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HIGH VOLTAGE SHORE CONNECTION CONTAINER GENERAL DESCRIPTION AND THE PROCEDURES FOR CONNECTING AND DISCONNECTING

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Abstract. High-voltage shore connections (HVSC) are an effective way to reduce air pollution in ports and their surroundings, as they allow ships to connect to a shore-based power source and shut down their diesel generators, thereby cutting off their pollution emissions. In order to be able to make this connection between the electrical grid on shore and the ship, it should be borne in mind that, in general, both systems operate at different voltages and frequencies. Therefore, the HVSC must be responsible not only for the transmission of energy from the power station onshore to the ship, but also vice versa, so that the two networks can connect properly. This paper presents a general description of HVSC system installed onboard a container vessel.

Keywords: *Cold-ironing, HVSC Container, 6.6kV MV switchboard, monitoring and control cabinet (SCS-MC).*

1. Introduction

Reducing pollutant gas emissions has become a priority environmental protection issue, regulated by European Union rules, imposing standards and regulations. To reduce pollution, ships are connected to a container that supplies high voltage electricity. Personnel operating this installation, as well as officers on board, must be authorized and ensure the safety of the equipment and operating personnel. Staff must be trained to avoid any possible faults that may occur.[1]

Given the role of the container, the operating personnel on board must ensure the connection to the shore, and then the personnel working directly with the machine, together with the personnel on board, must make the connection to the main supply switchboard installed in the container.

The High Voltage Shore Connection System is designed to provide electrical power during berthing. The shore-based supply needs to be 6600V at 60c/s. At the moment this equipment meets the standard designed on US west coast. [2]

In maritime areas, such as ports, approach channels and main waterways (Panama, Suez canals, Elbe river etc.), where ship traffic is heavy, the decrease of emissions from ships is very important. It affects human health and the environment. [3,4]

One solution for reducing emissions during port docking is the use of high voltage on-shore power supply systems (HVSC) also variously known as cold ironing, alternative marine power, shore supply or shore power. Alternative marine power covers provision of shoreside electrical power to a vessel while its main and auxiliary engines are turned off. As a result this solution will enable the vessel to meet upcoming strict clean air regulations when berthed at terminals, without generating harmful noise and air pollutants caused by active diesel engines. [5,6,7]

The international standards that must be applied are:

IEC/ISO/IEEE 80005-1:2019 – Utility Connections in Port. Part 1: High Voltage Shore Connection (HVSC) systems. General requirements; IEC/ISO/IEEE 80005-2:2016 – Utility Connections in Port. Part 2: High and Low Voltage Shore Connection systems. Data communication for monitoring and control; IEC/ISO/IEEE 80005-3:2016 – Utility Connections in Port. Part 3: Low Voltage Shore Connection (LVSC) systems. General requirements; IEC 62613-1:2018 – Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-Systems) - Part 1: General requirements.; IEC 62613-2:2018 - Socket outlets and ship plugs for high-voltage shore connection systems (HVSC systems). Part 2: Requirements for dimensional compliance and interchangeability of products intended for use by different types of ships; IEC 62613 addresses the needs in terms of plugs, socket-outlets and ship couplers (ship connectors and inlets), of the IEC/ISO/IEEE 80005-1:2016; IEC 60092-101:2018 – Electrical installations in ships. Part 101: Definitions and general requirements; IEC 60092-503:2007 – Electrical installations in ships - Part 503: Special features - AC supply systems with voltages in the range of above 1 kV up to and including 15 kV. [13]

2. HVSC Container

The container is a standard high cube 40’ container. It is divided in 2 compartments. The back of the MV Switchboard and the cable reels are in a locked room during operation to avoid personal damage in case of arc flash. Before opening the earthing switch in panel A2 of the switchboard make sure that the door is locked and secured. [8]

Furthermore, room heater, air dryer and Harting-Plug are in the high voltage compartment. In the operator room are the front of the MV Switchboard, the remote control for cable reel shore and the Monitoring and Control Cabinet (short MC-Cabinet).

