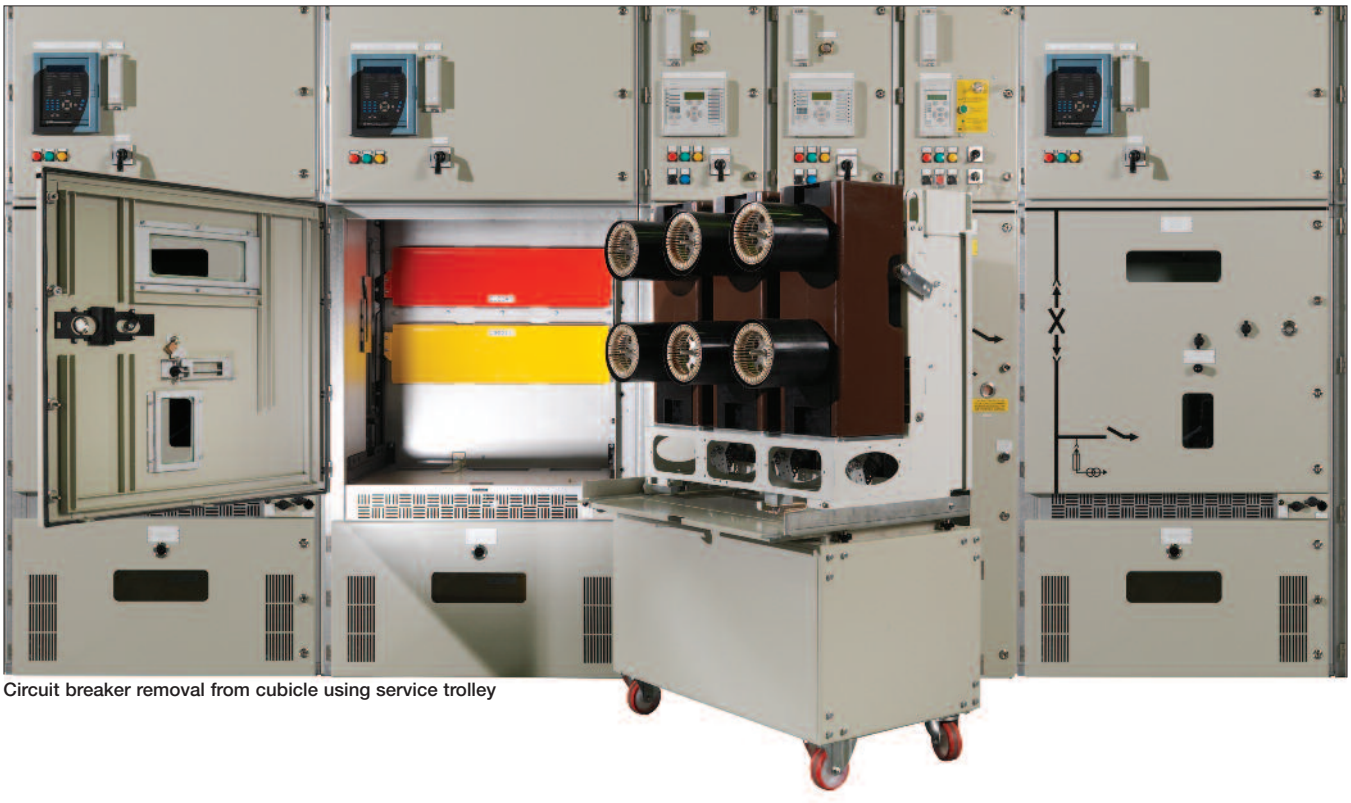

Racking Circuit Breaker


Operating Circuit Earth Switch

Earthed metal safety shutters are operated by the movement of the circuit breaker being racked between the 'Test/Disconnected' and 'Service' positions.

Shutter operation is as follows:

- Shutters are positively driven open, priming a high-integrity mechanism for subsequent close-operation.
- Shutters can be individually propped in the ‘Open’ position. They can be either closed manually or, on re-insertion of the circuit breaker to the ‘Service’ position, normal operation is automatically restored.
- Shutters can be individually padlocked in the ‘Closed’ position.
- Shutter operation can be checked by using an optional manual operation device.

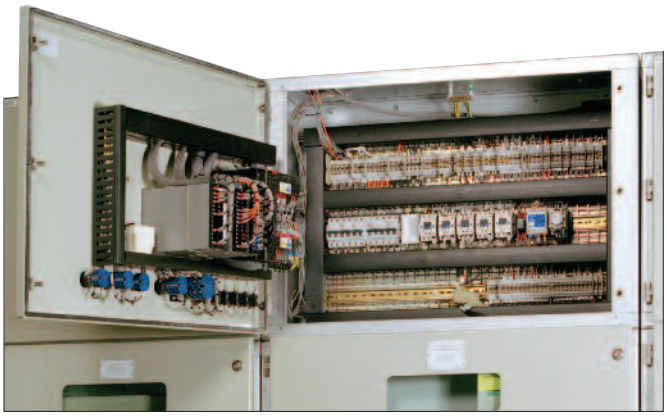


Circuit breaker removal from cubicle using service trolley

CIRCUIT BREAKER SWITCHGEAR

Circuit breakers are withdrawn and inserted utilising the service trolley. Full interlocking is provided as follows:

