



Part of Energy Queensland

Substation Standard

Standard for Switchgear Selection

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Abstract: The purpose of the standard is to assist with selection of circuit breakers for substation applications.

Keywords: Substation, Circuit breaker, Gas Insulated Switchgear, Disconnecter, Switchboard

Standard for Switchgear Selection

CONTENTS

1	Overview	5
1.1	Purpose	5
1.2	Scope	5
2	References	5
2.1	Legislation, regulations, rules, and codes.....	5
2.2	Controlled documents	5
2.3	Other documents	6
3	Definitions and abbreviations	6
3.1	Definitions	6
3.2	Abbreviations	8
4	Switchgear selection	9
4.1	Ratings to check	9
4.2	Environmental factors	9
4.3	Where to use what technology	9
4.3.1	Metal enclosed vs not metal enclosed	9
4.3.2	Live v dead tank circuit breakers.....	10
4.3.3	Gas Insulated Switchgear	10
4.3.4	Hybrid switchgear	10
4.3.5	Ring Main Unit	10
4.3.6	Automatic circuit reclosers	10
4.3.7	Single pole switching	10
4.4	Special operations	11
4.4.1	Capacitor bank switching	11
4.4.2	Reactor bank switching	11
4.4.3	Charging currents	11
4.4.4	Transformer energisation.....	11
5	Switchgear Selection Options	11
5.1	Circuit Breakers and Switchgear	11
5.2	Current transformers	12
5.3	Voltage transformers.....	12
5.4	Standard relay locations.....	13
6	Ratings and Switchgear Characteristics	13
6.1	General Ratings	13
6.2	Circuit breakers	13
6.2.1	Peak withstand current	13

Standard for Switchgear Selection

6.2.2	Operating sequence	14
6.2.3	Electrical endurance	14
6.2.4	Mechanical endurance.....	14
6.2.5	Network Classification	14
6.2.6	Charging currents	14
6.2.7	Requirements for simultaneity of poles	15
6.3	Disconnecter and earth switch requirements.....	15
6.3.1	Disconnecter mechanical endurance	15
6.3.2	Earth switch electrical endurance	15
6.4	Metal enclosed switchgear	16
6.4.1	Internal Arc Classification	16
6.4.2	Loss of service continuity class.....	16
6.5	Insulating oils	16
6.6	Insulation gases	16
6.7	Interrupters	16
7	Design and construction.....	17
7.1	Mounting requirements	17
7.2	Internal arc venting and pressure relief devices	17
7.3	HV connections.....	17
7.4	Bus Tie Cable Considerations.....	17
7.5	MV Metal-Enclosed Switchgear Extension Considerations.....	18
7.5.1	Considerations for staging of metal-enclosed switchgear.....	18
7.5.2	Typical outage requirements.....	18
7.5.3	Considerations with joggle panels.....	18
Annex A	20
Capacitor bank switching inrush calculations	20
Appendix A	21
Revision History	21

Standard for Switchgear Selection



TABLES

Table 1: Switchgear Commonly Available	12
Table 2: Relay Operated C&I Substations.....	12
Table 3: Charging currents.....	15
Table 4: Simultaneity of poles	15
Table 5: Typical joggle panel sizes	18

EQUATIONS

Equation 1: Time constant	13
Equation 2: Equations for the calculation of capacitor bank inrush currents	20

Standard for Switchgear Selection

1 Overview

1.1 Purpose

To provide direction on the selection of switchgear to be used with Energy Queensland Substations. The standard also provides rating information and attributes specific to switchgear which is not covered in other standards.

1.2 Scope

This standard applies to all circuit breakers for zone substation application. It includes reclosers, ring main switchgear, medium voltage (MV) air insulated, and gas insulated switchgear, high voltage (HV) gas insulated switchgear and outdoor MV and HV circuit breakers.

The standard is not tied to contractual specifications unless directly called for in a Technical Specification.

The standard is manufacturer agnostic. Details of the actual switchgear on contract can be found in the relevant technical instructions.