The existing components in a container that supplies a ship operating at high voltage are:

Cable reel- fibre optic, control cable and protective earth, plug, including power, control and fibre optic cable contacts for shore connection according to standards required by individual ports,cable management system, electric drive for the cable reel , cable reel control box - for control and monitoring of reel and auxiliaries, monitoring and control cabinet - interface for safety interlocks between shore and ship installation, communication between ship and shore, scope of information to be exchanged according to individual port specifications, interface to ship automation system, medium voltage switchboard, transformer, 2nd reel for connection to ship. To release the cable to shore 2 side doors are provided. The door showing to pier side needs to be opened before bringing out the cable by the roller guide. A remote-control box – stored in the front room – contains all necessary push buttons and lamps for control – figure.1[9]

To release the cable to ship floor plates, have to be removed. A remote-control box – stored next to the cable reel ship – contains all necessary push buttons and lamps for control.

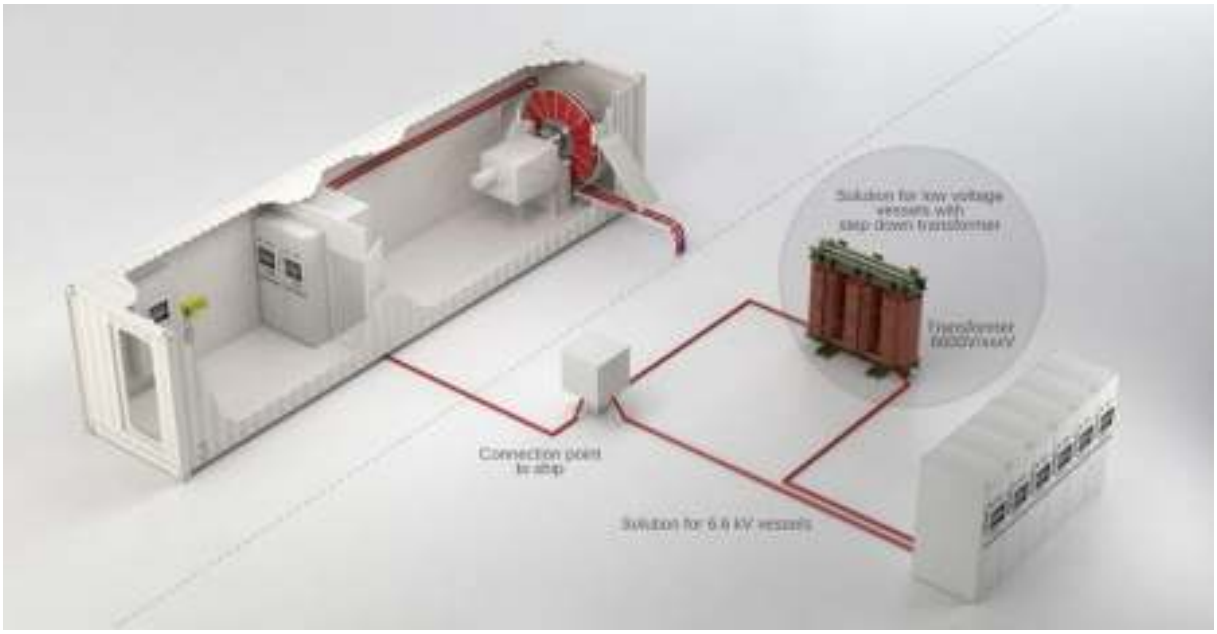

Fig. 1. HVSC system installed onboard a container vessel. [9]

During sailing the door between operator room and high voltage compartment has to be open. Air dryer should be switched to 60%, function is indicated by a green lamp. Heater should be switched to half power for both knobs. This is marked by green triangles. Function is indicated by a running fan and sensible heat. [10,11]

2.1.1. Components inside of HVSC Container

The 6.6kV MV switchboard (2 panels) is located in the HVCS Container. The incoming panel (A2) is connected to the cable reel shore and the shore supply system. The panel (A1) is connected to the cable reel ship. The switchgear (circuit breaker, disconnector and earthing switches) is controlled by a PLC from the MC - Cabinet, which is located in the Container. – Figure. 2

Under normal conditions, the 6.6kV MV switchboard is in “REMOTE” mode (“LOCAL” being only for service).