- The circuit breaker cannot be racked from the 'Test/Disconnected' position to the 'Service' position unless:
  - Racking system interlocks are engaged
  - Circuit breaker is open
  - Front door is closed
  - Earth switch is open
  - Racking interlock is not present
- The circuit breaker cannot be racked from the 'Service' to the 'Test/Disconnected' position unless the circuit breaker is open.
- The earth switch can only be closed with the circuit breaker in the 'Test/Disconnected' or 'Withdrawn' position.
- The door cannot be opened unless the circuit breaker is in the 'Test/Disconnected' position.
- The circuit breaker can only be closed in either the 'Service' or 'Test/Disconnected' positions.



Circuit Breaker Cubicle Low Voltage Compartment

700mm VCB Cubicle

CURRENT TRANSFORMER

The standard arrangement is for protection and metering CTs to be of a toroidal design and accommodated on cast resin insulated, earthed-screen bushings located in the cable termination chamber.

The earthed screen is between the primary insulation and the CT and permits the use of low voltage (600V insulated) CTs, up to four of which can be mounted on each bushing. If specified, cast resin primary-wound CTs can be provided.

CTs mounted on earthed-screen bushings

VOLTAGE TRANSFORMERS

Cast resin circuit (and busbar) VTs are located in a dedicated section at the bottom of the cubicle.

VTs are mounted on a withdrawable truck for racking to and from the Service position. VT insertion is therefore effected in a safe, controlled manner. The VT primary fuses are located within the primary contact arms.

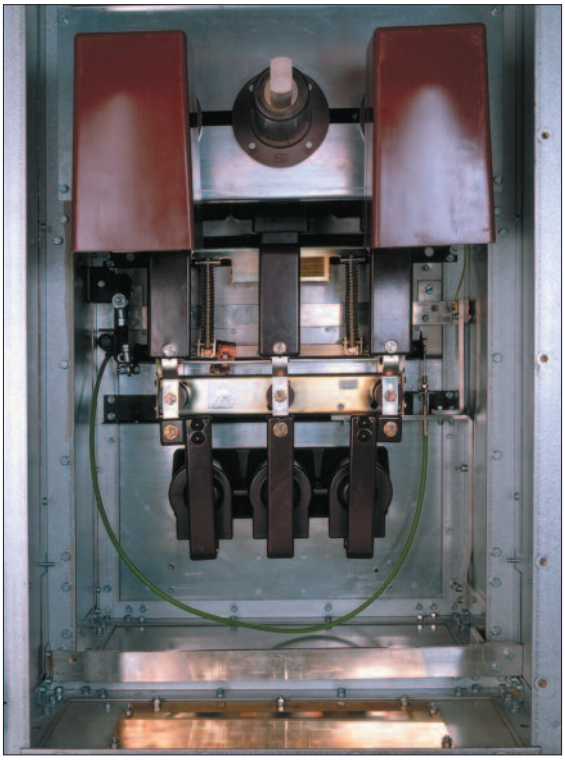
The VT compartment includes a padlockable, earthed metal shutter which covers the primary fixed contact spouts. The shutter is positively driven open by the racking in and out of the VT, priming a high-integrity mechanism for subsequent close-operation.

Busbar VTs are mounted in an identical arrangement to circuit VTs in a dedicated cubicle or bus transition section.

Withdrawn VT on truck

CIRCUIT EARTHING

A cable earth switch is housed in the rear of the cubicle directly connected to the CT bushings. Operation of the earth switch is via a drive shaft which is fully interlocked with the circuit breaker operation. Earth switches are available rated up to 50kA 1 sec, 95kV BIL and 36kV 1 min.