2 References

2.1 Legislation, Regulations, Rules, and Codes

Document	Type
<i>Electricity Act 1994</i> (Qld)	Legislation
Electricity Regulation 2006 (Qld)	Regulation
<i>Electrical Safety Act 2002</i> (Qld)	Legislation
Electrical Safety Code of Practice – Works, 2020 (Queensland Government)	Code
Electrical Safety Regulation 2013 (Qld)	Regulation
National Electricity Rules	Regulation
<i>Queensland WH&S Regulation 2011</i>	Legislation

2.2 Controlled Documents

Document	Alternative Doc ID
Standard for Climate and Natural Hazard Resilience - 3057510	STNW3007
Standard for HV Equipment Ratings - 26945507	STNW3015
Standard for GIS Applications - 3053734	STNW3045
Standard for Cables and Cable Installations – 12737281	STNW3018
Standard for Busbar Conductor Selection - 3062690	STNW3014
Standard for Interlocking - 3060386	STNW3046

2.3 Other Documents

Capacitor Bank Inrush Current Calculator – STNW3051

AS 62271.1 - High-voltage switchgear and controlgear, Part 1: Common specifications for alternating current switchgear and controlgear

AS 62271.100 - High-voltage switchgear and controlgear - Part 100: High-voltage alternating-current circuit-breakers

AS 62271.102 - High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches

AS 62271.200 - High-voltage switchgear and controlgear - Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

AS/NZS 62271.203 - High-voltage switchgear and controlgear - AC gas-insulated metal-enclosed switchgear for rated voltages above 52 kV

AS 62271.301 - High-voltage switchgear and controlgear - Dimensional standardization of terminals

IEC 62271-1 - High-voltage switchgear and controlgear - Part 1: Common specifications for alternating current switchgear and controlgear

3 Definitions and Abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

Cable charging breaking capacity	Breaking capacity for which the specified conditions of use and behaviour include the opening of an insulated cable operating at no-load (AS 62271.100)
Line charging breaking capacity	Breaking capacity for which the specified conditions of use and behaviour include the opening of an overhead line operating at no-load (AS 62271.100)
loss of service continuity category LSC	Category defining the possibility to keep other compartments and/or functional units energised when opening an accessible high-voltage compartment (AS62271.200)
Category LSC2	Functional unit having at least an accessible compartment for the high-voltage connection (called connection compartment), such that, when this compartment is open, at least one busbar can remain energised and all other functional units of the switchgear and controlgear can be operated normally (AS 62271.200)
Category LSC2A	Functional unit of category LSC2 such that, when any accessible compartment (other than the busbar compartment of a single-busbar switchgear and controlgear) is open, at least one busbar can remain energised and all other functional units of the switchgear and control can be operated normally (AS 62271.200)
Category LSC2B	Functional unit of category LSC2A, where the high-voltage connections (e.g., cable connections) to the functional unit can remain energised

Standard for Switchgear Selection

	when any other accessible high-voltage compartment of the corresponding functional unit is open (AS 62271.200)
Category LSC1	Functional unit having one or more high-voltage compartments, such that, when any of these accessible high-voltage compartments is open, at least one other functional unit cannot remain energised (AS 62271.100)
Circuit-breaker class C1	Circuit-breaker with low probability of restrike during capacitive current breaking as demonstrated by specific type tests (AS 62271.100)
Circuit-breaker class C2	Circuit-breaker with very low probability of restrike during capacitive current breaking as demonstrated by specific type tests (AS 62271.100)
circuit-breaker class E1	Circuit-breaker with basic electrical endurance not falling into the category of class E2 (AS 62271.100)
Circuit breaker class E2	Circuit-breaker design so as not to require maintenance of the interrupting parts of the main circuit during its expected operating life, and only minimal maintenance of its other parts (circuit-breaker with extended electrical endurance) (AS 62271.100)
Circuit-breaker class M1	Circuit-breaker with normal mechanical endurance as demonstrated by specific type tests (AS 62271.100)
Circuit-breaker class M2	Frequently operated circuit-breaker for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests (AS 62271.100)
Circuit-breaker class S1	Circuit-breaker intended to be used in a cable system
Circuit-breaker class S2	Circuit-breaker used in a line-system
Multiple (parallel) capacitor bank Back to back capacitor bank	Bank of shunt capacitors or capacitor assemblies each of them switched independently to the supply system, the inrush current of one unit being appreciably increased by the capacitors already connected to the supply (AS 62271.100)
Peak (making current)	Peak value of the first major loop of the current in a pole of a circuit-breaker during the transient period following the initiation of current during a making operation NOTE 1 The peak value may differ from one pole to another and from one operation to another as it depends on the instant of current initiation relative to the wave of the applied voltage. NOTE 2 Where, for a polyphase circuit, a single value of (peak) making current is referred to, this is, unless otherwise stated, the highest value in any phase.
Primary switchgear	Switchgear with a nominal current rating of 1250A or more