When there is no shore connection present, the switchgear is in a safe position, disconnected and earthed. The disconnector and earthing switches are manually driven units. The circuit breaker is driven by a motor. The switching status is checked and monitored by the system PLC. [12]

The cable reel for ship side is a double spiral construction to pay out or store slow reeling HV cable. A winding speed of 12m/min is designed. There are no safety or limit switches.

The cable reel for shore side is a double spiral construction to pay out ore store slow reeling HV cable. A winding speed of 12m/min is designed. Safety switches will stop the drive when no cable is left on the drum. Automatic torque reduction will be done when the cable will be winded up approximately 5m before the plugs reach the container flap.

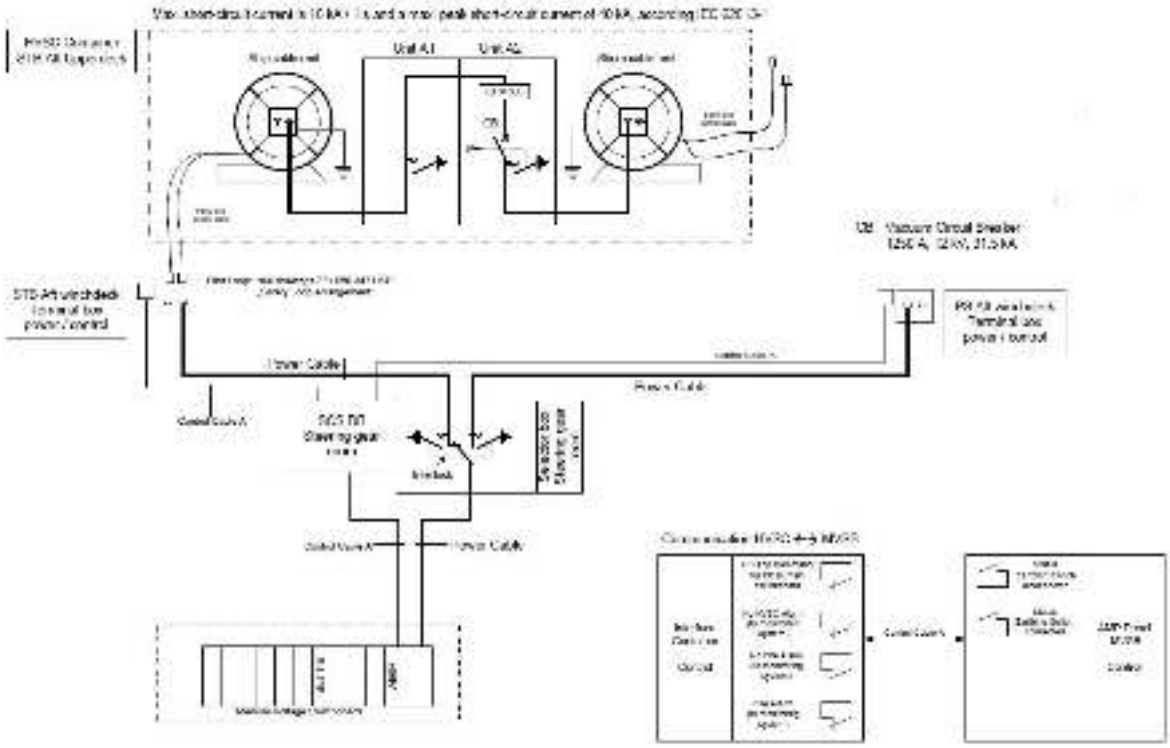

Fig. 2. Components inside of container and connections between container - shore and container - vessel

The monitoring and control cabinet (SCS-MC) is arranged in operator room of the HVSC Container. This MC-Cabinet is the essential unit for measuring, controlling and communication. The signals are monitored in the PLC of the HVSC system. The status of the system, help and fault information are shown on the touch screen window.