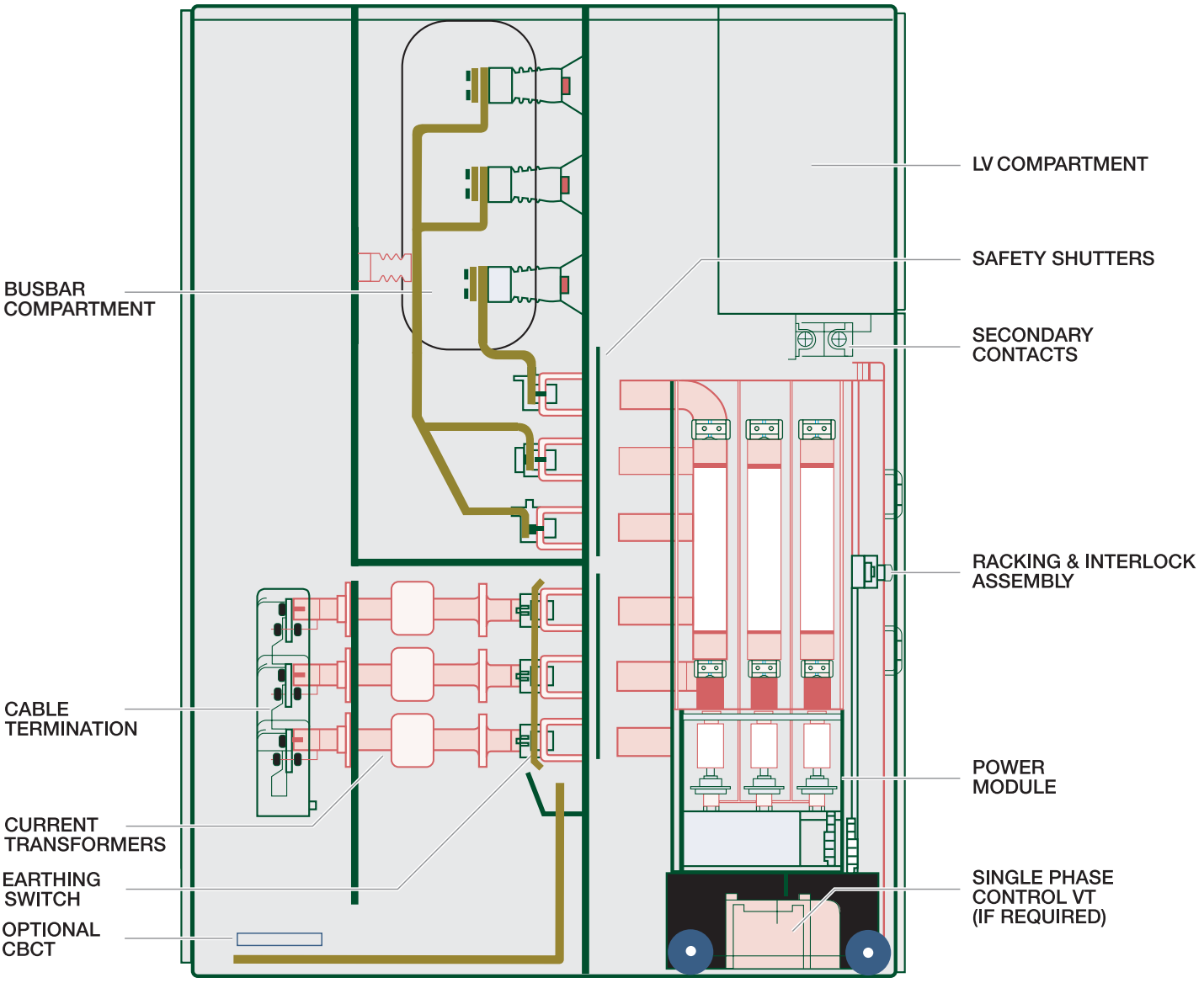
Circuit Earth Switch

CONTACTOR SWITCHGEAR

Fused vacuum contactor units (VCU) are designed to form a suite of flush front cubicles with the circuit breaker sections, without the need for busbar adaptation or transition.

VCUs are rated for operation at 400A at 7.2kV and are available as electrically held or mechanically latched. In addition to their use as motor starters, the VCUs are ideally suited to transformer or capacitor feeder applications. As with the circuit breaker assembly, the VCU cubicle is designed for interlocked closed-door operation and consists of distinct sectionalised areas:

- Contactor Compartment
- Busbar Compartment
- Cable Termination Compartment
- Low Voltage Compartment



Cross-section of Contactor Cubicle with Contactor Truck in 'Isolated' Position

CONTACTOR TRUCK

The contactor truck is fully withdrawable and contains the following equipment and devices:

- 400A rated vacuum contactor
- HRC fuses
- Fused single-phase control VT (if required)
- Fully insulated, segregated moulded fuse-carrier and conductor assembly
- Facility to accommodate three fuse lengths
- Blown primary fuse trip assembly
- Shrouded primary male isolating contacts
- Secondary multiple contact auxiliary plug
- Contactor status indicator

Withdrawal of Vacuum Contactor Truck

INTERLOCKED OPERATION

The contactor truck and cubicle assemblies are fully interlocked to ensure complete operator safety. Interlocks are provided as follows:

- The truck cannot be moved from the 'Service' or 'Test/Disconnected' positions unless the contactor is open.
- The contactor cannot be closed unless the truck is in the 'Service' or 'Test/Disconnected' position.
- The truck cannot be racked into the 'Service' position until the cubicle door is closed.
- The cubicle door cannot be opened unless the truck is in the 'Test/Disconnected' position.
- The earth switch is automatically opened by a direct driven mechanism when the truck is racked towards the 'Service' position.

The contactor truck can be locked in the 'Test/Disconnected' position by means of padlocking the cubicle door mechanism.

