	TECHNICAL SPECIFICATION	No. I-ET-3010.00-5140-700-P4X-005
	CLIENT:	SHEET: 1 of 15
	JOB:	--
	AREA:	
SRGE	TITLE: REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS	INTERNAL ESUP

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AREA:

SHEET: 2 of 15

TITLE:

**REQUIREMENTS FOR HUMAN ENGINEERING DESIGN
FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS**

INTERNAL

ESUP

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1. OBJECTIVE

This technical specification establishes the general human engineering design criteria for electrical equipment, installations and man-machine interfaces (MMI) on offshore units.

2. REFERENCE STANDARDS, RULES AND DOCUMENTS

The Unit Project and installations shall comply with all rules and regulations stated by Brazilian Authorities, Classification Society and International Standards. Following these mandatory requirements, the Unit Project shall comply with requirements of documents listed in 2.3 (second priority in case of conflict). Any deviation shall be submitted to PETROBRAS approval.

2.1. Standards

- ASTM F1166 Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities;
- ASTM F1337 Standard Practice for Human Systems Integration Program Requirements for Ships and Marine Systems, Equipment, and Facilities;
- IEC 60073 Basic and Safety Principles for Man-machine Interface, Marking and Identification – Coding Principles for Indicators and Actuators;
- IEC 60417 Graphical Symbols for Use on Equipment - Database Snapshot;
- IEC 60447 Basic and Safety Principles for Man-machine Interface, Marking and Identification - Actuating principles;
- IEC 60617 Graphical Symbols for Diagrams - Database Snapshot;
- ABS 86 Guidance Notes for the Application of Ergonomics to Marine Systems.

2.2. Rules

- NR-10 Norma Regulamentadora do Ministério Brasileiro – Segurança em Instalações e Serviços em Eletricidade;
- NR-12 Norma Regulamentadora do Ministério Brasileiro – Segurança no Trabalho em Máquinas e Equipamentos;
- NR-17 Norma Regulamentadora do Ministério Brasileiro – Ergonomia;
- NR-26 Norma Regulamentadora do Ministério Brasileiro – Sinalização de Segurança;
- NR-37 Norma Regulamentadora do Ministério Brasileiro – Segurança e Saúde em Plataformas de Petróleo.

2.3. Documents

- [1] I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS;
- [2] I-ET-3000.00-0000-940-P4X-002 – SYMBOLS FOR PRODUCTION UNITS DESIGN;

[3] I-ET-3010.00-5400-947-P4X-002 – SAFETY SIGNALLING.

3. GENERAL CONDITIONS

3.1. General

- 3.1.1. During Detailed Design of the installations and specification of the electrical equipment, ergonomic aspects and human factors shall be taken into account, in order to facilitate the operation, inspection and maintenance of the systems and electrical equipment, and avoid injuries to the staff, during all the lifetime of the offshore unit.
- 3.1.2. It shall be taken into account the practices and recommendations of the standards referred at item 2, as well as the requirements explicitly stated in this Technical Specification.
- 3.1.3. Concerning to details of installations and equipment under its scope of supply, the BIDDER shall be the responsible for the fulfilment of these practices and requirements.
- 3.1.4. In this specification, man-machine interface (MMI) means any “parts of the equipment intended to provide a direct means of communication between the operator and the equipment, and which enable the operator to control and monitor the operation of equipment. Such parts may include manually operated actuators, indicators and screens” (definition from IEC 60447).
- 3.1.5. The International System of Units (SI) shall be used in documents and MMIs. All numeric signalling and indication shall have the correspondent unit indicated.

3.2. Critical Systems Design Criteria

- 3.2.1. Emergency, essential, safety and critical equipment and systems shall have simple, intuitive and functional conception. This is intended to minimize the possibility of manoeuvring mistakes during manual actuation by operator at critical or stressed condition, even in case of failure at intrinsic automation of the equipment, or at the screen of the man-machine interface (MMI) of the equipment, or at data communication with A&C - Automation and Control System.

4. MAN-MACHINE INTERFACES

The design of the man-machine interfaces shall take into account ergonomic principles and cognitive factors in order to minimize the human error factors, and to maximize the operational safety.


