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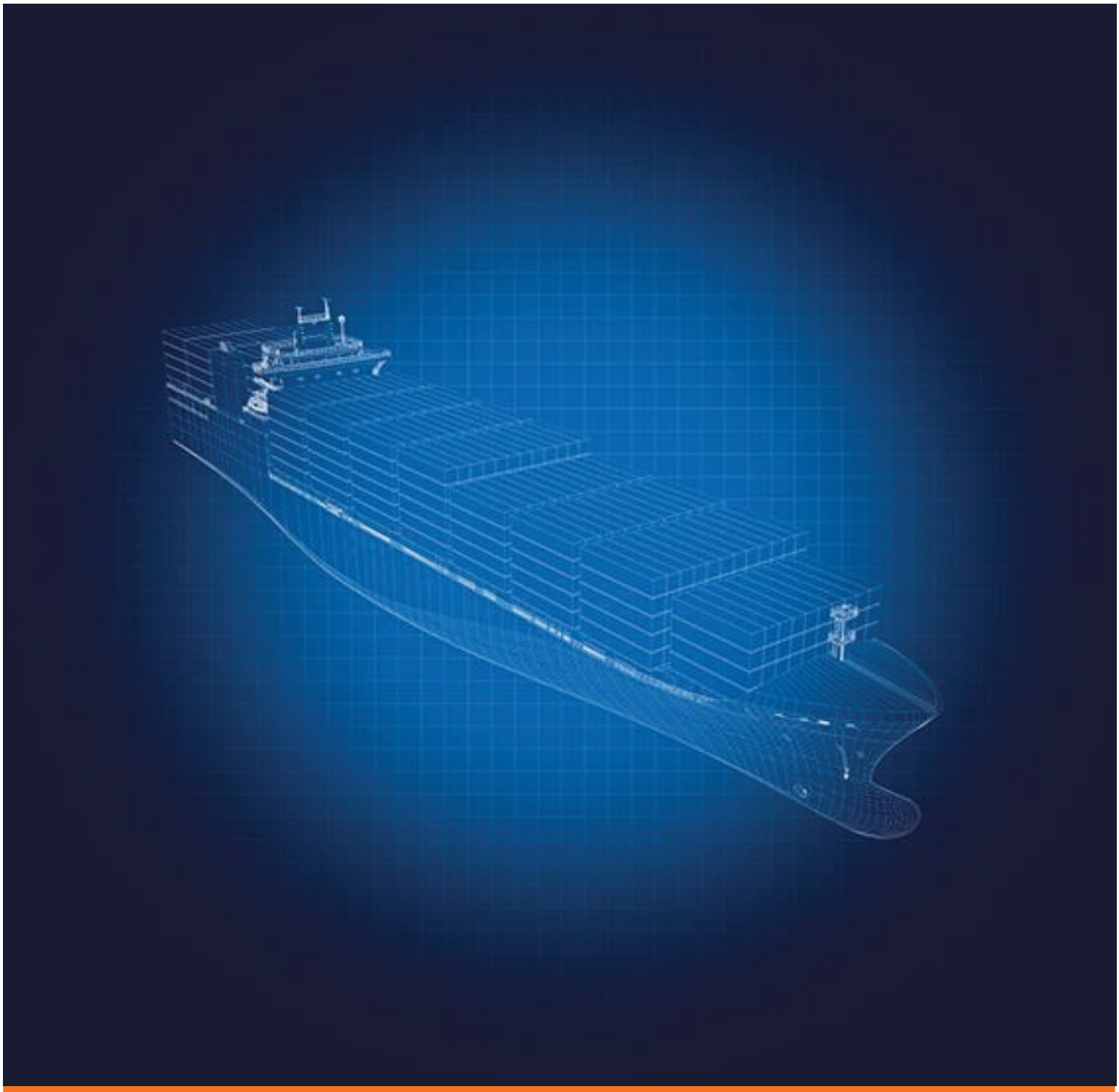