Racking VCU Behind Closed Door

VCU Cubicle Showing Shutters and Guide Rails

CUBICLE ASSEMBLY

The cubicle accommodating the contactor truck incorporates:

- Truck guide rails
- Primary contact spouts
- Padlockable busbar and circuit shutters
- Circuit earth switch operating mechanism

CIRCUIT EARTHING

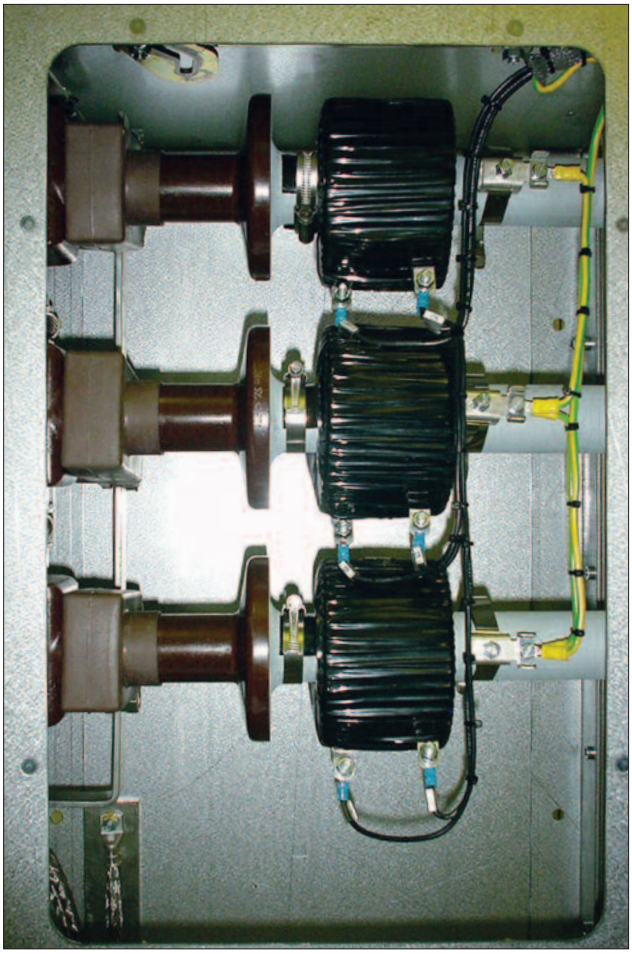
The VCU includes a circuit earth switch mounted in the cable termination chamber which is fully interlocked with the contactor truck.

The standard operation of the circuit earth switch is manual closing by means of a pushbutton mounted on the front of the contactor truck cubicle.

Two further options are available for automatic operation of the earth switch:

- The earth switch is automatically applied when the contactor truck is racked from the 'Service' position to the 'Test/Disconnected' position.
- The earth switch is automatically applied on removal of the contactor truck out of the cubicle from the 'Test/Disconnected' position.

The earth switch, once applied, can only be opened by racking the contactor truck into the 'Service' position. The earth switch can be padlocked both when open and closed.



CTs mounted on earthed-screen bushings

CURRENT TRANSFORMERS

As with the circuit breaker sections, CTs are mounted on earthed-screen bushings, located in the cable termination compartment on the load side of the fused contactor assembly. The bushings are fully rated for the maximum continuous current and for the let-through energy of the maximum rated fuse.

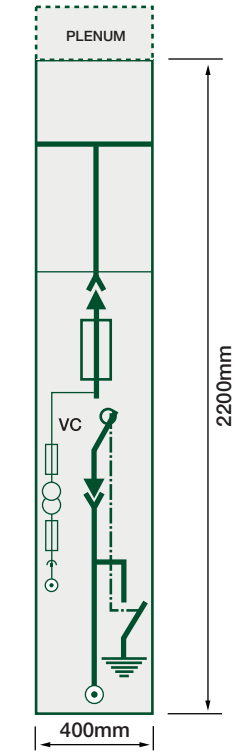
CONTROL VOLTAGE TRANSFORMERS

In the majority of applications an individual single-phase control voltage transformer is incorporated on the base of the contactor truck. Primary fuses for the VT are also mounted on the truck housed within the moulded fuse carrier assembly.

Alternatively, an externally derived control supply can be utilised for the contactor coils and other auxiliaries. In this case, with the use of an optional 'umbilical' test lead, the contactor truck can be tested when removed from the cubicle.

CONTACTOR SWITCHGEAR

The VCU design incorporates contactors in either electrically-held or mechanically-latched configurations.



