



Pumped Storage Power Plants Solution

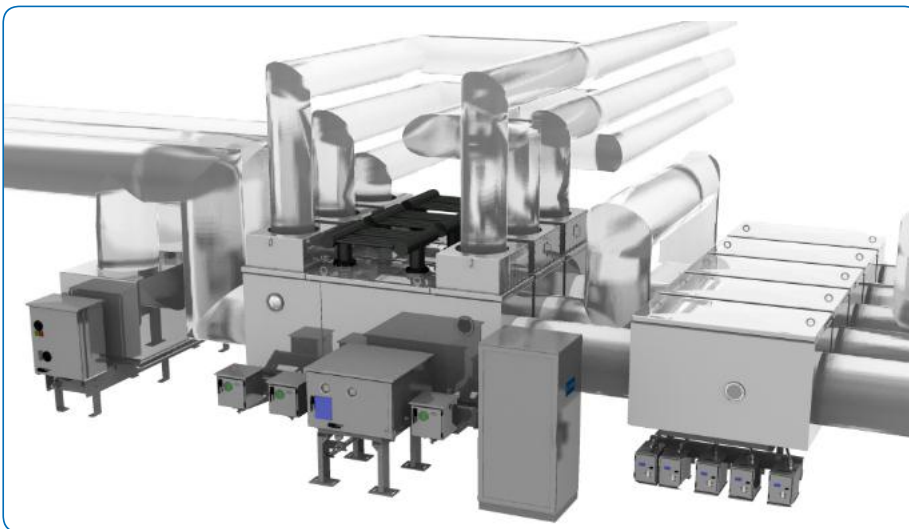
Flexibility for Grid Operators

Pumped storage power plants are the largest and most cost-effective means of storing energy for electricity grids. It is also an economically and environmentally efficient way of stabilizing supply on a minute-to-minute basis. When demand is low, a pumped storage power plant (PSP) uses off-peak electricity to pump water from a lower reservoir to a higher reservoir. Then, when demand is high, the water is released and flows down to the lower reservoir through turbines that, within seconds, generate electricity and feed it into the network.

Modular Arrangement of Switching Devices including GCB

GE offers an integrated solution for PSP protection schemes **based on FKG type** including generator circuit breaker, phase reverse disconnecter, braking switch, starting and back-to-back switches. GE's circuit breakers are equipped with full spring-operated mechanisms offering the highest reliability in the world (according to CIGRE inquiry A3.06 - 2012). They are also designed and suitable for pumped storage applications, ensuring a high number of operations requested each day with reduced maintenance cost.

Consistency and operational compatibility is ensured by the complete provision of the PSP unit, including a centralized control cabinet as well as electrical and mechanical interlocking devices to ensure the safety of the personnel and the equipment. The circuit breaker is warranted for 20,000 operations (CO), according to customer requirements.



Applications

- Hydro power plants up to 600 MW
- Special solution for pumped storage power plants including:
 - GCB module with switches for Static Frequency Converter (SFC) and back-to-back connection
 - 5-phase disconnecter and phase reversal module
 - Electrical braking switch
- Altitude up to 3 000 m above sea level

Key Benefits

- Flexible solution with all equipment from unique manufacturer ensuring operational compatibility and reliability
- Modular arrangement allows improved adaptability to project specific requirements and layout
- Generator circuit breaker and braking switch with utmost reliable full spring mechanism
- Recommended monitoring system CBWatch3 for preventive maintenance
- Interlocking system ensures high level of safety
- Dedicated Service team for customer support
- Dedicated training at factory and site

Braking Switch (BS)

The braking switch is designed to perform an electromagnetic braking of the generator by short-circuiting the 3 phases thanks to its **high making capability**, allowing to reduce the time of shutdown before being able to reverse the operation cycle.

Starting Disconnecter Switch (SDS) on Generator Side and Back-to-Back Switch on Transformer Side

Starting disconnecter and back to back switches are located on the generator and transformer sides of the GCB. These switches ensure starting in pumping mode instead of production mode and vice-versa, as required. SDS alone or combined SDS with back to back solution are available according to the power plant layout. The SDS and BtB switches are designed to withstand the **most severe short time currents** incurred in PSPP applications.