Standard for Switchgear Selection

Secondary switchgear	Switchgear with a nominal current rating of less than 1250A
Ring Main Unit	Medium voltage, metal-enclosed, secondary switchgear. Sometimes also called underground distribution switchgear.
Gas insulated switchgear	Switchgear manufactured to AS/NZS 62271.203
Hybrid switchgear	Switchgear that combines gas-insulated internal switching functions with air-insulated external interfaces, typically forming a single-bay module. Multiple primary switching functions (e.g. circuit breaker, disconnectors, earthing switches and instrument transformers) are integrated within one or more metal-enclosed, gas-insulated compartments, with bushings providing air-insulated interfaces for connection to external conductors. This may be called mixed-technology switchgear.
Shall	Indicates that a statement is mandatory
Should	Indicates a recommendation advisable (non-mandatory)
Single capacitor bank	Bank of shunt capacitors in which the inrush current is limited by the inductance of the supply system and the capacitance of the bank of capacitors being energised, there being no other capacitors connected in parallel to the system sufficiently close to increase the inrush current appreciably (AS 62271.100)

3.2 Abbreviations

This list does not include well-known unambiguous abbreviations, or abbreviations defined at their first occurrence within the text.

AC	Alternating current
ACR	Automatic circuit recloser
AIS	Air insulated Switchgear
CB	Circuit breaker
CT	Current transformer
DC	Direct current
EQL	Energy Queensland Limited
GIS	Gas Insulated Switchgear
IAC	Internal arc classified switchgear and controlgear
MV	Medium voltage (11-33kV)
LSC	Loss of service continuity category
RMU	Ring Main Unit
STATCOM	Static Synchronous Compensator

SVC	Static var Compensator
VT	Voltage transformers

4 Switchgear Selection

4.1 Ratings to Check

Before switchgear can be selected for an application the following attributes shall be considered for the application:

- Network voltage
- Network current rating requirements including normal, short term and emergency allowances
- Fault levels
- Review X/R for substations with high fault levels
- Wind ratings (outdoor only)
- Operating sequence
- Suitability for special applications (where applicable)
- Instrument transformers are suitable (where applicable)
- Control and motor voltage
- Network Line \ Cable charging
- Bus rating (where applicable)
- Cable entry (where applicable)
- Size and number of cables per phase (where applicable)

4.2 Environmental Factors

Switchgear shall meet the requirements of the Standard for Climate and Natural Hazard Resilience (STNW3007). The manufacturer's requirements for indoor switchgear shall be compared to the site conditions (particularly for existing sites).

4.3 Where to Use What Technology

4.3.1 Metal Enclosed vs Not Metal Enclosed

For voltages at 33kV and below, metal enclosed switchgear installed inside a building is preferred. At 66kV and above, AIS bus is preferred with air insulated connections to switchgear. For sites with 66kV and above and constrained footprint, GIS installed inside a building may be preferred over AIS.

Alternative arrangements are permitted to address installation or site-specific considerations if determined fit for purpose.

4.3.2 Live vs Dead Tank Circuit Breakers

For outdoor, air insulated insulations, dead tank circuit breakers should be used for all installations except at 245kV. Dead tank circuit breakers have the following benefits compared to live tank circuit breakers:

- Included current transformers (eliminates maintenance associated with post type current transformers)
- Separate CT marshalling box not required

Minimised protection zone overlap which are closer to the interrupting point and protected within the primary plant.

The use of a live tank breaker to fit an existing footprint or avoid unnecessary replacement of a current transformer is acceptable.

Live tank breakers shall be used at 245kV to align to legacy practices.