MAXIMUM RATING
50kA 400A 7.2kV

VACUUM CONTACTOR DATA

TYPE FORM			ELECTRICALLY HELD	MECHANICALLY LATCHED
RATED INSULATION VOLTAGE		(kV)	7.2	
RATED OPERATIONAL VOLTAGE		(kV)	3.3/6.6	
RATED OPERATIONAL CURRENT CATEGORY AC-4		(A)	400	
RATED FREQUENCY		(Hz)	50/60Hz	
INTERRUPTING CAPACITY (DUTY 0.2 MIN. –CO)		(kA)	6.3	
MAKING CURRENT (100 TIMES)		(kA)	4	
BREAKING CURRENT (25 TIMES)		(kA)	3.2	
SHORT TIME CURRENT	(12S)	(kA)	4	
	(1S)	(kA)	8.0	
RATED IMPULSE WITHSTAND VOLTAGE		(kV)	60	
RATED WITHSTAND VOLTAGE (1 min.)		(kV)	20	
SWITCHING FREQUENCY	(OPS'/HOUR AC3)		1200	
ENDURANCE	MECHANICAL LIFE		2.5×10^6	0.25×10^6
	ELECTRICAL LIFE		0.25×10^6	
CONTROL CIRCUIT SUPPLY		(VDC)	100-250V	
		(VAC)	100-240V	
ALLOWABLE CONTROL VOLTAGE FLUCTUATION			85% TO 100%	
CLOSING COIL INRUSH		(W)	500	
HOLDING LOAD		(W)	60	
SHUNT TRIP LOAD		(W)	500	
CLOSING TIME		(mS)	70-80	
OPENING TIME		(mS)	15-25	
MINIMUM PICK-UP VOLTAGE			85%	
DROP-OUT VOLTAGE			65%	
AUXILIARY CONTACTS	CONTACT ARRANGEMENT		3NO-3NC 2NO-2NC	
	OPERATIONAL VOLTAGE		48-480VAC 220VDC	
	THERMAL CURRENT	(A)	10	
	AC CAPACITY	(VA)	700 (PF 0.35)	
	DC CAPACITY	(W)	60 (L/R 150mS)	
MAXIMUM LOAD	MOTORS	(kW)	1500/3000	
	TRANSFORMER	(kVA)	2000/4000	
	CAPACITORS	(kVA)	2000/2000	

CABLING ARRANGEMENTS

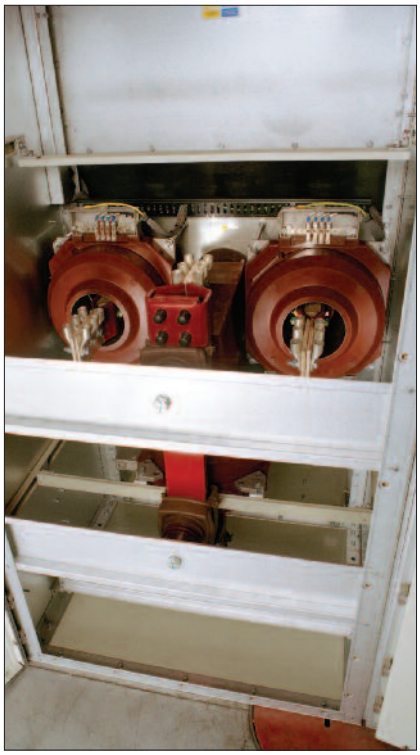
PRIMARY POWER CABLE ACCOMMODATION

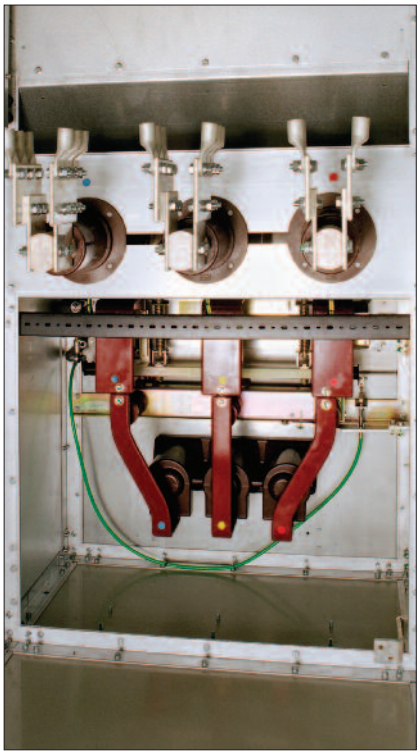
Power cable access is from the rear and can be either top or bottom entry for single or three-core cables. The standard cubicle depth, depending on the required IAC level, is 1600mm but for cubicle widths of 700mm / 1000mm, this can be extended to 2000mm (2105mm for 63kA rating) to facilitate the larger cables required at higher current ratings, or as dictated by high ambient temperatures and / or long run lengths.

Power cable termination shrouds are provided for CT bushing cable terminations.

