Australian Government

MARL049 Demonstrate advanced knowledge of marine control systems and automation

Release: 1

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Modification History

Release 1. This is the first release of this unit of competency in the MAR Maritime Training Package.

Application

This unit involves the skills and knowledge required to operate control systems onboard a commercial vessel. It includes advanced knowledge of control theory and knowledge required to analyse the operation and performance of signal transmissions systems, electronic transmitters, final control element arrangements, electronic temperature sensors and transmitters, governors, proportional-integral-derivative (PID) electronic controllers, machinery space monitoring alarm and control systems.

It also includes knowledge of fault-finding techniques for control systems, measurement and test equipment used for fault finding electronic apparatus, operational applications of analogue and digital programmable logic controllers (PLCs), and procedures for programming, operating, and maintaining PLC controlled systems.

This unit applies to people working in the maritime industry in the capacity of:

- Electro-Technical Officer (STCW Electro-Technical Officer Unlimited)
- Engineer Class 1 (STCW Chief Engineer Unlimited)
- Engineer Class 2 (STCW Second Engineer Unlimited).

Licensing/Regulatory Information

Legislative and regulatory requirements are applicable to this unit.

- This unit is one of the requirements to obtain Australian Maritime Safety Authority (AMSA) certification as an Electro-Technical Officer (STCW Electro-Technical Officer Unlimited), Engineer Class 1 (STCW Chief Engineer Unlimited) or Engineer Class 2 (STCW Second Engineer Unlimited)   meet regulatory requirements this unit must be delivered consistent with Marine Orders and with the relevant sections of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).
- Those regulatory requirements include STCW International Maritime Organization (IMO) model course competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Pre-requisite Unit

Not applicable.

Competency Field

L – Engineering

Unit Sector

Not applicable.

Elements and Performance Criteria

ELEMENTS	PERFORMANCE CRITERIA
Elements describe the essential outcomes.	Performance criteria describe the performance needed to demonstrate achievement of the element.
1 Explain control theory	**1.1** Open loop systems are distinguished from closed loop systems
	1.2 Time lag is distinguished from time constant
	1.3 Closed loop manual, time-based automatic open loop and feed forward open loop are explained
	1.4 Effect resistance and capacitance has on process system response is demonstrated
	1.5 Transfer function is established and defined
	1.6 Effect of variations in undamped natural frequency on control systems is illustrated
2 Analyse signal transmissions systems used for monitoring, controlling and shutting down machinery	**2.1** Methods and limitations of different signal transmissions systems are compared
	2.2 Standard pneumatic system and standard analogue 4-20 Milliampere (mA) system of signal transmission are compared and contrasted

		2.3	Operation of a nozzle flapper and pneumatic amplifier unit is analysed and applied to transmitters, basic controllers and valve positioners
		2.4	Control air supply system is defined
		2.5	Principle of operation of direct and reverse acting pneumatic relays and application is clarified
		2.6	System of a communications bus using digital signal transmission with optical and electronic systems is explained
		2.7	Limitations and advantages of a communications bus system are analysed
3	**Analyse electronic and pneumatic transmitters**	**3.1**	Principles of operation of a typical 4-20 mA transmitter are explained
		3.2	Application of strain gauges and changes in capacitance as sensors for pressure and differential pressure transmitters are outlined
		3.3	Methods of testing transmitter outputs are explained
		3.4	Application of differential pressure transmitters to liquid level sensing in both open and closed tanks is analysed
		3.5	Pneumatic temperature transmitter is defined
		3.6	Effect of changes in ambient temperature on thermocouples and resistance temperature detectors (RTD) is explained
		3.7	Testing procedures and methods of simulation for both RTDs and thermocouples are explained
		3.8	Characteristics and application of thermistors are outlined
		3.9	Use of a differential pressure transmitter to measure flow is analysed and compared with non-restrictive electronic systems
4	**Evaluate final control element arrangements**	**4.1**	Pneumatic, electric and hydraulic actuation are compared and contrasted
		4.2	Arrangements for locking pneumatic control valves in

		their last position on air failure are outlined
	4.3	Operating principle of pneumatic valve positioners is explained
	4.4	Control valve trim characteristics are explained
	4.5	Control valve selection for machinery space duties are analysed
	4.6	Arrangements to provide fail safe requirements are outlined
5 Evaluate electronic temperature sensors and transmitters	**5.1**	Colour coding of tails and compensating cables for thermo couple types are identified
	5.2	Temperature/millivolt (mV) outputs and application of common thermo couple types are illustrated
	5.3	Relationship between resistance and temperature for PT100 resistance temperature device and method of testing three wire arrangements is explained
	5.4	Arrangements of interfacing thermo couples and RTDs with 4-20 mA systems and 1-5 volt (V) interface cards are analysed
	5.5	Effect of changes in ambient temperature on thermocouples and RTD is explained
6 Analyse PID electronic controllers	**6.1**	Common controller actions and applications are outlined
	6.2	Principle of operation of an electronic analogue 3-term controller and how adjustments are made is explained
	6.3	Typical controller settings for a PID controller are detailed
	6.4	Open loop response and PID controller testing and calibration are demonstrated
	6.5	Application of modern single loop digital controller is explained
	6.6	Programming requirements for manual and auto-tuning when adjusting digital controllers are demonstrated