3. Operation of the Touch screen

The touch screen is the man machine interface (MMI) of the shore connection system. The display informs the user about all important operational values, alarms and start interlocks.

After switching on the power supply for the MC-Cabinet, the system screen boots up and shows the “Overview” window (Figure 3). [10]

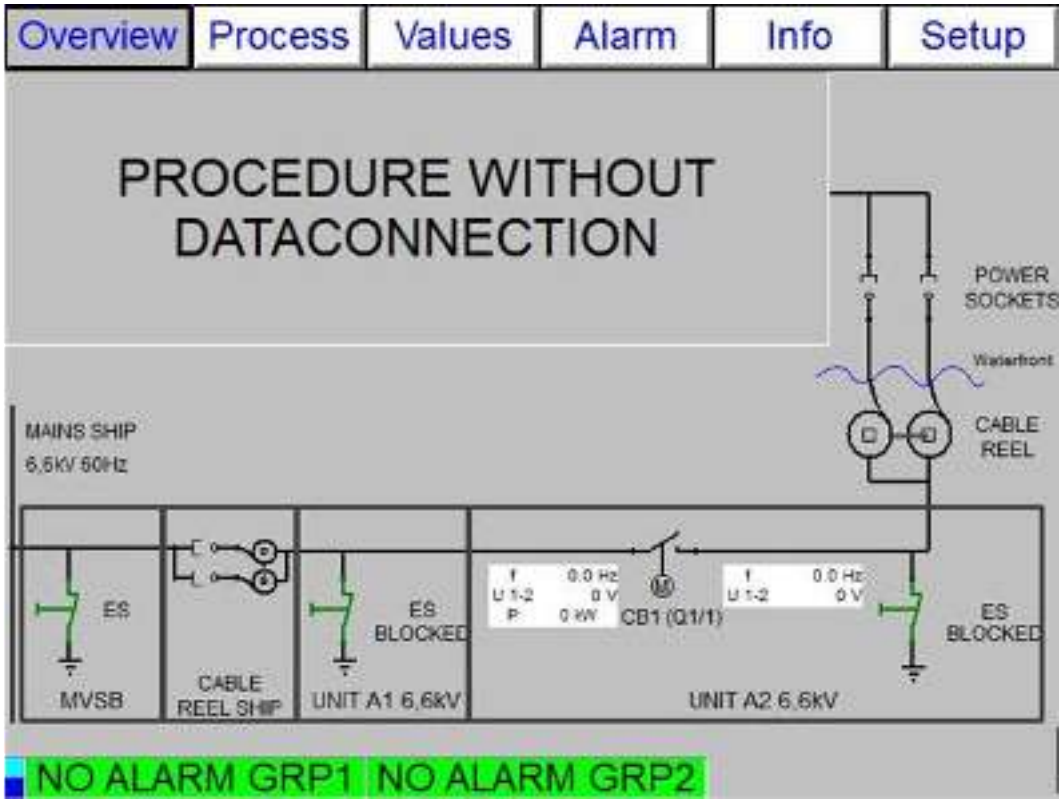

Fig. 3. Touch screen Overview window.

Several operational values as well as the state of the most important connectors and several active status indicators are displayed in this window.

The other windows "PROCESS", "VALUES", "ALARM", "INFO" and "SETUP" can be selected by pressing the relevant buttons.

A toggle indicator at the bottom left of the screen (light-blue and dark-blue) shows that the CPU is operating properly.