MAXIMUM RECOMMENDED CABLE ACCOMMODATION

Cubicle Width	Top Entry	Bottom Entry
400mm	2 x 3 core 185mm^2	2 x 3 core 185mm^2
700mm	6 x 1 core 630mm^2	6 x 1 core 1000mm^2
or	4 x 3 core 400mm^2	4 x 3 core 400mm^2
1000mm	6 x 1 core 630mm^2	6 x 1 core 1000mm^2
or	6 x 1 core 1000mm^2	9 x 1 core 1000mm^2
1000mm	6 x 1 core 1000mm^2	9 x 1 core 1000mm^2
or	4 x 3 core 400mm^2	4 x 3 core 400mm^2





VCB Cable Termination Compartment showing CTs and Multiple Lugs

VCU Cable Termination Compartment c/w Optional CBCT

SECONDARY AUXILIARY CABLING

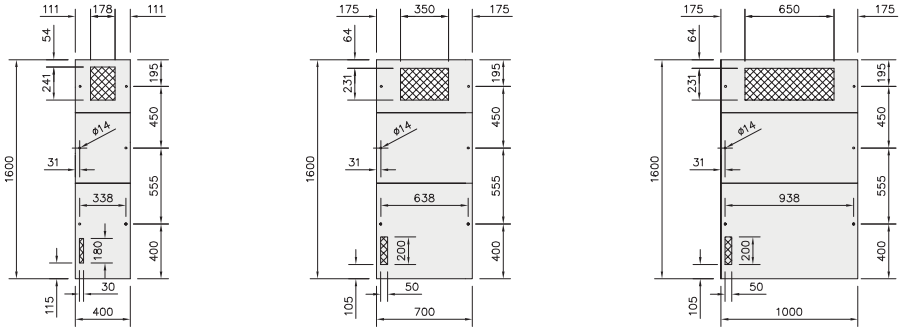
Secondary cable accommodation is either at the rear or directly via the LV compartment gland plate at the top front of the cubicle. Cables may also enter the front of the cubicle from below and be linked to the LV compartment via metal clad trunking.

A further option is for a top rear mounted external cable box arranged for bottom entry. Auxiliary cables enter from below and are routed through the primary cable termination compartment in fully segregated trunking.

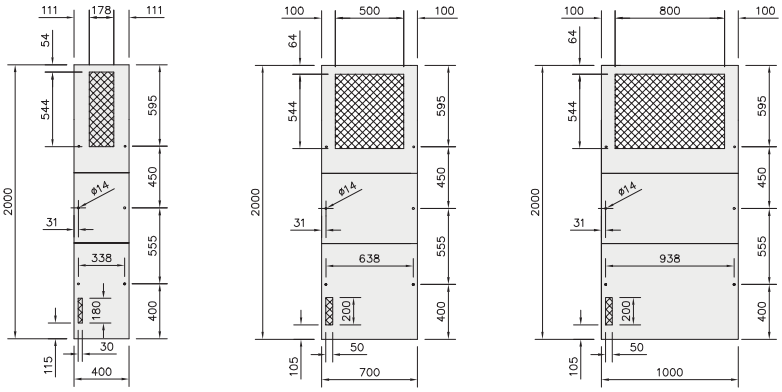
Bus wiring within a switchboard is routed directly between the LV compartments of each cubicle.