4.1. Electrical Panels and Electrical Package Unit Control Panels

- 4.1.1. Man-machine interfaces for electrical panels and for electrical package unit control panels shall comply with the IEC 60073 and ASTM F1166.

4.1.2. The colour coding usage shall be according to Table 1.

Table 1 - Colour Coding for Man-Machine Interfaces

Colour	Type	Function	Recommendations for Use
Flashing (Blinking) Red	<ul style="list-style-type: none"> • Frame around symbol in HMI 	<ul style="list-style-type: none"> • High severity alarm 	<ul style="list-style-type: none"> ▪ a high-severity emergency condition exists; ▪ high-potential damage for equipment or persons; ▪ any corrective action shall be taken; ▪ system or equipment with problem and operation is degraded, or not possible.
Red	<ul style="list-style-type: none"> • Frame around symbol in HMI 	<ul style="list-style-type: none"> • High severity alarm acknowledged 	<ul style="list-style-type: none"> ▪ a high-severity emergency condition has occurred, but it has already been acknowledged by the operator.
Flashing (Blinking) Yellow	<ul style="list-style-type: none"> • Frame around symbol in HMI 	<ul style="list-style-type: none"> • Low severity alarm 	<ul style="list-style-type: none"> ▪ a low-severity emergency condition exists; ▪ low-potential damage for equipment or persons; ▪ any corrective action must be taken; ▪ system condition that indicates occurrence of an electrical event; ▪ system or equipment with problem, but operation is possible.
Yellow	<ul style="list-style-type: none"> • Frame around symbol in HMI 	<ul style="list-style-type: none"> • Low severity alarm acknowledged 	<ul style="list-style-type: none"> ▪ a low-severity emergency condition has occurred, but it has already been acknowledged by the operator.
Yellow	<ul style="list-style-type: none"> • Physical or virtual signalling Lamp • Symbol in HMI 	<ul style="list-style-type: none"> • Protection actuated • Tripped • Overloaded 	<ul style="list-style-type: none"> ▪ Equipment tripped by electrical protection or by ground fault.
Red (1)	<ul style="list-style-type: none"> • Physical or virtual signalling lamp • Symbol in HMI 	<ul style="list-style-type: none"> • On • Energized • Closed 	<ul style="list-style-type: none"> ▪ status indication of system or equipment operating; ▪ status indication of load on / energized; ▪ status indication of functional unit with voltage at output terminals (energized) ⁽³⁾; ▪ status indication of switching device closed.
Red (2)	<ul style="list-style-type: none"> • Physical or virtual push button 	<ul style="list-style-type: none"> • Load control 	<ul style="list-style-type: none"> ▪ command to stop (turn off) load; ▪ command to open switching device.
Green (1)	<ul style="list-style-type: none"> • Physical or virtual signalling lamp • Symbol in HMI 	<ul style="list-style-type: none"> • Ready to start • Off • De-energized • Open 	<ul style="list-style-type: none"> ▪ status indication of system or equipment stopped; ▪ status indication of load off / de-energized; ▪ status indication of functional unit without voltage at output terminals (de-energized); ▪ status of power switching device open; ▪ status indication of ground switch closed (only for representation of grounding switch).