TECHNICAL SPECIFICATION

METRO Project

Ferry – for reference only

2021

WÄRTSILÄ

TECHNICAL SPECIFICATION

Content

1 ELECTRICAL AND AUTOMATION SYSTEMS

1.1 Automation systems

The Wärtsilä Integrated Automation System (WIAS) is based on standard components, with PLC process stations and PC operator stations. All process stations are connected by an Ethernet ring network, ensuring redundant communication. Process control is distributed in PLCs located in local field termination cabinets (FTC), close to equipment to monitor and control. PLCs contain software for control and safety functions, while PCs contain the graphical user interface and storage of historical alarm and trend data. Redundant PC servers ensure that no single PC failure will result in loss of monitoring and control of the system. Advanced network switches with diagnostic data and protection functions are used for the process network.

The basic elements in the philosophy for automation system are economy, availability, safety, interface and operation. In this way, the automation system is adapted to keep maximum information level with a minimum of personnel onboard. High availability of the equipment results in both good economy and high safety. This is the ongoing thought by modulation and segregation of the Vessel Automation System's operation units (PLC's) and network solutions. Standardisation has been a general philosophy in terms of network solutions, serial communication and hardware connections to I/O.

Process pictures are developed in tight cooperation with customer.

General features of WIAS includes:

Operator Stations; All operator stations in ECR and bridge will have full access to all operations. However, it is also possible to add operator stations with limited access in for instance the chief engineer's office or other locations.

Alarm System; The alarm system contains all features needed for a main alarm system. Alarms can be divided into 16 alarm groups. The system contains alarm pages for presentation of active alarms and for presentation of historical alarms. Alarm pages have advanced filter functionality. From alarm pages it is possible to navigate directly to process pictures that contain the component that generates the alarm. For alarms related to field signals, termination information from I/O-list can be displayed. The alarm system will interface to audible and visual alarm columns in engine rooms.

Trend System; Analog values will be logged as time series. Sample rate will depend on the characteristics of the value to sample. Fast fluctuating values can e.g. Be sampled every 1 – 5 s. Historical data for alarms and trends are stored for at least 12 months.

Trend and Alarm analysis; The system contains an advanced system for viewing trends in real time and for analysing historical data. User pages can be configured freely with combination of trend values and alarms in the same picture. Configurations can be saved for later use. It is possible to navigate directly from process pictures to a trend picture and view the trend for the selected process value.

Command control system; The command control system ensures that operation of equipment and acknowledge of alarms within defined process areas only is possible from one operator location at a time. Normally 16 groups/areas are used, but up to 26 is possible. The command control system contains functionality and operator dialogs like "Ask", "Send" and "Take", to transfer control between the different operator locations in a safe and unambiguous way.

Security; Operation of the system is password protected. Normally an “Operator” user will be defined with ordinary access to operation of systems and equipment. In addition an “Administrator” user will be defined for more advanced system maintenance, modification of settings etc. More users and security levels can be agreed upon.

Watch Call system; A separate page for Watch call system contains overview and configuration of the Watch Call system. This page shows status of the system, who is on duty, and it is possible to adjust timers, call the different person (both on and off duty) etc.

System Overview; This is a separate page displaying the hardware components of Wärtsilä IAS and PMS systems. This page display status of individual components, including status of process network and will be helpful in case of faultfinding.

Self-diagostics; IAS and PMS contain a lot of self-diagnostic functions for monitoring of pcs, process network and controllers and the different components of these. When faults occur, alarms are activated and the System Overview page will normally display more detailed information about the fault.

Hour counter page(s); Overview of all electrical motors and pumps, displaying running hours. Information from this page(s) can be transferred to external maintenance system.

Integration of I/O-list; The as-built I/O-list will be integrated with IAS. It will be used when the operator requests termination information from the alarm page. From a separate I/O-list page it is also possible to view and search/filter the contents of the I/O-list.

Integration of P&ids: For process pictures where P&ID drawings are available in Autocad or Pdf file formats, the drawings can be integrated in the IAS process picture. By selecting “P&ID” button, a pop up window will show the drawing.