4.3.3 Gas Insulated Switchgear

Gas insulated switchgear shall be used for indoor applications of 66kV and above. For outdoor applications at 66kV and above, GIS can be considered where there are space constraints and concerns with housing the GIS in a building. Outdoor GIS shall be avoided where possible due to the risk of long term issues such as inability to handle environmental conditions, accelerated corrosion and degradation of seals and moisture ingress into auxiliary components. Many GIS suppliers do not recommend outdoor GIS installations.

GIS shall be installed in line with the standard for GIS (STNW3045). The climatic requirements of the installation shall be checked against the rating of the GIS. Where the GIS does not meet the climatic requirements, it shall be installed indoors, or a different technology used.

4.3.4 Hybrid Switchgear

Hybrid switchgear can be used for single bay customer connections only at this stage.

4.3.5 Ring Main Unit

Ring main units may be used within substations as the main switchgear in cases where the required rated nominal current is less than or equal to 630A. The protection schemes shall be as per the standards and advice from the protection team. Where a higher rating is required, primary switchgear shall be used.

4.3.6 Automatic Circuit Reclosers

Automatic circuit reclosers are available for use within air insulated substations that can utilise secondary switchgear. These are suitable for basic applications typically for single bay substations or retrofitting into existing outdoor substations already constructed with reclosers. The level of protection and control provided by the recloser shall be confirmed sufficient by protection.

4.3.7 Single Pole Switching

Single pole switching shall be used where three pole switching is identified as unsuitable for the switching application. This is applicable for circuit breakers at 66 kV and above which can separate pole operation. Staggered pole operating mechanisms are not standard and are not considered for greenfield installations unless required.

Where a study identifies that single pole switching is required, a single pole circuit breaker with a point on wave controller shall be used to reduce the effect of inrush currents or transient recovery voltages.

To match legacy installations, single pole mechanism circuit breakers should be installed at 245kV. Point of wave controllers is not required unless determined by a study.

4.4 Special Operations

4.4.1 Capacitor Bank Switching

For capacitor bank switching a circuit breaker with a C2 and M2 classification shall be used. The site specific capacitive current, inrush current(s) and inrush frequency shall be checked against the ratings of the circuit breaker.

The Capacitor bank Inrush Calculator has been developed to calculate the in-rush currents and frequency; calculations are as per Figure H.3 from AS 62271.100. Refer to Annex A

4.4.2 Reactor Bank Switching

For reactor bank switching a transient switching study shall be completed to determine the suitability of the circuit breaker for the switching case and any required mitigating factors. Single pole, point on wave switching shall be considered as the first mitigating option if transient recovery voltages are excessive for the switchgear or other plant exposed.

4.4.3 Charging Currents

Where long cable or line sections with no intermediate loads are installed the applicable cable or line charging rating of the switchgear shall be checked. Typically, higher voltage switchgear has higher charging ratings and may be required where long cables \ lines are installed. Section 6.1.6 lists the standard rated charging currents.

4.4.4 Transformer Energisation

Where large power transformers are energised in weak networks, energisation studies shall be completed to determine the effects of energisation on the network. These studies shall determine the suitability of three pole switching. Single pole, point on wave switching shall be considered as the first mitigating option if the impact to network voltages at time of energisation are outside planning allowances.

5 Switchgear Selection Options

5.1 Circuit Breakers and Switchgear

Table 1 and Table 2 show various common types of switchgear available across Energy Queensland's voltage ranges. These common types are normally on period contracts and available for use. Refer to the associated technical instructions for specific details of the switchgear.

Standard for Switchgear Selection

Table 1: Switchgear Commonly Available

	11 kV	22 kV	33 kV	66 kV	145 kV	245 kV
Recloser	X	X	X			
Indoor RMU	X	X	X			
Outdoor RMU	X	X	X			
Primary Switchboard	X	X	X			
Live tank CB (3 pole)				X	X	
Live tank CB (single pole)				X	X	X
Dead tank CB (3 pole)			X	X	X	
Dead tank CB (single pole)				X	X	
GIS				X	X	
HIS (3 pole)				X	X	
HIS (single pole)				X	X	

Table 2: Relay Operated C&I Substations

	11kV C&I Sub LV Connection to customer	11kV C&I Sub HV Connection to customer (single bus)	11kV C&I Sub HV Connection to customer (multiple buses)
Indoor RMU	X	X	
Primary Switchboard			X

5.2 Current Transformers

The standard current transformers included with contracted switchgear have been selected to work with the period contract relays (at the time of the tender process), network characteristics and standard plant requirements. The use of non-standard CTs is not preferred and should not be required on green field sites.