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Colour	Type	Function	Recommendations for Use	
Green (2)	<ul style="list-style-type: none"> Physical or virtual push button 	<ul style="list-style-type: none"> Load control 	<ul style="list-style-type: none"> command to start (turn on) load; command to close switching device. 	
Blue	<ul style="list-style-type: none"> Physical or virtual signalling lamp Symbol in HMI 	<ul style="list-style-type: none"> ESD actuated 	<ul style="list-style-type: none"> functional unit shut off by ESD command; functional unit shut off by emergency stop button of MCC or CDC. 	
White	<ul style="list-style-type: none"> Physical or virtual signalling lamp 	<ul style="list-style-type: none"> Blocked Extracted Grounded 	<ul style="list-style-type: none"> equipment blocked for maintenance; circuit-breaker, contactor, switch or drawer extracted, or in test position; outgoing feeder with terminals grounded for safety maintenance; equipment not available; equipment or device in communication failure. 	
Grey (shadow)	<ul style="list-style-type: none"> Symbol in HMI 	<ul style="list-style-type: none"> Blocked Extracted Grounded 	<ul style="list-style-type: none"> equipment blocked for maintenance; circuit-breaker, contactor, switch or drawer extracted, or in test position; outgoing feeder with terminals grounded for safety maintenance; equipment not available; equipment or device in communication failure. 	
<p>Notes:</p> <ol style="list-style-type: none"> 1) According to NR-10; 2) Based on IEC 60073, for non-illuminated actuators; 3) Functional units with more than one switching device in series shall be represented in red when all switching devices are close (output terminals are energized). Each individual power switching device shall be represented separate; 4) See ANNEX B – STANDARD FOR ELECTRICAL EQUIPMENT REPRESENTATION, for standard symbols associated with colour rules. <p>4.1.3. Control or auxiliary panels for essential and emergency equipment (UPS, EGCP, battery charger, etc.) shall have analogue instruments in order to provide instant reading at critical conditions, despite the existence of the local MMI.</p> <p>4.1.4. For each panel type, instruments shall be, at least, according to Table 2. Other instruments can be added after PETROBRAS approval.</p>				



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Table 2 - Minimum Instruments for Electrical Equipment

INSTRUMENT PANEL / FEEDER	kW Meter	kVA Meter	KVAr Meter	Power Factor Meter	Voltmeter	Ammeter	Field Ammeter and Voltmeter	Frequencymeter	Temperature Meter	Ground Fault Detector	Synchroscope	Operation Hour Meter	kWh Meter	Control Voltage Indicator	Others
	Main Generator Control and Protection Panel (TGCP)	@	@	@	@	@ VV CS	@ CS	d	FF	M@ E@ CS	d	@ LS L25	CO	d IT	LP
Power Management System (PMS)	d	d	d	d	VV @ (6)	d	d	FF			@ LS L25			LP	SIN
Auxiliary Generator Incoming Cubicle					@ CS	@ CS								LP	
Auxiliary Generator Power and Control Panel (AGCP)	@	@	@	@	@ VV CS	@ CS	@	FF	M@ E@ CS	LG	@ LS L25	CO	d IT	LP	
Emergency Generator Incoming Cubicle					@ CS	@ CS								LP	
Emergency Generator Power and Control Panel (EGCP)	@	@	@	@	@ VV CS	@ CS	@	FF	M@ E@ CS	LG	@ LS L25	CO	d IT	LP	
Hull Generator Control Panel (HGCP)	@	@	@	@	@ VV CS	@ CS	@	FF	M@ E@ CS	LG	@ LS L25	CO	d IT	LP	
MV Incoming MCC Cubicle from Transformer					a CS	a CS				LG				LP	SIN
MV Incoming Switchgear Cubicle from Generator					@ CS	@ CS				LG				LP	SIN
MV Incoming MCC Cubicle from Generator					@ CS	@ CS				LG				LP	SIN
MV MCC Backfeeder					a CS	a CS				LG				LP	SIN
MV Switchgear General Outgoing Feeder	d	d	d	d	d	d				LG				LP	SIN
MV Switchgear Outgoing Feeder for Transformer	d	d	d	d	d	@ CS			d	LG				LP	SIN
MV Switchgear Outgoing Feeder for Motor	d	d	d	d	d	d			d	LG		CO		LP	SIN
MV MCC Outgoing Feeder for Motor	d	d	d	d	d	d			d	LG		CO		LP	SIN
MV VSD Incoming					d	d									
MV VSD Outgoing	d	d	d	d	d	d		d	d	LG		CO		LP	
LV Switchgear Incoming Cubicle and Backfeeder	d	d	d	d	a CS	a CS				VΩ LG				LP	
LV Switchgear Outgoing Feeder for Motors	d			d	d	d				LG					
LV Switchgear General Outgoing Feeder				d	d	d				LG					