In the case of a fault, the green "NO ALARM GRP1" or "NO ALARM GRP2" indicator will change to a red flashing "ALARM GRP1" or “ALARM GRP2” indicator.

If the coming fault is acknowledged, the appropriate indicator stops flashing and lights permanent red as long the failure is still active. If the error goes, it must be acknowledged again that the indicator lights green again.

3.1. Process window/ Connect Window

The shown “Process” window (Figure 4) contains two more windows “Connect” and “Disconnect”.

The “Connect” window (Figure 2) is helpful to carry out the connecting procedure of the system.

The left-hand column called “CONTROL” includes buttons with the same function as the hardware technology realized push button in the front door above the panel. Furthermore, the Look of this button shows the status of the procedure. If the procedure has not reached the right point, the respective button is covered with gray gitter and is not able to push.[12]

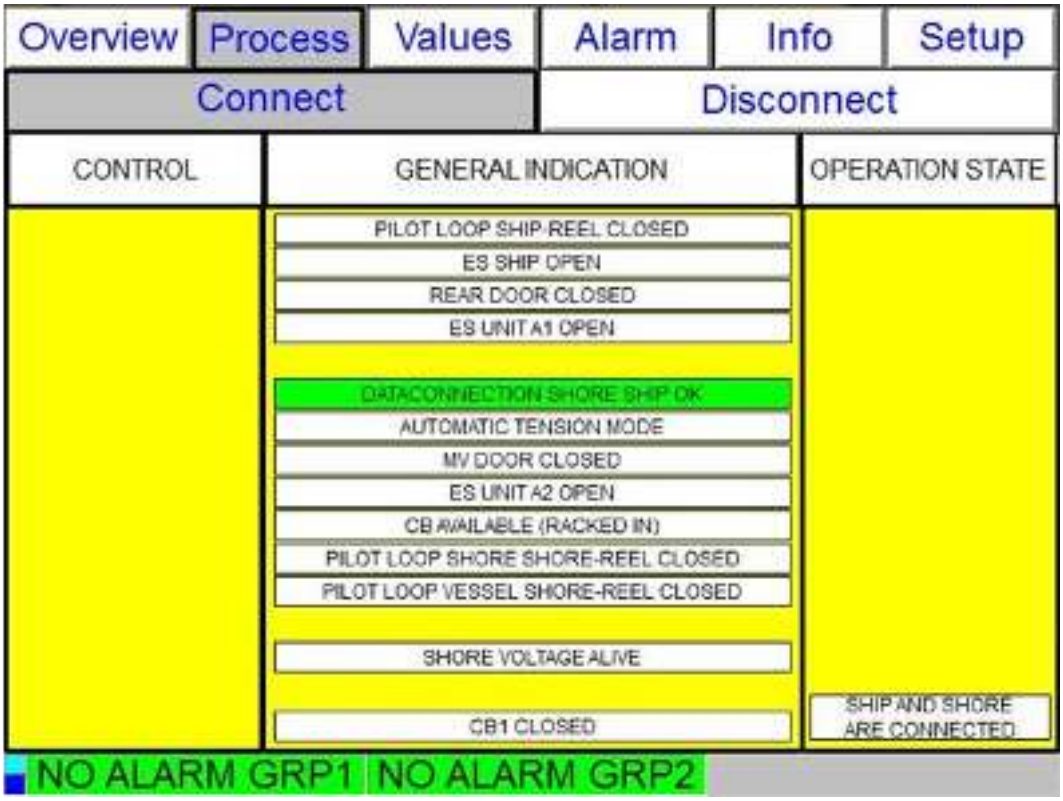

Fig. 4 Touch screen Process and Connect window.

General indications, such as start interlocks and important output signals, are displayed in the middle column. A white background means not active, and a green background means that the signal is active. If all indications up to the height of “SHIP AND SHORE ARE CONNECTED” indication are green and there is no fault present, the system can be started.