Generator Circuit Breaker (GCB)

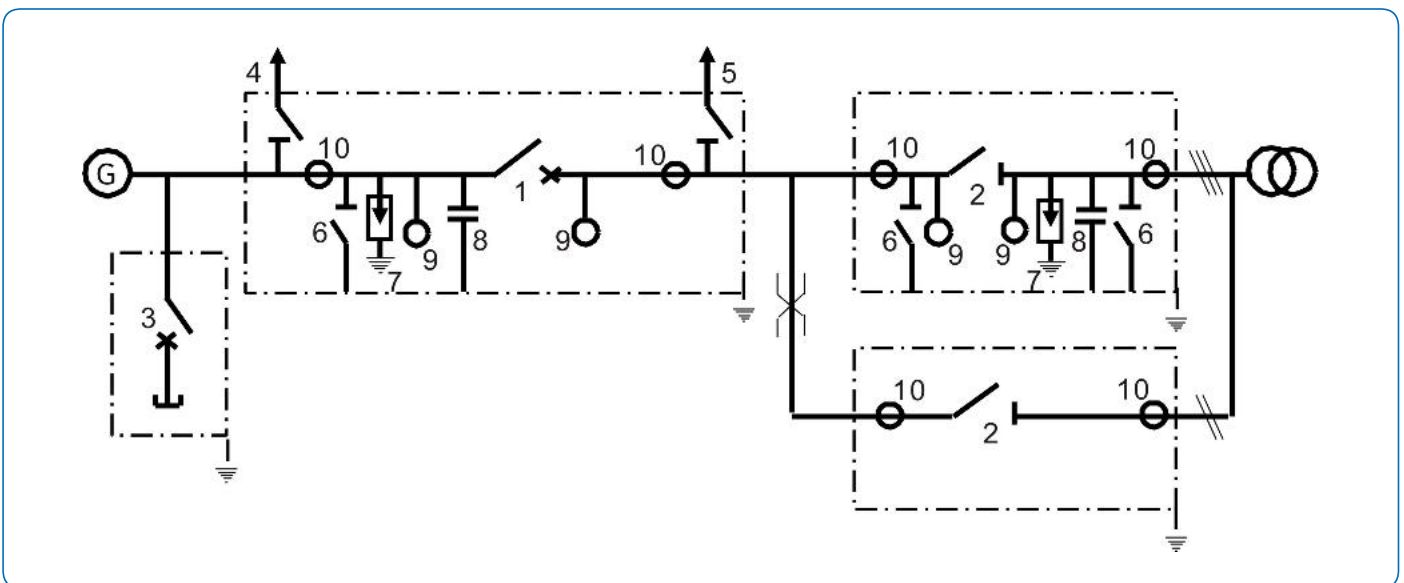
The use of a GCB increases the overall availability of the power plant. It also ensures safe, reliable, economical operation and protection of the power plant. The GCB is the key element for pumped storage power plants, allowing switch off before mode reversing by the disconnectors (from production to pumping or reverse). The main function of a GCB is certainly the **protection of the generator and step-up transformer** in case of a short circuit.

Phase Reverse Disconnecter Switch (PRDS)

The phase reversal disconnecting switch serves the purpose of electrical inversion of two phases in a pumped storage power plant after it has been disconnected from the system. Electrical inversion of two phases is mandatory as it allows to reverse the direction of rotation of the generator and so the turbine. It consequently enables the turbine to work either on pumping or generating mode. The PRDS also provides isolating distance of active parts to **ensure safety and electrical insulation** when in open position.