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INSTRUMENT PANEL / FEEDER	kW Meter	kVA Meter	KVAR Meter	Power Factor Meter	Voltmeter	Ammeter	Field Ammeter and Voltmeter	Frequencymeter	Temperature Meter	Ground Fault Detector	Synchroscope	Operation Hour Meter	kWh Meter	Control Voltage Indicator	Others
	LV MCC Incoming Feeder & Lighting Distribution Panels (for IT systems)					a CS	a CS				DT				LP
Ballast Pump Starter	a					a								LP	
AC UPS Incoming Feeder					a CS										
AC UPS Outgoing Feeder					a CS					LG					
DC UPS Incoming Feeder					a CS										
DC UPS Outgoing Feeder					a					LG					
GENERIC DC UPS Incoming Feeder					a CS										
GENERIC DC UPS Outgoing Feeder					a										
LV Main Distribution Panels up to 240V connected to transformers secondary windings					a CS	a CS				VΩ					
LV Main Distribution Panels up to 240V connected to AC UPS					a CS	a CS				VΩ	L25				
LV Main Distribution Panels up to 240V connected to DC UPS					a	a				VΩ					
Heating Systems Panels					a CS	a CS				VΩ					
Heat Tracing Panels					a CS	a CS				VΩ					
AC Lighting panels Incoming Feeder					a CS										
DC Lighting panels Incoming Feeder					a										

LEGEND	
@	circular analogue indicator, scale 250°, frame 4.1/4"
a	analogue indicator, frame 96mm with 90° deflection scale
CO	Counter
CS	selector switch with 3 positions + 1 off, for voltmeter and ammeter and with the necessary number of positions + 1 off for temperatures detector
d	digital indicator or workstation
DT	grounding detector with 3 lamps + pushbutton test, for ungrounded or high resistance earthed system
E	winding (temperature)
FF	duple frequency meter
IT	Integrator

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L25	Indicator Lamp for relay function 25 closing		
LG	pilot lamp or led indicating ground fault detected (it may be integrated to multifunction relay or of isolation monitoring device - IMD)		
LP	pilot lamp or led with label "LIGADO", for each feeder		
LS	3 lamps for synchronizing (triangular arrange)		
M	bearing (temperature)		
S	overload scale		
SIN	synoptic/LED diagram at panel front		
VV	duple voltmeter		
VΩ	indicator of ground-fault, for ungrounded system or high resistance earthed system. It may be the Isolation Monitoring Device – IMD		
<p>Notes:</p> <ol style="list-style-type: none"> 1) Incoming, tie and backfeed circuits of essential and auxiliary switchgears could require other instruments when synchronization is foreseen; 2) The instruments @, a, FF shall have direct reading. They shall not be derived from relays and circuit-breakers with incorporated reading. 3) Analogue indicators shall be selected so that at full load the pointer shall range between 50% and 75% of full scale. 4) Analogue indicators shall have a green mark indicating the rated value of the measured variable. 5) Analogue indicators shall have red marks indicating the maximum and minimum limit values for the measured variable; 6) For Power Management System (PMS) it shall be provided two voltmeters (V), one for each bus bar of main switchgear; 7) Operation hours refers to the equipment or package (generator, motor, etc.); 8) The frequencymeter shall have the nominal frequency in the center of the scale and shall have a minimum range of ± 8% of the rated frequency; 9) The kW Meter shall have a scale showing at least 15% of the rated power as the reverse power. 10) The drawers for Slop and Ballast Pump shall have kW meter for Semi-Submersible Platform. <p>4.1.5. It shall be avoided:</p> <ol style="list-style-type: none"> a) Instruments with non-linear scale or that demand use of scale factors or interpolations for reading; b) Instruments with a single digital display for multiples variables, with button or menu selection, except that included in multifunction relays; c) Instruments with digital display for variables with fast changing; d) Vibrating reed frequency meter. <p>4.1.6. The placement and mounting heights limits for instruments and control devices shall comply with Figure 1.</p>			

- 4.1.7. If it is not possible to read the instruments or displays according to the heights limits indicated in Figure 1, a standard mobile platform should be supplied, made of light and resistant material, as FRP.
- 4.1.8. Mounting heights for common electrical fixtures (e.g. lighting panels) mounted to a bulkhead (wall-mounted) shall comply with Figure 2.