For brownfield applications undergoing partial upgrades, there may be difficulty aligning standard CT specifications to existing protection schemes not earmarked for replacement. In this case, various options may exist. If the use of non-standard CT's is the most practical solution, consult Substation Standards.

For RMU style switchgear utilising toroidal CTs, the internal diameter of the CT will be a limiting factor for the size of cable that can be installed. Ensure there is sufficient clearance to pass through and terminate the HV cable and cable screen.

5.3 Voltage Transformers

Where voltage transformers are required, and the switchgear type supports their installation as part of the switchgear then the voltage transformers should be installed as part of the switchgear.

For neutral voltage displacement protection, the preference is for 3-phase 5-limb or single-phase voltage transformers.

5.4 Standard Relay Locations

Where practical, the preference is for feeder protection relays to be installed on MV metal enclosed switchgear. For relays to be installed onto new switchgear the switchgear must meet the following requirements:

- AFLR rated
- Duplicate feeder protection installed
- High speed bus protection installed (installed off switchgear)
- Isolation and test facilities are to be installed on the front of the switchgear

For GIS the protection relays shall be installed separately from the GIS.

For outdoor AIS switchgear, the protection relays shall be installed separately from the switchgear.

6 Ratings and Switchgear Characteristics

6.1 General Ratings

Primary ratings are detailed in STNW3015 Standard for HV Equipment Ratings. This section provides additional rating information not included in the STNW3015.

6.2 Circuit Breakers

6.2.1 Peak Withstand Current

In addition to fault ratings described in STNW3015 the following shall apply to circuit breakers.

The standard time constant of 45ms is used for the ratings of the standard circuit breakers to be included on contract.

Where the maximum fault level is 80% or greater than the rating of the circuit breaker then the time constant shall be checked. In cases where the time constant is greater than 45ms a circuit breaker with the next short circuit rating from the R10 series shall be used.

R10 series is 10, 12.5, 16, 20, 25, 31.5, 40, 50, 63, 80 and all ten-fold multiples thereof.

The time constant can be calculated using the X/R ratio as shown in Equation 1

$$\tau = \frac{1}{2\pi f} \left(\frac{X}{R} \right)$$

Equation 1: Time Constant

The Australian standard for High-voltage switchgear and control gear – part 1 common specifications (AS 62271-1) states that a time constant of 45ms covers the majority of cases and corresponds to a peak withstand current of 2.5 times the rated short-time current. With a 25kA short time withstand current the peak withstand current shall be 62.5kA.

The Australian standard for High-voltage switchgear and control gear – part 1 common specifications (AS 62271-1) further states that for a time constant up to 120ms a peak withstand current should be 2.7 times the rated short-time current. Using a factor of 2.7 and backward calculating from a peak

withstand current of 62.5kA the maximum allowable fault current is 23.1kA where the time constant is between 45-120ms.

6.2.2 Operating Sequence

The rated operating sequence of the circuit breaker shall be sequence “O – t – CO – t' – CO” as per (AS 62271.100, 2019).

The preferred operating sequence times are:

t= 0.3 seconds and t'= 15 seconds for substation applications which are intended for rapid auto reclosing, or

t = 3 minutes and t' = 3 minutes for other applications which are not intended for rapid auto reclosing.

Where switchgear has multiple use cases the switchgear shall be rated for auto reclose as defined at the start of this section.

6.2.3 Electrical Endurance

Circuit breakers rated \leq 52kV have an electrical endurance rating. These circuit breakers shall be rated to E2.

6.2.4 Mechanical Endurance

Circuit breakers used to switch reactive plant used for network support, capacitor banks, reactors, Statcom and SVCs shall be M2 class.

Circuit breakers not used to switch reactive plant should be rated to M1 class or higher.

6.2.5 Network Classification

As a minimum, circuit breakers shall meet the values of Table 24 or Table 25 of AS 62271.100 with respect to the transient recovery voltage and network classification of the circuit breaker. A first pole to clear factor (kpp) of 1.5 shall be used at 132kV and below and 1.3 at 245kV.