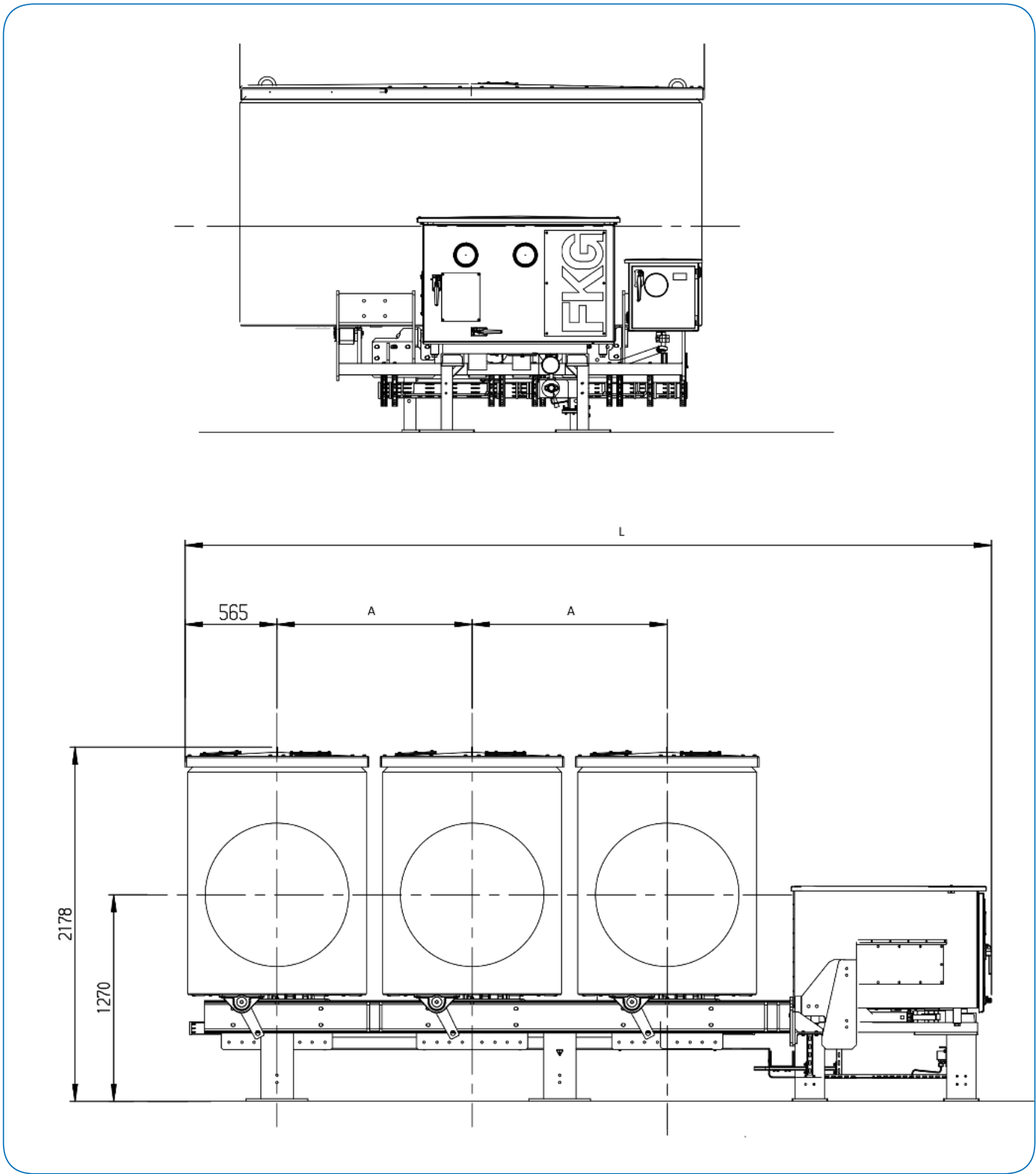
Single-Line-Diagram and Components (example below*)

- | | |
|---------------------------------|--------------------------|
| 1. Circuit breaker | 6. Earthing switch |
| 2. Disconnecter | 7. Surge arrester |
| 3. Braking switch | 8. Capacitor |
| 4. Starting disconnecter switch | 9. Voltage transformers |
| 5. Back-to-back switch | 10. Current transformers |