FLOOR FIXING & GLAND PLATE DETAILS

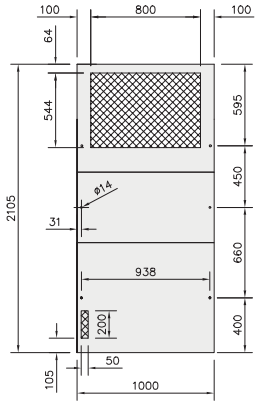
BOTTOM ENTRY STANDARD DEPTH 1600mm



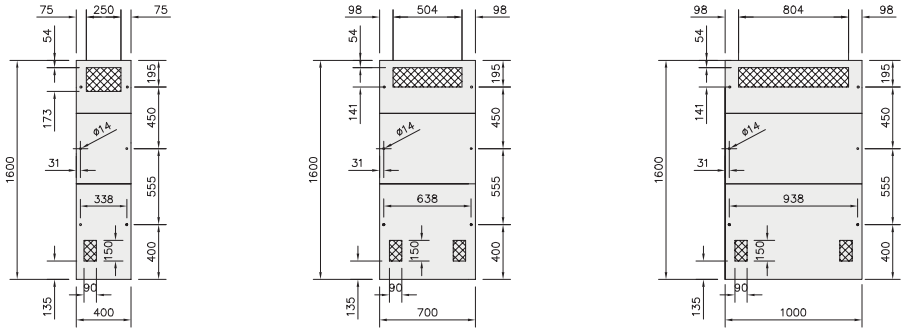
BOTTOM ENTRY EXTENDED DEPTH 2000mm



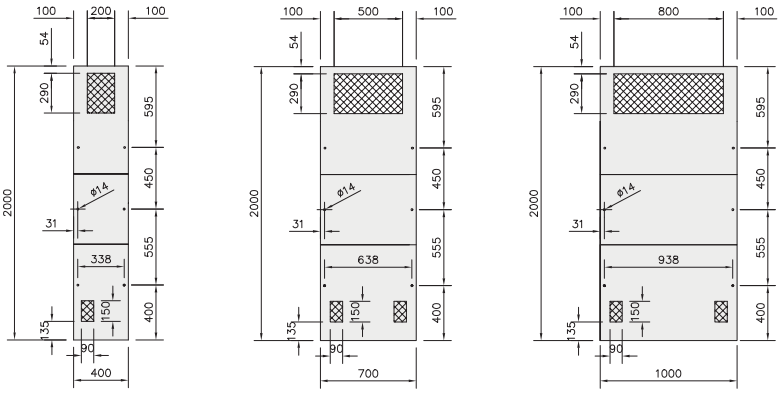
BOTTOM ENTRY EXTENDED DEPTH 2105mm



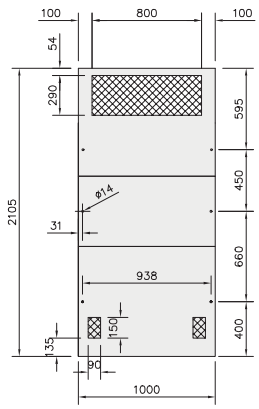
TOP ENTRY STANDARD DEPTH 1600mm



TOP ENTRY EXTENDED DEPTH 2000mm

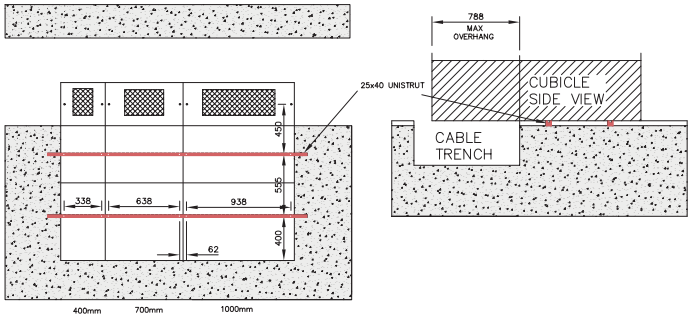


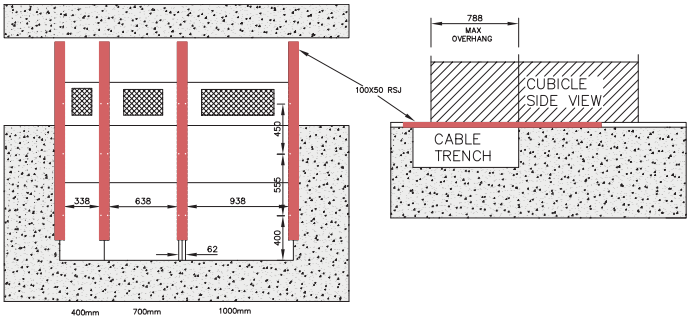
BOTTOM ENTRY EXTENDED DEPTH 2105mm



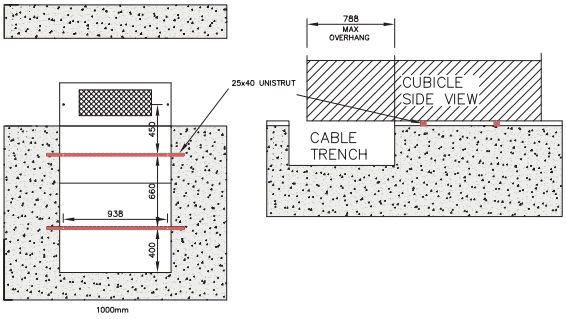
RECOMMENDED SUBSTATION FOUNDATION LAYOUTS

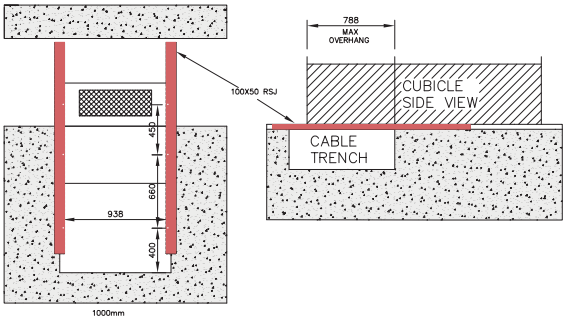
RATINGS UP TO 50kA





63kA RATING





INTEGRATED PROTECTION, CONTROL AND MONITORING SYSTEMS

With over 20 years' expertise in the design and manufacture of IPCMS (Integrated Protection, Control and Monitoring System) technology, Powell remains committed to the satisfaction of customers' continually evolving and increasingly sophisticated system requirements through a flexible and innovative approach, designed to consistently deliver systems which are safe, reliable and responsive, and which can be applied across all industry sectors.

A typical IPCMS in a large process environment will have a system architecture as shown, with the process plant being controlled by a DCS at the highest level and at the switchgear level, intelligent protection relays / bay controllers for distribution circuits, and Motor Manager 6 for motor circuits.

Flexible system design and proven communication gateways such as CMAC (Communications, Management and Control Computer), allow integration of all items of electrical plant, such as UPS, Generator UCPs and VSDs, in addition to MV and LV switchgear. A wide range of device communication protocols are supported, including Modbus RTU, Modbus TCP and IEC 61850 power utility automation protocol.