Class S1 can be used for circuit breakers supplying primarily underground networks. Class S2 should be used for primarily overhead networks. Indoor metal-enclosed switchgear rated at S1 can be used in primarily overhead networks where S2 is not available.

6.2.6 Charging Currents

The rated cable and line charging breaking currents of the CB shall meet or exceed.

Table 3: Charging currents

Voltage (kV)	Line (A)	Cable (A)
12	10	25
24	10	31.5
36	10	50
72.5	10	125
145	50	160
245	125	250

6.2.7 Requirements for Simultaneity of Poles

The maximum difference between contacts touching or separating during three pole operations shall be as per Table 4.

Table 4: Simultaneity of poles

Operation	Single Interrupter	Multiple Interrupters in series
Closing	<1/4 of a cycle	<1/6 of a cycle
Open	<1/6 of a cycle	<1/8 of a cycle

6.3 Disconnecter and Earth Switch Requirements

6.3.1 Disconnecter Mechanical Endurance

The disconnecter mechanical endurance has been selected as M1 (2 000 operations). This is to align with the M1 circuit breaker endurance. There is no need to maintain M2 on reactive plant disconnectors that require M2 circuit breakers.

6.3.2 Earth Switch Electrical Endurance

To reduce the impact of switching errors earth switches should be rated for fault make (electrical endurance E1 or higher) where practical. There are 3 classes of electrical endurance, E0: no fault making capacity, E1: 2 fault making operations and E2: 5 fault making operations.

For outdoor, air insulated earth switches, it is not practical to achieve a rating greater than E0. This is acceptable due to switching practices to prove de-energised prior to applying earths.

A typical GIS bay has 3 earth switches, bus side CB earth switch, line side CB earth switch and line earth switch. The line earth switch shall have fault making capability (E1 or greater) due to the limited ability to test and prove de-energised. While it is possible for the remaining earth switches to be fault making rated this would significantly increase the cost and size of the switchgear. Earth switches within GIS shall be interlocked as per STWN3046 Standard for Interlocking to reduce the chance of incorrect application of an earth onto energised plant as low as reasonably possible. Where this has been completed, E0 earth switches are acceptable for bay and bus earthing of GIS.

6.4 Metal Enclosed Switchgear

6.4.1 Internal Arc Classification

All MV switchgear shall be IAC classified with the following requirements:

- Duration 1 second
- Accessibility type A and FLR (front lateral and rear) for new installations.
- Prospective fault current shall equal the rated short time current of the switchboard

Existing installations may need to be type A and front only if existing room design cannot permit lateral and rear protection provided fault pressures are directed away from normal operating positions.

6.4.2 Loss of Service Continuity Class

For primary switchgear LSC2 shall be used, LSC2B is preferred. The loss of service continuity should be applicable for IAC arc ducting.

For secondary switchgear (RMUs) should be LSC2, LSC2B is preferred. LSC1 is acceptable where it is not practical to maintain a higher rating. The loss of service continuity should be applicable for IAC arc ducting.

6.5 Insulating Oils

Insulating oils in switchgear shall not be used for new switchgear installations.

6.6 Insulation Gases

For switchgear utilising insulating gases, insulating gases used by Energy Queensland are SF₆ gas and dry air (clean air). Proprietary gases shall be avoided to avoid manufacturer dependence and obsolescence risks.

Insulating gas pressures will vary depending on aspects such as the insulating gas, application and voltage level. Refer to the manufacturers documentation for correct and minimum operating pressures.

Closed pressure systems have allowable limits for leakage rates and shall have the ability to replenish lost insulating gas.

Sealed pressure systems have sufficient gas for the life of the plant and no ability to replenish gas.

Dry air or clean air is compressed air intended to imitate natural air (approx. 80% N₂, 20% O₂) that has been purified to remove moisture, CO₂, and impurities, resulting in a gas with very low humidity and stable dielectric properties. There has been a recent global push to phase out SF₆ gas due to its environmental impacts with dry air being adopted across many medium voltage applications. Dry air is Energy Queensland's preferred alternative insulating gas to SF₆ and should be used in standard plant where practical and cost effective.

6.7 Interrupters

Modern circuit breakers used within Energy Queensland utilise either vacuum interrupters or SF₆ interrupters.