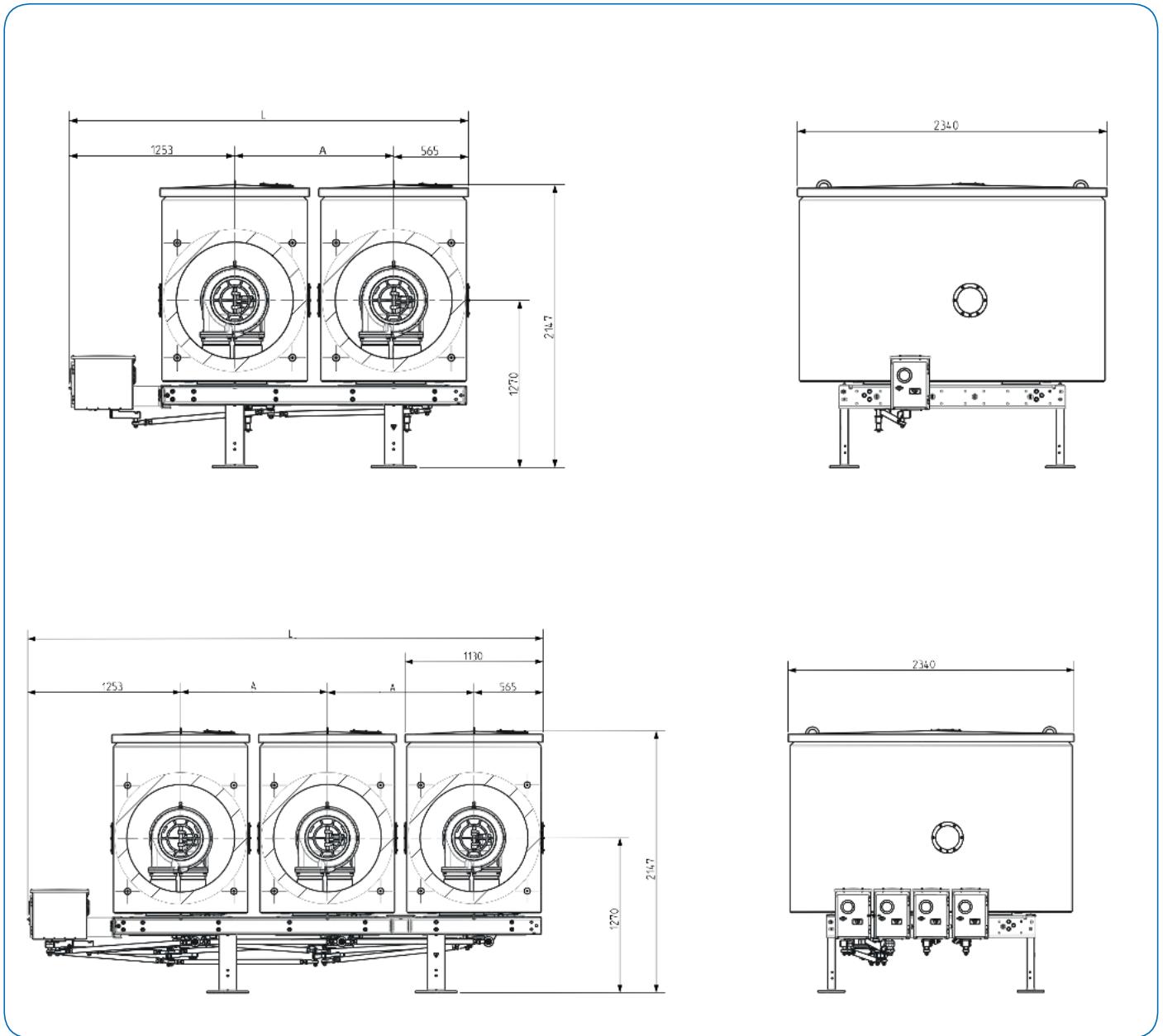
* Other arrangements are possible.