Cargo charge/discharge reports; When control of cargo tanks is included, separate cargo reports are generated as one or more graphical pages per cargo type. Reports can be generated during charge/discharge of cargo. Reports can also be printed.

Communication interfaces; Industry standard communication protocols like Modbus/RTU, Modbus/TCP, NMEA, canopen, OPC and more are supported by WIAS, ensuring easy integration with external systems.

IAS functionality

The IAS contains alarm, monitoring and control functionality for:

- Engines and propulsion
- Ship systems:
  - Ballast
  - Fuel oil handling
  - Bilge
  - Cooling
  - Ventilation

Communication interfaces

The following communication interfaces are included:

- Fire alarm system
- GPS
- VDR
- Conning
- Maintenance system
- Hydraulic Power Unit (HPU)
- Interface to external load calculator
- Interface to external tank sounding

Operation and HMI

The following operator stations are included:

Operator stations on bridge **2**
Pointing device.....Trackball
Keyboard.....Compact
Display .....26 inch

Printer on bridge **1**
Operator stations in engine control room **2**
Pointing device.....Trackball
Keyboard.....Compact
Display .....26 inch

Printer on ECR **1**

Signals

Signals for Wärtsilä equipment and other ship systems, defined before design freeze, is based on a calculation of 3090 I/O (1490 hardwired and 1600 serial).

Rates for additional signals and changes after design freeze is defined in commercial offer.

Field Termination Cabinets (FTC)

The system includes:
Cabinets..... 5
Dimension(HxWxD).....1800 x 800 x 400 mm
Weight (approximately) ..... 110 kg
Ingress Protection IP55
Colour ..... RAL 7035

Each FTC contains one controller (PLC) with hardwired I/O signals and optional communication interfaces. Each PLC is capable of handling approximately 650 signals in total. Approximately 250 hardwired signals can be connected to each FTC/PLC, depending on I/O-type. Each PLC has one CanOpen interface. Up to 4 Modbus/RTU communication links can optional be added (not included). I/O-signals and communication links must therefore be distributed on the different FTCs accordingly.

Remote diagnosis system

Equipment enabling remote diagnosis through an existing communication link to shore is included. Wärtsilä can then connect to IAS onboard the ship. This depends on the quality of the communication link between the ship and shore. In this way Wärtsilä can access both HMI system and PLC, and have the same view as the operator. The debug views that show the programming sequences in the PLCs can also be accessed.

This makes it possible to assist the crew in fault finding and corrections. Possible rectification will normally not be performed from land (even though this is possible), but the crew can be guided to perform these. The following table gives an overview of the operations and information accessible from the remote system, provided that equipment is delivered by Wärtsilä:

Wärtsilä equipment	Monitor	Configure
Operator stations (HMI)	x	x
Panels for Extension Alarm System (EAS)		x
Network switches, process network	x	x
IAS controllers (PLCs)	x	x

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PMS controllers (PLCs)	x	x
Propulsion Control System	x	
Power Distribution / Switchboards	x	x
Power drives for propulsion	x	x
Generators	x	
Diesel Engines	x	

The “Remote diagnosis” system will be delivered as a part of the scope for commissioning and guarantee. After the guarantee period, the ship owner can continue with this service as a service agreement.

Extension alarm system (EAS)

An extension alarm system with panels for installation in officer’s cabins and public areas is included.
Panels on bridge 2
Panels in other locations 2

The panels are colour displays with display size of 7 inches. All displays have touch screen. The main page of EAS displays shows the EAS alarm groups with alarm status of each group. For each group it is possible to view the latest unacknowledged alarm with text description. Each panel is mounted in a box with a buzzer.

Deadman alarm system

A deadman alarm system consisting of:
Reset panels 2

1.1.2 Power Management System (PMS) 1

Power Management System (PMS) is a group function and comprises control and surveillance of electric power production and consumption. The system controls and monitors the generators, switchboards and consumers.

Following functions are included:
Supervision
Manual operation of breakers
Load dependent start
Load dependent stop
Automatic changeover
Monitoring of critical parameters
Load Control of “dynamic” consumers to prevent overload on generators. Power available to thrusters and main propulsion converters
Blackout prevention

Energy Management System (EMS) is a group function as part of the PMS including the hybrid control.