Vacuum interrupters are a sealed vacuum chamber which extinguish arcs quickly by preventing ionization of gases during contact separation. They provide high dielectric strength, minimal

maintenance, and long operating life, making them ideal for reliable circuit breakers, especially in the medium voltage range. Vacuum interrupters shall be used for switchgear at 33kV and below. Vacuum interrupters may be used at higher voltages where confirmed suitable. This is likely as insulating gases transition from SF₆ to dry air.

SF₆ interrupters use the gas SF₆ as the arc quenching medium. Energy Queensland typically utilises SF₆ interrupters in SF₆ filled switchgear at 66kV and above. The electric arc decomposes the gas producing solid and gaseous compounds such as SO₂ and HF.

7 Design and Construction

7.1 Mounting Requirements

The mounting requirements are particularly important for metal enclosed switchgear and GIS.

Indoor metal enclosed is typically mounted on Unistrut which shall be within level tolerance specified by the manufacturer. Unistrut shall be embedded into the floor for withdrawable switchgear however Unistrut can be either embedded or installed on top of floor if non-withdrawable. The Unistrut shall protrude above the floor a small amount and no floor is allowed to be above any of the Unistrut where the switchgear will be.

Where indoor metal-enclosed switchgear is installed in a building expected to undergo switchgear extensions or replacements, allowances for adjusting floor mounting locations should be as large as possible to maximise the chance of a successful replacement or extension.

GIS is typically installed directly to the floor with adjustable legs to achieve the specified level tolerance of the switchgear.

7.2 Internal Arc Venting and Pressure Relief Devices

All switchgear IAC venting or pressure relief devices shall vent and deflect emissions away from normal operating positions in the event of an internal arc fault.

For internally arc classified equipment, the preference is to duct and vent internal arc pressures externally from the building. If ducting is not available from the manufacturer or no appropriate external venting location is available, venting into a room is permitted as per manufacturer design advice. Venting into basements can be allowed where sufficient ceiling height will limit exposure to operators from downward venting. Venting into cable ducts and pits shall be avoided where possible.

7.3 HV Connections

Switchgear connections shall comply with AS 62271.301, STNW3014 Busbar Design and STNW3018 Cables and Cabling.

Where indoor metal-enclosed switchgear is installed in a building expected to undergo switchgear extensions or replacements, floor penetrations for exit cables should be as large as possible to maximise the chance of a successful replacement or extension.

7.4 Bus Tie Cable Considerations

The following must be taken into consideration with using a cable connection to extend connect two separate switchgear buses:

- Protection scheme across the cable
- Additional bus section created

- Rating of existing CB and suitability of the CTs
- Design transfer load to be allowed for in the event of a transformer outage
- Maximum cable size to connect to existing CB

7.5 MV Metal-Enclosed Switchgear Extension Considerations

7.5.1 Considerations for Staging of Metal-Enclosed Switchgear

When planning the ultimate arrangement of switchgear, the timing any possible extensions shall be considered. Typical switchgear contracts are a minimum of 5 years with possible extensions. Additional space for a joggle panel, plant manoeuvring and egress shall be included in the ultimate layout, where it is expected that the construction of the ultimate stage of the switchgear is outside the contract period or expected availability of the switchgear.

The preferred option to extend switchgear (MV switchboards and GIS) is to use the same switchgear from the original manufacturer. This however may not be possible if the equipment has been made obsolete from the manufacturer.

Where it is not possible to get the same switchgear (e.g., switchgear is no longer manufactured) a joggle panel can be used. Where a joggle panel is used additional space is required for the extension. Typical width required for joggle panels is shown in Table 5. These values are a guide only; manufacturer specific details will be required for each project.

Table 5: Typical Joggle Panel Sizes

Voltage (kV)	Typical width (mm)
11	500
22	800
33	800

Another extension option is to cable from an existing CB to a panel on the new switchgear (typically a circuit breaker panel). Circuit breaker panels are preferred as these are an EQL standard product and are rated for the cable charging currents. Note this option will create an additional bus section and will require appropriate bus protection schemes.

7.5.2 Typical Outage Requirements

Typically, an outage will be required during the design stage for the manufacturer to measure up the location of the bus bars.

Bus outages are required to install new and commission new panels.