Generator Circuit Breaker



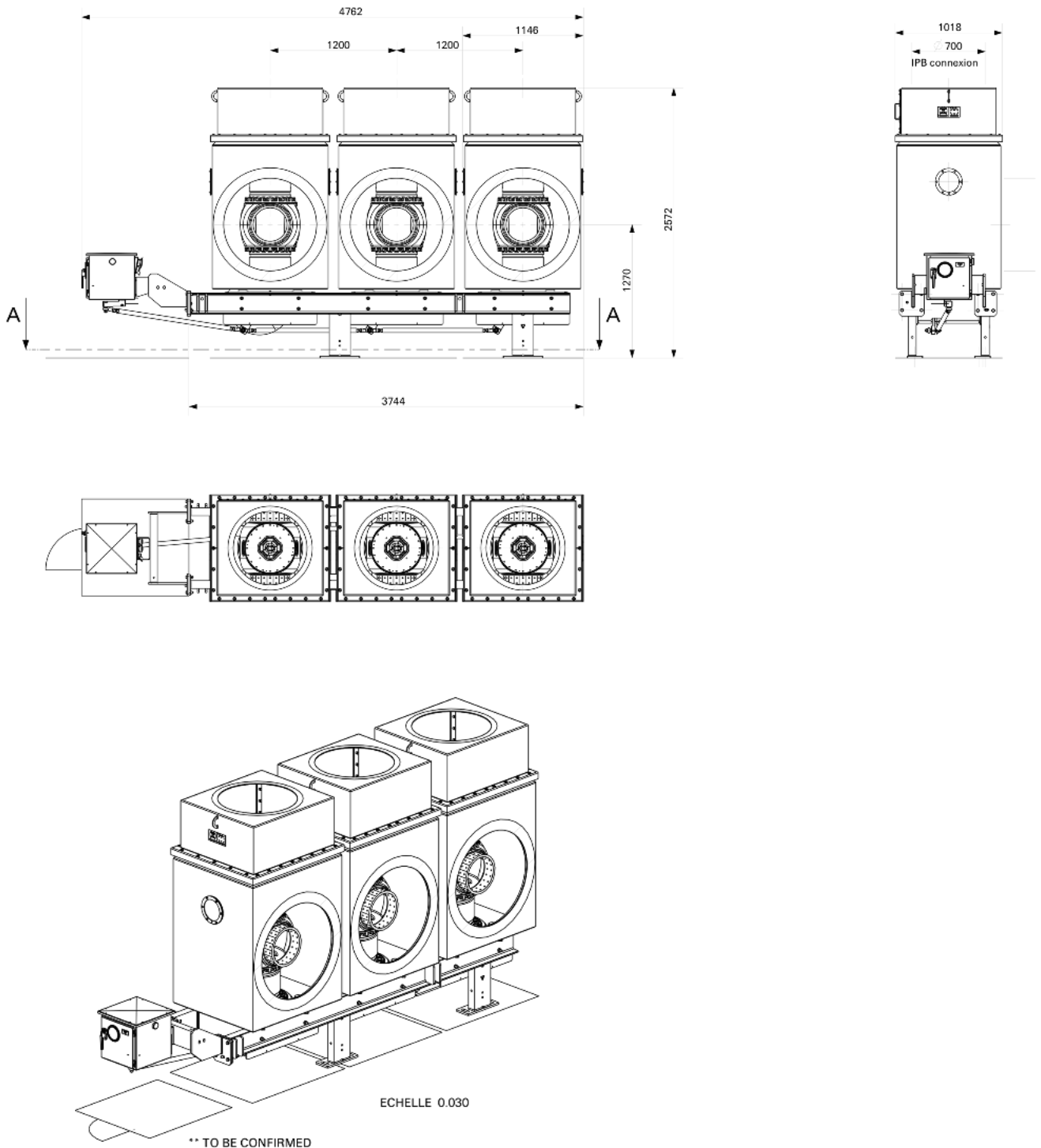
A = Phase Spacing Distance.
 Additional data on request (i.e. FKG2(S/M), FKG1(F/X) GCB type).