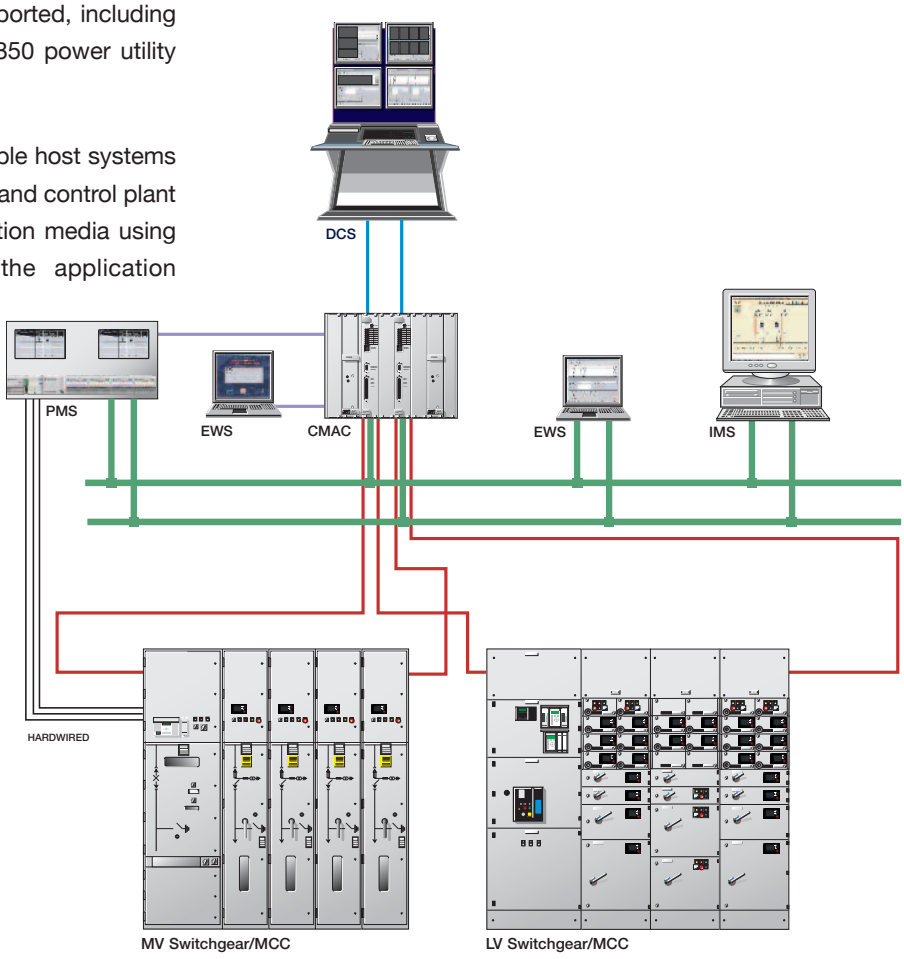
The communication gateways allow multiple host systems such as DCS and SCADA to acquire data and control plant simultaneously with different communication media using industry standard protocols to suit the application requirement.

The SCADA-based EWS (Engineering Workstation) allows access to the vast amount of data available from the intelligent devices through comprehensive monitoring of installed equipment. Features include historical trending, global sequencing of events, disturbance recording, predictive maintenance and device parameterisation. Server/client architecture allows multiple access across plants and remotely via web access.

For more complex electrical networks, the IPCMS can be expanded to incorporate logic control and power management functions such as control, monitoring, synchronising and load sharing / fast acting load shedding of generators.

For smaller process applications, Motor Manager 6 has the optional capability to communicate directly with a DCS or PLC control system via the following industry-standard open protocols:

- Modbus RTU
- Modbus TCP (Ethernet)
- Profibus DP
- Devicenet



Motor Manager 6

OUTDOOR SWITCHGEAR APPLICATIONS

As further evidence of our commitment to providing our customers with innovative solutions to their application requirements, we are able to offer the Type 298 switchgear range in a fully weatherproof, IP66 configuration, suitable for installation outdoors.

This option is ideally suited to applications where space is at a premium and where a purpose-built switch-room or modular housing is not suitable, for example on a remote wellhead offshore platform.

Lift off rear covers to facilitate cabling

Standard Type 298 equipment is mounted inside a stainless steel enclosure which incorporates a welded steel fabricated base facilitating transportation in one section and minimised installation time. Cable access is at the rear and cable entry can be accommodated from the top or from below. Cables enter via gland-plates or transits.

Auxiliary doors, with polycarbonate windows, provide easy access to racking mechanisms for contactors and circuit breakers and to protection relays and control devices.

A primary door is provided to facilitate removal of circuit breakers or contactors from the assembly.



Type 298

Medium Voltage IEC Switchgear and Motor Control Centres

incorporating PowlVac™ Vacuum Circuit Breakers

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