The actual operating state is displayed in the right-hand column. This means, for example, that all these indicators turn green (active) while the system is running up to the "ship and shore are connected" state. The indications have to be processed point by point, from top to bottom.

3.2. Disconnect Window

The “Disconnect” window (Figure 5) is helpful to carry out the disconnecting procedure of the system.

The left-hand column called “CONTROL” includes buttons with the same function as the hardware technology realized push button in the front door above the panel. Because it is a Stop Button here it is always able to push also in an emergency case.

General indications, such as interlocks and important output signals, are displayed in the middle column. A white background means not active, and a green background means that the signal is active. If all indications are white the system can be disconnected by pressing the “SHORE CONNECTION OFF” button. The indications have to be processed point by point, from top to bottom.

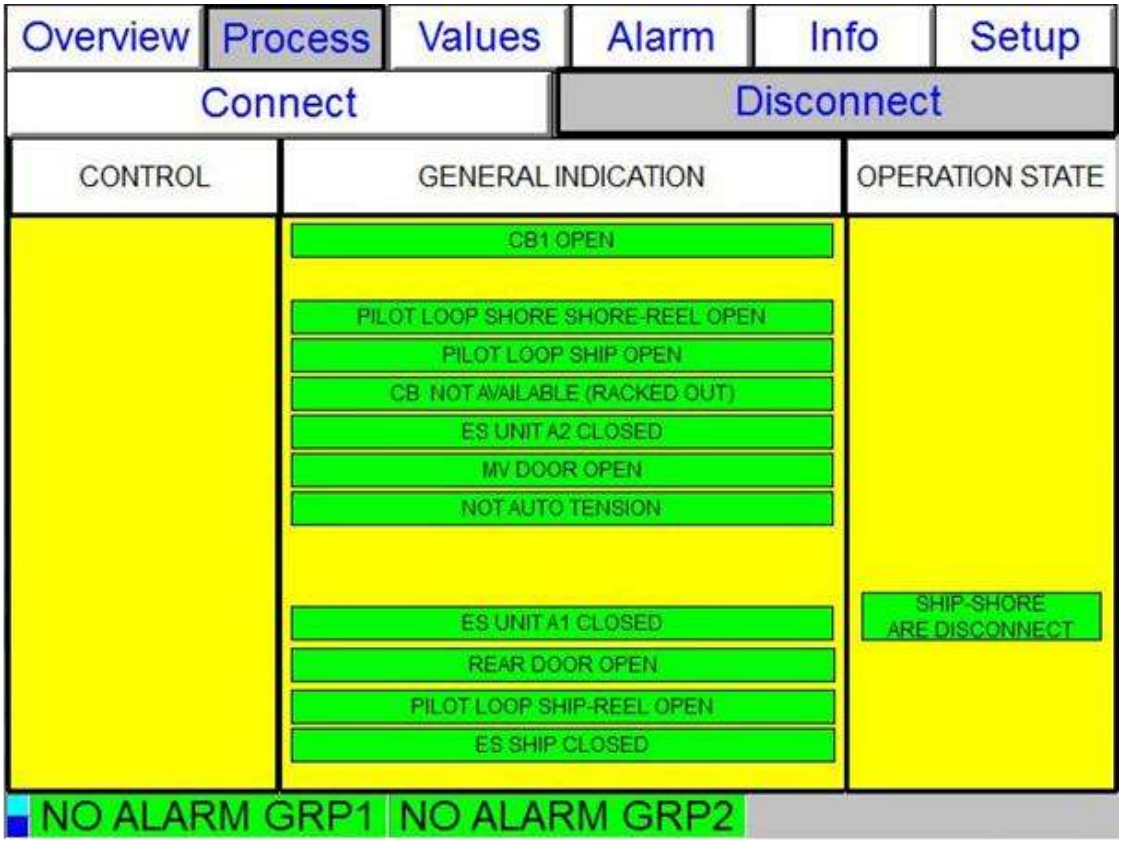

Fig. 5 Touch screen Disconnect window.