Phase Reverse Disconnecter Switch (Type 3+2 phases)



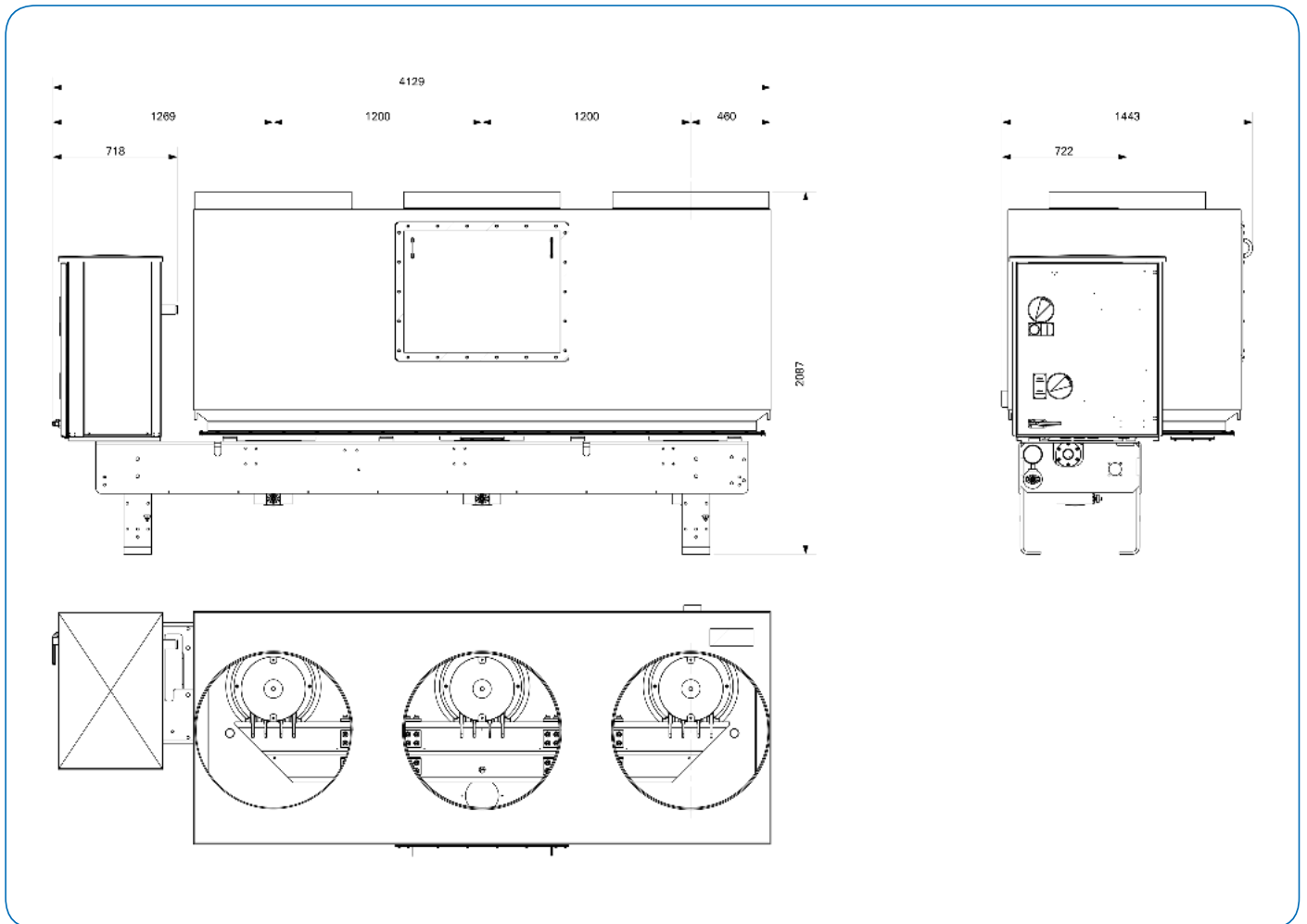
A = Phase Spacing Distance.
 Additional data on request.

Starting Disconnecter Switch (SDS) / Back-to-Back (BtB) Switch



A = Phase Spacing Distance.
Additional data on request.