Wärtsilä EMS is based on intelligent control principles to monitor and control the overall efficiency and availability of the power on-board.

The main functions for the EMS are to control and monitor all basic control of the DC-bus, generator and thrusters, including:

- Battery charging and state of charge control
- All mode control
- DC link control for the inverter system
- Charging control
- Measuring and energy management control

Number of control cabinets in switchboard room 2
Dimension (H x W x D)..... 1800 x 800 x 300 mm
Ingress Protection IP44
Colour ..... RAL 5017 or RAL 7035

1.2 Marine Switchboards

All switchboards are based on Marine switchboard system.

This is a metal enclosed system which is type tested up to 690V, 1600A and 80kA short circuit current (RMS), 176kA (peak). According to IEC 60439-1.

All circuit breakers (CB) are of Schneider (Merlin Gerin) make.

CB > 630A are withdrawable air circuit breakers (ACB) which can be motor operated, and CB < 630A are fix mounted and manually operated MCCB.

Busbars are made of electrolytic copper.

The protection degree of the switchboards is IP 22.

Analyses included:

- Short circuit analysis both according to IEC 61363 and IEC 60909
- Selectivity study (Discrimination study) including setting table
- Harmonic analysis

1.2.1 Marine Switchboard 1

400 V Main -- 4M deep

Nominal voltage: ..... 400V AC
Nominal frequency: ..... 50 Hz
Normal current of busbar: ..... 1600 A
Rated short circuit level (RMS): ..... 65 kA
Preliminary dimensions (LxDxH): ..... 6960x 816 x 2216 mm
Estimated weight: ..... 4500 kg
Estimated heat dissipation: ..... 4542 W

All cables are expected to come from below with termination from the rear of the switchboards.
Hence the switchboards must have at least 60 cm free space at the back.

This switchboard is due to the high short circuit level equipped with Arc protection for fast isolation in case of fault.

The switchboard consists of the following:

Generator CB - 2000A (NW20) W16V14 2
Bus link CB – 2000A (NW20) 2
Feeder CB – 800A (NW08) Thrusters 4
Feeder CB – 1600A (NW16) Battery 1
Shore connection CB – 1500kW 1
Feeder CB – 100A (NS100) 40
Feeder CB – 630A (NS400) Transformer 6

1.3 Generators

Synchronous marine generators self-excited, self-regulated, self-ventilated, three phase, constant voltage, salient poles rotor, brushless, built in accordance with IEC 34 standard.

Technical data:

Power output	1055.00 kW / 1250 kVA
Power factor	0.80
Nominal voltage	400 V
Frequency	50 Hz
Speed	1800 rpm
Protection	IP44
Mounting	IM1001
Cooling method	IC8A1W7
Bearings	Sleeve bearings
Insulation class / temp. rise	F / F
Ambient temperature	≤ 50 °C
Cooling water temperature	≤ 38 °C
Pressure drop	0.5 Bars
Colour	RAL 5019 Capri Blue

Construction

The frame and the end shields are of welded or cast construction, treated with primer for protection against corrosion. The outer surfaces are treated at the factory with paint finish. The rotors are designed to withstand the vibration caused by the prime mover and the stresses appearing at 120% rated speed.

Water cooling

The generator is cooled with a shaft mounted fan. The cooling air is circulated inside the generator through a double tube air-to-water heat exchanger.

Sleeve bearings

Sleeve bearings are of split type. They are spherically seated to facilitate easy assembly and maintenance.

Brushless excitation

The excitation system comprises an electronic voltage regulator, an exciter and a rotating diode bridge. The voltage regulator controls the generator output voltage, supplying the excitation current to the exciter. The exciter and the diode bridge operate as an amplifier and supply the excitation current to the generator main poles.

Overcurrent capability

The stator winding withstands a current, which can be over 3 times the rated current for at least 2 seconds.