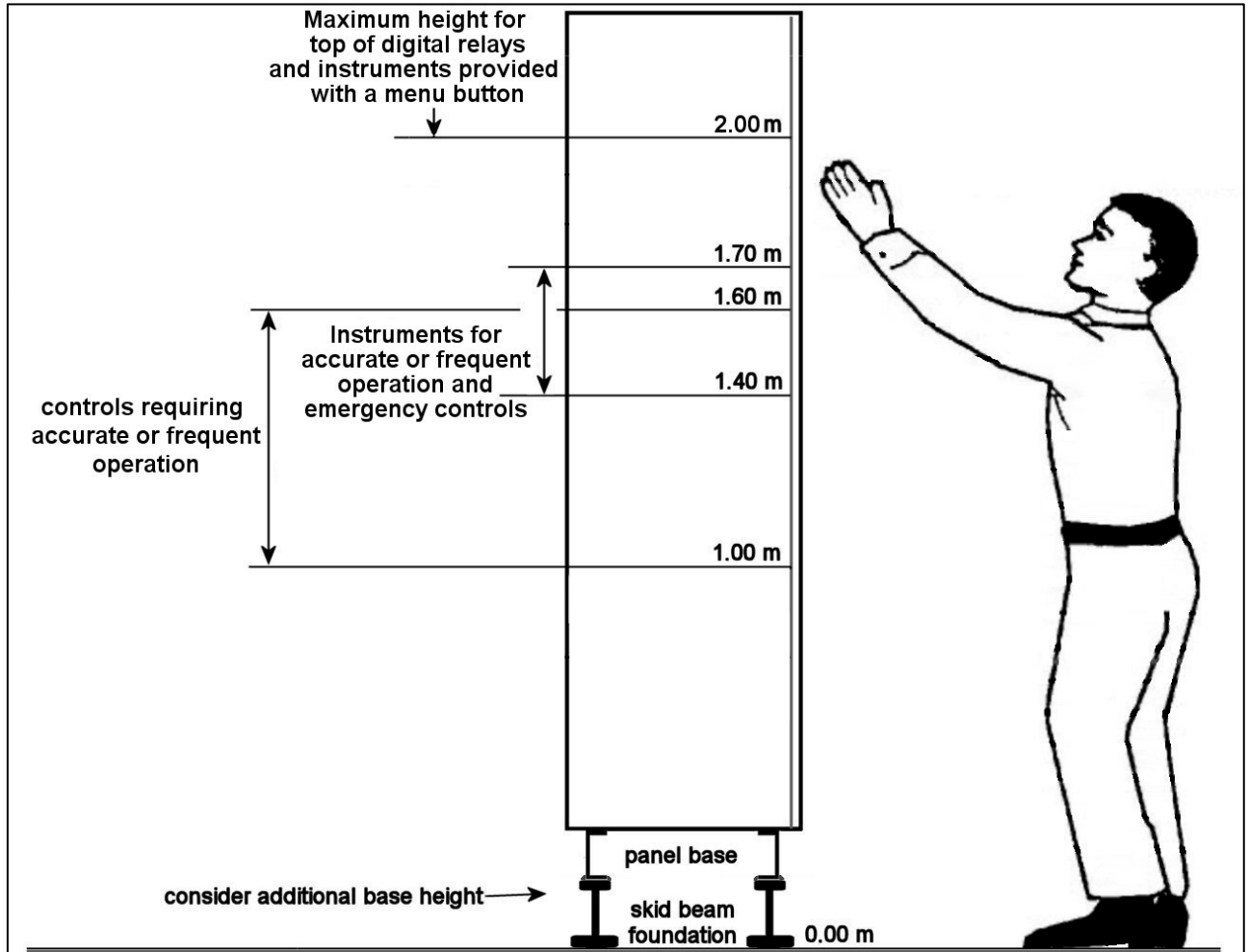


Figure 1 Mounting height for instruments, displays and controls – typical sketch

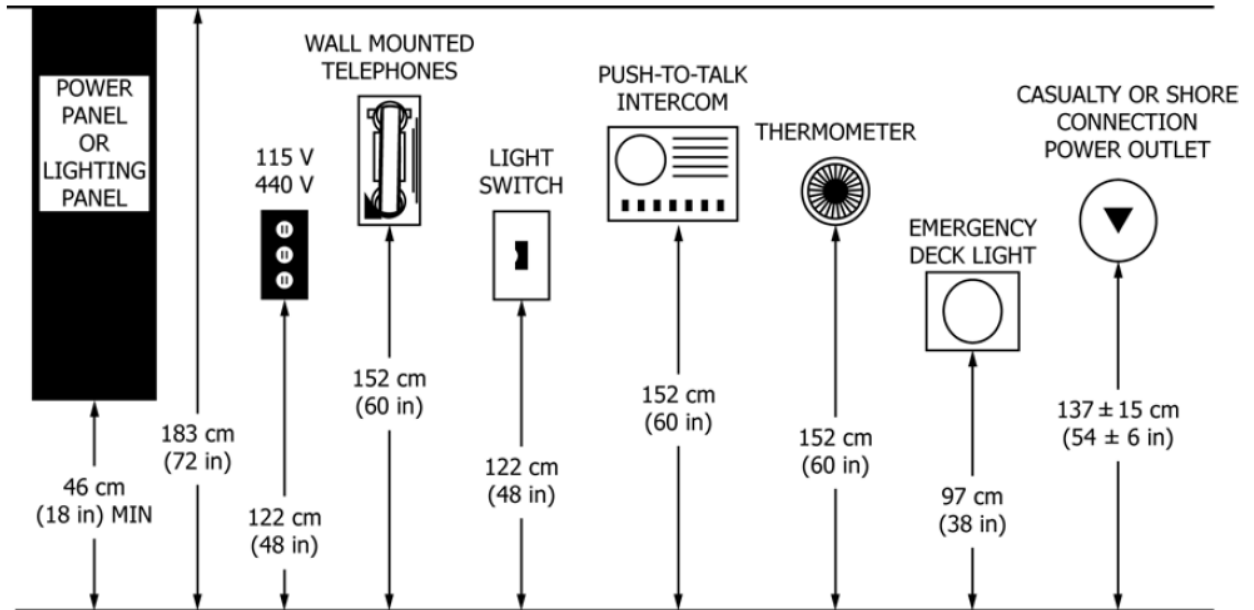


Figure 2 Mounting height for common electrical fixtures

4.2. Controls

- 4.2.1 The position and direction of control movement and the corresponding expectation action shall be according to Figure 3.
- 4.2.2 Whenever possible, pushbuttons and switches shall be protected against accidental operations.