The actual operating state is displayed in the right-hand column. This means, for example, that all these indicators turn green (active) while the system is running up to the "ship-shore are disconnected" state.

4. Faults

The faults of the system are divided in two types of alarms:

All essential components faults and emergency failure are failure of

Alarm GRP1: Faults which cause an immediate shut-down of the system.

If one of these faults occurs, the system will be stopped immediately with a switch-off command to the circuit breaker in the MVSB. Also the pilot loop shore will open immediately and the circuit breaker on shore has to open. A common alarm will be send to the ship via Interface. The single alarms will be shown on the display at the MC-Cabinet. Due to the immediate shut-down, a BLACKOUT cannot be avoided if the system is operating in single operation mode.

Alarm GRP2: Faults which cause a no shut-down of the system but prevent to switch on the shore connection.

If one of these faults occurs, the system will not be stopped immediately. A common alarm will be sent to the ships via Interface. The single alarms will be shown on the display at the MC-Cabinet. If the system is not connected and one of these faults occurs it is impossible to start up the connect procedure and give the order to close the circuit breaker on shore or in the MVSB on ship.

After a configurable time after system start the shore connection system is monitored. If a fault occurs, an alarm will be indicated. The cause of the fault will be shown on the display (ALARM GRP1 or ALARM GRP2 window) of the panel on the MC cabinet. The shore-ship connection is to be checked, the

parameters are checked and then the energy supply is made. The supply of electricity from the shore must be smooth, without changing the electrical parameters - power, voltage drop, overvoltages and overloads.[13,14]

5. Conclusions

Ships, when stationed in port, stop the diesel generators and are supplied with an energy source from the shore, the power load of the ship being transferred to the port power supply, through a container, without interrupting the services on board. From the container, through a cable, the ship is connected to provide electricity for the naval power system. When anchored, ships need electricity for loading, unloading, heating, iluminating and the functioning of the operation of electroenergetic installments. Normally, the required power is provided by diesel generators, which pollute. By using the electricity from the shore, through the container, the gases that affect the environment are eliminated.

Many ports have already installed high voltage power plants for the ships with HVSC containers and the percentage is still rising. Polluting emissions from ships are expected to be reduced by 20% in the coming years.

This paper describes the role of the HVSC container that connects the ship to electrical equipment on shore at high voltage, with the aim to reduce pollution in ports and its surroundings. It also highlights the importance of automation system in such processes, considering that the number of ships operating at high voltage is constantly increasing. The components of the installation and the process of coupling the container to the ship and to the electrical port equipment were also detailed above.

The systems used for the protection of Medium Voltage switchboard in container are: ANSI 50 (Short-circuit Protection); ANSI 51 (Independent Overcurrent Pro.); ANSI 46 (Current Asymmetry); ANSI 87 (Differential Protection); ANSI 87N (Earth fault); ANSI 27 (Undervoltage); ANSI 59 (Overvoltage); ANSI 59N (Voltage Displacement); ANSI 81L (Underfrequency); ANSI 81H (Overfrequency); ANSI 40 (Underexcitation). For plugs, socket-outlets and ship couplers for high-voltage shore connection (HVSC) systems, the maximum short-circuit current is 16 kA / 1 s and the maximum short-circuit peak current is of 40 kA, according to IEC 62613-2.

Defects that cause the system to shut down immediately can be identified rapidly through the touch screen panel. Once these are found, it leads to the alarms and warning lights to be triggered and the disconnection procedure is initiated. If an alarm occurs from GRP1, the entire system is disconnected, initializing the procedure which leads the ship to blackout. In order to restart the HVSC system onboard, the ship needs approval from the port terminal. Afterwards, the reconnection procedure can be started.

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