Accessories:

- Anti-condensation heater 230 VAC
- 6 pieces of Pt-100 in stator windings, (3 in use and 3 as spare)
- One Pt-100 in each bearing
- Air/water heat exchanger (Double pipe type, material: Cu-Ni/90-10)
- Pt-100 in cooling air circuit
- Leakage detector
- MCT frames for cables

1.4 Motors

Azimuth thruster motors, built in accordance with IEC 34 standard.

Technical data:

Starting method	Frequency converter
Output power	370 kW
Nominal speed	+/- 1000 rpm
Direction of rotation	Bidirectional
Voltage	400 V
Frequency	50.00 Hz
Motor type	IN-SC
Mounting arrangement	IM1101
Insulation class / temp. rise	F / F
Degree of protection	IP54
Degree of protection terminal box	IP54
Method of cooling	IC8A1W7
Bearings	Antifriction
Ambient temperature	≤ 45 °C
Cooling water temperature	≤ 38 °C
Power factor	0.89
Pressure drop	0.500 Bars
Colour	RAL 5005 Blue

Water cooling

The motor is cooled with a shaft mounted fan. The cooling air is circulated inside the motor through a double tube air-to-water heat exchanger.

Antifriction bearings

Antifriction bearings are standard grease lubricated bearings.

Motor have the following accessories:

- Heating elements 230V
- 6 x Pt100 in windings
- 1 x PT100 per bearing
- 2 x Pt100 in cooling air
- Air/water heat exchanger (Double pipe type, material: Cu-Ni/90-10)
- Water leakage contact

1.5 Power drives

The Wärtsilä frequency converter is a constant voltage source, direct freshwater cooled transistor based converter. The voltage produced for the electric motor is Pulse Width Modulated (PWM), with an open loop vector control strategy. Closed loop can be delivered as an option. This ensures an accurate rpm control, and a minimum need for instrumentation. The AC/DC conversion is performed via diode bridges/active rectifier, which allows for four quadrant operation of the thruster motors.

The electric motors must be constructed with special emphasis on the fact that they are fed by PWM converters.

The possible control strategies to be applied are: Torque control, speed control and power control. The internal control system of the frequency converter interfaces the main switchboard and the thruster control system, thus rapid load reduction can be executed if a generator fails (black out prevention).

The Frequency converters are directly connected to the 400V power generation and distribution system. The active rectifier reduces the harmonic voltages (THD) on the main switchboard according to class required level without any need for further filters or transformers. It can in some cases also improve the total THD on the main switchboard.

Frequency Converters for Induction/squirrel cage rotor motors are:
The Azimuth thruster drives includes 370 kW / 400 V IGBT-based frequency converters.

Technical Data:

Pulses no of supply rectifier: ..... NA
Rated output power: ..... 370 kW
Maximum rated output current: 670A
Supply voltage (+/-10 %): ..... 400 V
Supply frequency (+/-5 %): ..... 50 Hz
Efficiency at rated power: ..... 97.50 %
Output voltage: ..... 0 – 400 V
Cooling medium: ..... Fresh water with corrosion inhibitors
Cooling method: ..... Directly to vessel fresh water system
Ambient temperature: ..... ≤ 45° C
Water inlet temperature: ..... 22° C ≤ T ≤ 38° C
Protected by enclosure: ..... IP 44
Standards: ..... IEC 61800-2-3, IEC 60721-3-3, M1, IEC 60146-1-1, IEC 60092
Cooling water flow (at max 4 bar): ..... 175.00 l/min
Losses to water (at 100 % load): ..... 35.60 kW
Losses to air (at 100 % load): ..... < 1.90 kW
Dimension (H x W x D) mm: 2231x1500x1000
Encoder: ..... With

1.6 Transformers

Power distribution Transformer

Technical data:

Rating ..... 99 kVA
Primary voltage level ..... 400 V
Secondary voltage level ..... 230 V
Frequency ..... 50 Hz
Type ..... Dry type
Insulation class / temp. rise (in sinus) ..... F / F
Enclosure ..... IP 23
Efficiency ..... 95.00 %
Windings ..... Al / Al
Max ambient temperature ..... 45 ºC
Cooling ..... AN
Losses to air at 100% load ..... 5 kW
Colour ..... RAL 7032 Grey