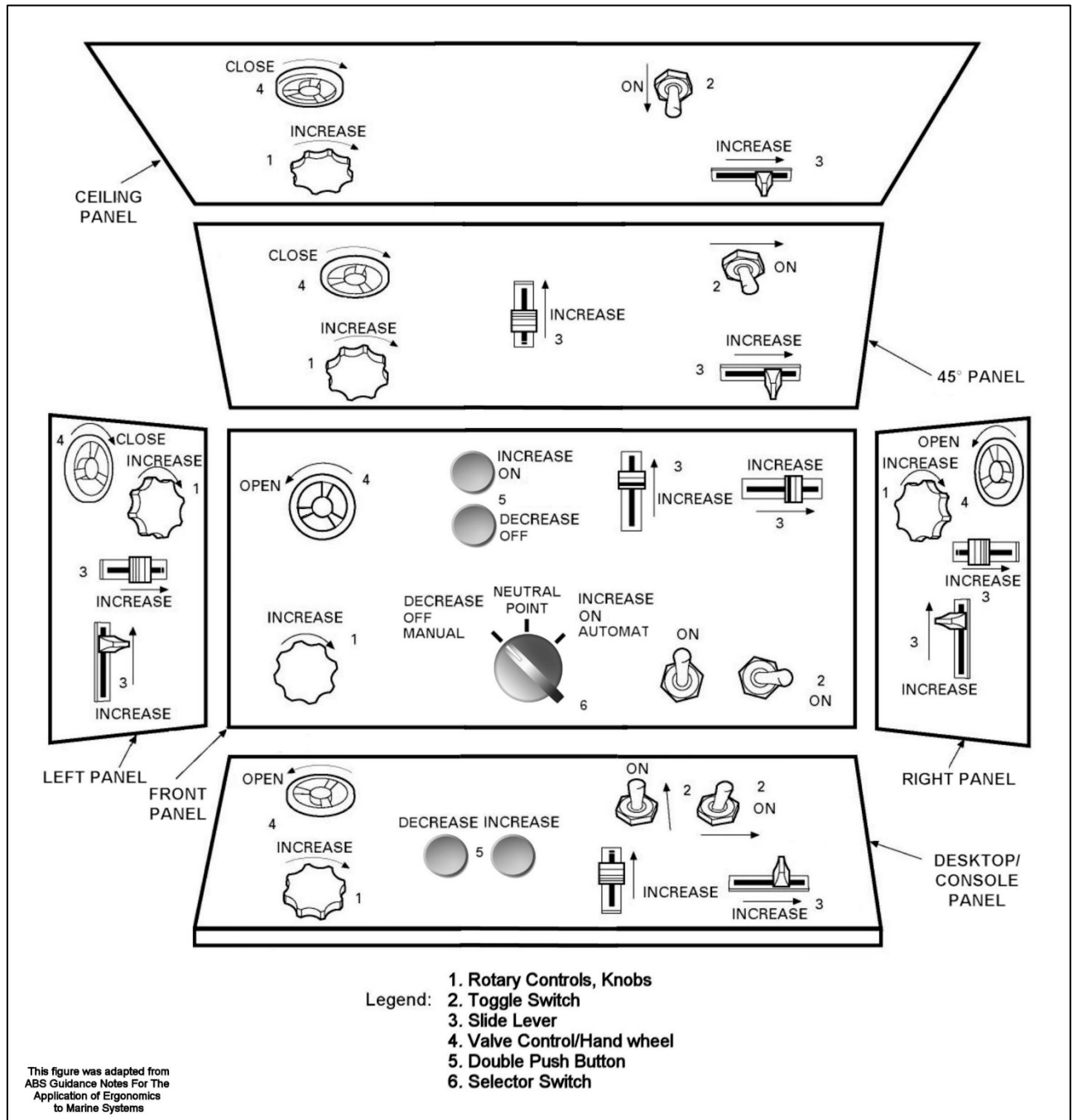


Figure 3 Control movement expectations – typical sketch

4.3. Labelling

4.3.1 Electrical CDCs, MCCs, AC UPS, DC UPS, Generic DC UPS, VSDs, soft-starters, transformers, distribution panels, electrical package unit power and control panels, field push buttons for local operation, push buttons for other functions, etc. shall have indication of the NAME and the FUNCTION of the equipment, in addition to the alphanumeric TAG at each outgoing/drawer.

- 4.3.2 Each component for manoeuvrings and monitoring, selector switches, pilot lamps, status indication, etc. shall have individual identification of function in Portuguese language. Annex A provides a simplified Portuguese translation for some usual electrical terms that shall be used.
- 4.3.3 Each cubicle with rear access shall have identification label affixed to backdoor equal to frontal identification label. These labels shall be installed in fixed parts and shall be visible when the doors are removed.
- 4.3.4 Each main part or device installed inside the panel shall have an indication label with the TAG of the component (according to equipment documents) and a clear description of the device function in Portuguese language, for instance, “Disjuntor de Interligação”, “Entrada CA”, “Disjuntor das Baterias”, etc.
- 4.3.5 Electrical equipment, classified areas, electrical equipment rooms and other areas shall have safety signalling according to requirements of Brazilian Ministry (*Ministério Brasileiro*), Brazilian Navy (*Marinha Brasileira*), *Diretoria de Portos e Costas* (DPC), Classification Society, mandatory international regulations and specific Technical Specifications. See [3] I-ET-3010.00-5400-947-P4X-002 – SAFETY SIGNALLING for safety signalling rules.
- 4.3.6 All signalling labels, warning signals, instruction manuals, alarms and procedures related to safety shall be in Portuguese language, or in both English and Portuguese languages.