7.5.3 Considerations with Joggle Panels

The following should be taken into consideration with using a joggle panel:

- Additional procurement and design time allowances for bespoke joggle panel purchase and design. These will be bespoke to both Energy Queensland and the manufacturer.
- A Bus outage to the existing site during design stage to confirm design requirements such as:
 - a) Busbar physical position

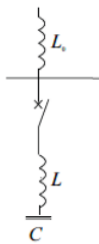
Standard for Switchgear Selection

- b) Earth bar physical position (station and frame earth if applicable)
 - c) Panel floor fixing and panel coupling points
 - d) Overall panel alignment (including arc ducting if fitted)
 - e) HV cable penetrations
 - f) Inter-panel wiring requirements
 - g) AC, DC and circuitry alignments (existing verses current contract items)
 - h) Frame and station earth insulation requirements (if frame leakage protection)
 - i) Joggle heater requirements
- At a minimum, matching existing basic plant ratings (e.g. rated voltages, rated currents)
 - At a minimum, matching existing internal arc classification ratings (via type testing as per AS 62271.200 or via extension of validity of type test as per AS 62271.1)
 - Matching gas pressures (if GIS)
 - Physical space and room egress requirements

Annex A

Informative

Capacitor Bank Switching Inrush Calculations



a) Connection of a single bank

$$i = U_r \sqrt{\frac{2}{3} \frac{C}{L_0 + L}} \approx U_r \sqrt{\frac{2}{3} \frac{C}{L_0}} \quad L_0 \gg L$$

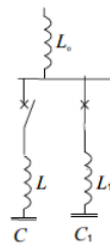
$$f_{ib} = \frac{1}{2\pi\sqrt{C(L_0 + L)}} \approx \frac{1}{2\pi\sqrt{CL_0}}$$

b) Connection when one bank is already connected

$$i = U_r \sqrt{\frac{2}{3} \frac{C_1 C}{(C_1 + C)} \times \frac{1}{(L_1 + L)}}$$

$$f_{ib} = \frac{1}{2\pi\sqrt{\frac{C_1 C}{(C_1 + C)} (L_1 + L)}}$$

$$S = \frac{U_r}{L_1 + L} \sqrt{\frac{2}{3}}$$



When $L_1 = L$ and $C_1 = C$ then:

$$i = U_r \sqrt{\frac{C}{6L}} \quad \text{and} \quad f_{ib} = \frac{1}{2\pi\sqrt{LC}}$$

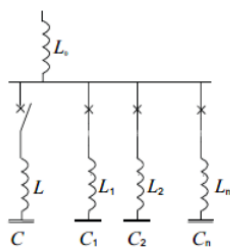
c) Connection when n banks are already connected

$$L' = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_n}} \quad \text{et} \quad C' = C_1 + C_2 + \dots + C_n$$

If $L_1 = L_2 = \dots = L_n = L$ and $C_1 = C_2 = \dots = C_n = C$, then

$$L' = \frac{L}{n} \quad \text{and} \quad C' = nC$$

$$i = U_r \frac{n}{n+1} \sqrt{\frac{2C}{3L}} \quad \text{and} \quad f_{ib} = \frac{1}{2\pi\sqrt{LC}}$$



L' and C' substitute L_1 and C_1 in figure H.3 b).

The calculation is correct if $L_1 \times C_1 = L_2 \times C_2 = \dots = L_n \times C_n$; in other cases it is an approximation.

Components

U_r	rated voltage	L	inductance in series with switched capacitor bank
i	inrush current peak	C	capacitance of switched capacitor bank (equivalent star value)
f_{ib}	inrush current frequency	$L_1, L_2 \dots L_n$	inductances in series with capacitor banks on source side
S	inrush current rate-of-rise	$C_1, C_2 \dots C_n$	bank capacitances (equivalent star values) on source side
L_0	source inductance		

Figure H.3 – Equations for the calculation of capacitor bank inrush currents

Equation 2: Equations for the Calculation of Capacitor Bank Inrush Currents

Annex A

Revision History

Revision date	Version number	Author	Description of change/revision
6/6/2023	1	A.Gabriel	Initial issue
20/05/2026	2 & 3	M Ridgley, J Lopez-Roldan, C Cuddihy	General revision.