Transformers have the following Accessories:
- Tapping ± 2x2.5%

Anti condensation heater:
Voltage ..... 230 V

Technical data:

Rating	1500 kVA
Primary voltage level	400 V
Secondary voltage level	600 V
Frequency	50 Hz
Type	Dry type
Insulation class / temp. rise (in sinus)	F / F
Enclosure	IP 23
Efficiency	95.00 %
Windings	Al / Al
Max ambient temperature	45 ºC
Cooling	AN
Losses to air at 100% load	75 kW
Colour	RAL 7032 Grey

Transformers have the following Accessories:
- Tapping ± 2x2.5%

Anti condensation heater:

Voltage	230 V

1.7 Hybrid battery solutions

1.7.1 Battery converter **1**

The DC-hub has one single power module. The power module is an AFE applications, which is connected to the existing AC-grid through a transformer. AFE output voltage is max 600V AC. The battery is directly connection to the DC-link without any form of protection as fuses nor breakers. Which means that the DC-link of the DC-hub is variable;

General cabinet data:

Quantity	1
Duty	S1
IP	44
Ambient temp.	45° C
Cooling water temp.	38° C
Cooling method	Fresh water cooled
Operation temp	0-45ºC/ 95 % moisture
Cooling medium	Fresh water with corrosion inhibitors
Cooling interface	Directly to LT fresh water system
Cooling water temp	Max 38 ºC, min 22 ºC (or above condensation level)
Weight	ca. 1100 kg
Execution	Marine
Classification Society	DNV GL
Water flow (l/min.)	>90
Heat dissipation (kW)	26,7kW at rated load, into cooling water
Heat radiation (kW)	< 2 kW, to ambient air Max.water design pressure	...10 bar / 16 bar test pressure
Pressure inlet max	10 bar
Pressure outlet max	8 bar
Nominal operation pressure	2 bar
Dimensions	[2238x2026x800 mm] [HxWxD], ref GA01 drawing
Standards general design	IEC 61800-5-1, IEC 60146-1-1
-Vibration	IEC 60721-3-3,M1,IEC 60092
-EMC	IEC 61800-3, C4 Communication Protocol: Modbus / TCP
Short circuit strength (DC-bus)	100kA
Short circuit strength (AC-bus)	30kA

AFE for AC SWBD

Quantity	1 per DC-hub
Type	PD3-1500-T4/T4
Rating	1550kVA (@600V)

Supply voltage ..... 900-1100 V DC
Output voltage ..... 600 VAC
..... Steady State: ±2,5% Output current,
continuously 0-1500A
Heavy duty current, IHD, continuously 1250A
Normal duty current, IND, continuously 1500A
Output frequency 50/60Hz
Filter LC
Output breaker..... Yes
Output breaker type ..... 2 x 3P isolation breaker
DC-link connection ..... Direct

Battery connection

1.7.2 EP Hybrid battery solution 1

Installation

The rack can be installed back to back or towards the wall, flexible

The Battery package(s) are connected to the DC switchboard through a DC/DC chopper.

The battery cells are connected to battery modules.

The battery modules are connected in series to battery racks.

The battery racks are connected in parallel to give the battery capacity.

Assembly of battery racks is yard responsibility.

The battery system also includes a Battery Monitoring System (BMS). This system takes care of the monitoring and safety of the batteries.

This is interfaced with the Hybrid controller

The control of the batteries with charging and discharging is done in the Hybrid controller integrated in the EMS/PMS system.

Local operation of the Energy Storage System/Electrical Energy System is included

Technical Data:

Rated Battery energy ..... 621 kW/h
Max power discharge ..... 1250 kW
Max power charge..... 1250 kW
Output voltage..... 900 - 1100 V
Ambient temperature..... ≤ 20° C
Cooling type ..... Air cooled
Racks in parallel..... 5
Dimension (W x D x H)..... 4325x738 x 2241 mm
Weight..... 8375 kg

Lifetime of battery will be confirmed after detailed operational profile is available.