4.4. Critical Operations

- 4.4.1 Critical operations at essential and emergency equipment (e.g.: UPS-bypass transference, automatic-manual transference, either in normal condition, functional tests or automation/supervision failure, etc.) shall be properly explained in Portuguese, in the equipment manuals and in electrical system manuals.
- 4.4.2 More infrequent or potentially dangerous operation shall have a warning label in Portuguese, with instructions attached at frontal of the control panels.
- 4.4.3 All emergency shutdown actuators (including shutdown actuators for diesel engines) shall have easy access, shall be identified by function warning label, and protected against accidental operation.

4.5. Electrical System Screens

- 4.5.1 In order to facilitate the communication and to minimize the possibility of operational mistakes due to memory lapse, all screens, regarding to the operation, control and supervision of the electrical system, shall have indication of the NAME and the FUNCTION of the equipment or panels, in addition to the alphanumeric TAG.

- 4.5.2 For design of MMI screens of Electrical System Workstations, PMS or any other screen for Electrical System or equipment, it shall be used the symbols and colours presented in ANNEX B – STANDARD FOR ELECTRICAL EQUIPMENT REPRESENTATION.

5. OPERABILITY, MAINTAINABILITY AND ACCESSIBILITY

5.1. Lighting Levels


- 5.1.1 The Detailed Lighting Project shall provide an adequate lighting level at all places, including the operation places of the equipment installed in the rooms (frontal of control panels, MMI consoles, etc.).
- 5.1.2 The lighting levels shall comply with Brazilian Ministry (*Ministério Brasileiro*), Classification Society, mandatory international regulations and [1] I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

5.2. Equipment, Accessories and Interfaces Location

- 5.2.1. See [1] I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS for electrical equipment location and positioning requirements.

6. ABBREVIATIONS

A&C	Automation and Control System
ABS	American Bureau of Shipping
AGCP	Auxiliary Generator Power and Control Panel
ASTM	American Society for Testing and Materials
CCM	Motor Control Center (“ <i>Centro de Controle de Motores</i> ”, in Portuguese language)
CCR	Central Control Room
CDC	Load Center Switchgear (“ <i>Centro de Distribuição de Cargas</i> ”, in Portuguese language)
EGCP	Emergency Generator Power and Control Panel
ESD	Emergency Shut Down
FRP	Fibre Reinforced Plastics
HGCP	Hull Generator Control Panel
HMI	Human-Machine Interface
IEC	International Electrotechnical Commission
LV	Low-voltage ($\leq 1\text{kV}$)
MCC	Motor Control Center
MMI	Man-Machine Interface
MV	Medium-voltage ($> 1\text{kV}$)
PMS	Power Management System
TGCP	Turbogenerator Control Panel
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive (Frequency Converter)

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7. ANNEX A – ELECTRICAL TERMS DICTIONARY FOR LABELLING

English	Portuguese
Actuated by ESD	Atuado por ESD
Actuated by Protection	Atuado pela Proteção
Arc Monitor	Monitor de Arco Elétrico
Batteries Circuit-Breaker	Disjuntor das Baterias
Bus	Barra
Busbar	Barramento
Circuit-breaker	Disjuntor
Closed	Fechado
Current	Corrente
Extracted	Extraído
Grounded	Aterrado
Heating Resistor (Space Heater)	Resistor de Aquecimento
MCC (Motor Control Center)	CCM (Centro de Controle de Motores)
On (signalling)	Ligado
Off (signalling)	Desligado
Open	Aberto
Power	Potência
Selector Switch	Chave Seletora
Switchgear	CDC (Centro de Distribuição de Cargas)
Tie Circuit-Breaker	Disjuntor de Interligação
Turn on (On) (control)	Liga
Turn off (Off) (control)	Desliga
Voltage	Tensão

8. ANNEX B – STANDARD FOR ELECTRICAL EQUIPMENT REPRESENTATION



ANNEX B.xlsx