7	**Explain procedure for transmitter calibration**	**7.1**	Procedure for transmitter calibration for both pneumatic and electronic transmitters is applied
		7.2	Test equipment is used for transmitter calibration
		7.3	Relationship between process variables and output signals is demonstrated in a graph
		7.4	Effects of transmitter dead band are defined
8	**Explain operation of pneumatic 3-term controller and controller adjustment procedures**	**8.1**	Operating principle of pneumatic 3-term controllers is outlined
		8.2	Procedure for adjusting 3-term pneumatic controllers is applied and effects if incorrectly adjustment are explained
		8.3	Integrated hand/auto station and 3-term controller are outlined and bumpless transfer is demonstrated
9	**Explain engine room monitoring systems**	**9.1**	Application of different speed sensing systems is analysed
		9.2	Operating principles of torque monitoring systems applied to propeller shafting are explained
		9.3	Arrangements of shaft power and indicated power monitoring are compared
		9.4	Capacitance sensing and float level monitoring systems are compared
		9.5	Operating principle of oil-water interface sensor is explained
		9.6	Methods of bearing temperature monitoring applied to diesel engine rotating parts are outlined
		9.7	Machinery space monitoring and alarm system from a central control room are outlined
10	**Evaluate performance of machinery space monitoring alarm and control systems**	**10.1**	Single, two and three element boiler water level control systems involving feedwater and cascade systems are analysed

		10.2	Requirements and systems to provide advanced combustion control systems and sequential control for burner management are outlined
		10.3	Concepts and arrangements for central cooling and load dependent cooling control systems are explained
		10.4	Main engine control arrangements for fixed pitch propeller and controllable pitch propeller (CPP) systems requiring sequential control are analysed
		10.5	Tests and procedures to meet unmanned machinery spaces (UMS) requirements are explained, and alarm and monitoring systems involving data loggers, alarm print outers, and trend analysis are evaluated
11	**Analyse governors**	**11.1**	Operating principle of proportional action hydraulic governors is explained
		11.2	Importance of spring stiffness in relation to response is clarified
		11.3	Purpose of an isochronous governor is outlined
		11.4	Principle of operation of an isochronous hydraulic governor is outlined
		11.5	Governor adjustments to allow operation of propulsion and power generation diesels in both shared load and standalone applications are specified
		11.6	Governor faults are diagnosed and interpreted, identifying and evaluating appropriate adjustments and maintenance to be made
		11.7	Specific governor applications requiring torque limitation, critical speed range avoidance are outlined
		11.8	Typical electronic governors are explained using labelled diagrams to indicate major components and features
		11.9	Response of a diesel engine governor on change in engine load using both feed-back and feed forward control is explained using labelled diagrams to indicate major components and adjustments
12	**Explain fault-finding techniques for control systems**	**12.1**	Governor adjustments are demonstrated, and effect of incorrect adjustments is explained

		12.2	Common defects in mechanical and electronic governors are itemised
		12.3	Indication of faults and procedures of fault finding in 4-20 mA loops are explained
		12.4	Fault-finding techniques in pneumatic control systems and their respective components are analysed
		12.5	Fault finding flow diagram is illustrated
		12.6	Off-limit performance, fault detection and principles of rectifications for common engine room control systems are evaluated
13	**Explain operational applications of analogue and digital PLCs**	**13.1**	Principles and operation of integrated circuit gates are explained
		13.2	Operational function of input/output devices connected to a digital PLC is detailed
		13.3	Methods of operation of flip flops, adders, counters, multiplexers and decoders are outlined
		13.4	Methods employed when changing set point values in a digital PLC are outlined
		13.5	Methods of programming PLCs are assessed
		13.6	Methods used for storing binary data and operating registers are explained
		13.7	Fibre optic data transmission systems are explained
		13.8	Procedure for connecting PLC to system control elements is outlined
		13.9	System operating procedure is outlined
		13.10	Procedure for modifying system and program as necessary to provide adequate and appropriate safety requirements is outlined
		13.11	Required documentation is prepared and accuracy is verified
		13.12	Maintenance and fault-finding procedures are outlined

14	**Explain typical machinery space control loops and UMS requirements**	**14.1**	Fuel oil heating, lube oil (LO) cooling and jacket water (JW) cooling loop showing cascade and split range systems are outlined
		14.2	Fuel oil viscosity control loop is outlined
		14.3	Common methods of boiler water control and simple combustion control with burner management for an auxiliary boiler are outlined
		14.4	Requirements and system arrangements for bridge control of main propulsion machinery, including changeover from local to bridge, are explained
		14.5	Common pressure control loops found in a ship's engine room are identified
		14.6	UMS requirements are outlined
		14.7	Troubleshooting procedures associated with control systems are outlined
		14.8	Procedures for software version control are outlined

Foundation Skills

Foundation skills essential to performance are explicit in the performance criteria of this unit of competency.

Range of Conditions

Range is restricted to essential operating conditions and any other variables essential to the work environment.

Unit Mapping Information

This unit replaces and is not equivalent to MARL026 Demonstrate intermediate knowledge of marine control systems and automation.

This unit replaces and is equivalent to MARL032 Demonstrate advanced knowledge of marine control systems and automation.

Links

Companion Volume implementation guide can be found in VetNet - https://vetnet.gov.au/Pages/TrainingDocs.aspx?q=772efb7b-4cce-47fe-9bbd-ee3b1d1eb4c2