Braking Switch (BS)



*A = Phase Spacing Distance.
Additional data on request.*

Technical Specifications

Modular Layout and Switching Devices	Unit	FKG2	FKG1
General			
Rated voltage	kV	27	27
Rated normal current (natural cooling) at 40°C	A	up to 8,400	up to 19,000
Frequency	Hz	50 / 60	50 / 60
Ambiant air temperature limit	°C	-25°C to +40 °C	-25°C to +40 °C
IPB temperature limit (Busbar / Enclosure)	°C	90/70 °C or 105/80 °C	90/70 °C or 105/80 °C
Protection degrees (enclosure / cubicles)		IP65 / IP55	IP65 / IP55
Phase spacing (X)	mm	1000 to 1200	1200 to 1500
Generator Circuit Breaker			
Rated short-time withstand current	kA	up to 80	up to 160
Rated peak withstand current	kA _{peak}	up to 220	up to 450
Rated duration of short-circuit	s	3	3
Rated system-source short-circuit breaking current	kA	up to 80	up to 160
Rated generator-source short-circuit breaking current	kA	up to 80	up to 160
Rated peak short-circuit making current	kA _{peak}	up to 220	up to 440
Rated short-circuit operating sequence		CO-30min-CO	CO-30min-CO
Rated opening-time	ms	35 +/-4	48 +/-2
Rated closing time	ms	115	100
Rated Power frequency withstand voltage (at sea level)			
- to earth	kV	60	60 (up to 84)
- across terminals (open contacts)	kV	60	60 (up to 80)
Rated lightning impulse withstand voltage (at sea level)			
- to earth	kV _{peak}	125	125 (up to 160)
- across terminals (open contacts)	kV _{peak}	125	125 (up to 150)
Phase Reverse Disconnecter Switch (PRDS)			
Rated short-time withstand current	kA	up to 100	up to 160
Rated peak withstand current	kA _{peak}	up to 330	up to 450
Rated duration of short-circuit	s	3	3
Rated Power frequency withstand voltage (at sea level)			
- to earth	kV	60 (up to 84)	60 (up to 84)
- across terminals (open contacts)	kV	60 (up to 101)	60 (up to 101)
Rated lightning impulse withstand voltage (at sea level)			
- to earth	kV _{peak}	125 (up to 160)	125 (up to 160)
- across terminals (open contacts)	kV _{peak}	145 (up to 186)	145 (up to 186)
Operating time (opening and closing)	s	3	3
Starting Disconnecter Switch and Back-to-Back Switch			
Rated short-time withstand current	kA	up to 160	up to 160
Rated peak withstand current	kA _{peak}	up to 440	up to 440
Rated duration of short-circuit	s	3	3
SDS / BtB Rated normal current (starting IPB) at 40°C	A	Up to 4,000	Up to 4,000
Rated Power frequency withstand voltage (at sea level)			
- to earth	kV	60	60 (up to 84)
- across terminals (open contacts)	kV _{peak}	60	60 (up to 96)
Rated lightning impulse withstand voltage (at sea level)			
- to earth	kV	125	125 (up to 160)
- across terminals (open contacts)	kV _{peak}	145	145 (up to 176)
Operating time (opening and closing)	s	3	3

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Technical Specifications

Braking Switch

Rated short-time withstand current	kA	up to 80	up to 160
Rated peak withstand current	kA _{peak}	up to 230	up to 450
Rated duration of short-circuit	s	3	3
Temporary over-current (during braking cycle)	A	up to 20,000 / 10 min	up to 32,000 / 10 min
Rated peak short-circuit making current	kA _{peak}	up to 220	up to 440
Rated Power frequency withstand voltage (at sea level)			
- BS closed : between HV terminals to earth	kV	60	60 (up to 84)
- BS open : between HV terminals to earth	kV	60 (up to 80)	60 (up to 80)
Rated lightning impulse withstand voltage (at sea level)			
- BS closed : between HV terminals to earth	kV _{peak}	125	125 (up to 160)
- BS open : between HV terminals to earth	kV _{peak}	125 (up to 150)	125 (up to 150)
Opening time (opening and closing)	ms	35 +/- 4	48 +/- 2
Rated closing time	ms	115	100

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