



Australian Government

MARL049 Demonstrate advanced knowledge of marine control systems and automation

Release: 1

MARL049 Demonstrate advanced knowledge of marine control systems and automation

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

Elements describe the essential outcomes.

1 Explain control theory

PERFORMANCE CRITERIA

Performance criteria describe the performance needed to demonstrate achievement of the element.

- 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

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| | 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

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| | 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 |

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| 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>

Assessment Requirements for MARL049 Demonstrate advanced knowledge of marine control systems and automation

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Performance Evidence

Evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the elements and performance criteria on at least one occasion and include:

- accessing information and sketching diagrams, and interpreting and explaining testing requirements related to control systems on commercial vessels
- applying relevant work health and safety (WHS)/occupational health and safety (OHS) requirements and work practices
- assessing own work outcomes and maintaining knowledge of current codes, standards, regulations and industry practices
- explaining advanced principles of marine automation and process control, and imparting knowledge and ideas verbally, in writing and visually
- identifying and interpreting numerical and graphical information, including schematic diagrams, relevant to control systems on commercial vessels
- identifying and suggesting ways of rectifying faults and malfunctions in control systems on commercial vessels
- identifying methods, procedures and materials needed to operate and maintain control systems on commercial vessels
- reading and interpreting written information related to operating control systems on commercial vessels.

Knowledge Evidence

Evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the elements and performance criteria and include knowledge of:

- actuators and control valves, including:
 - electric
 - hydraulic
 - pneumatic
- analogue and digital programmable logic controllers (PLCs)
- Australian Standards for drawing symbols/layouts for schematic diagrams
- automatic control engineering and safety devices
- bridge control systems

- characteristics and functions of temperature, pressure and viscosity of fuel
- concept of 'fail safe' philosophy
- concepts of unmanned machinery spaces (UMS), and automated monitoring and control of machinery
- control and monitoring of ship machinery
- control:
 - loops
 - theory
- design features and system configuration of automatic control equipment and safety devices, including:
 - general requirements
 - generator and distribution system
 - main engine
 - steam boiler
- design features and system configuration of operational control equipment for electrical motors, including:
 - distribution
 - effects of varying frequency and voltage of alternating current (AC) motors
 - emergency power
 - insulated gate bipolar transistor (IGBT) motor speed control
 - motor control and protection
 - motor speed control by thyristors
 - three phase AC motors
 - three phase generators
 - three phase synchronous motors
 - three phase transformers
- design features of high voltage (HV) installations
- differential pressure transmitters
- electronic:
 - electronic systems circuit diagrams
 - temperature sensors and transmitters
 - transmitters
- electronic, power electronics
- faults, including:
 - earths
 - electronic component failure
 - high resistance joints
 - open circuits
 - power supply faults
 - short circuits

- fault-finding techniques for control systems
- features of hydraulic and pneumatic control equipment
- final control element arrangements
- governors and governor adjustments, including mismatching between prime mover types and responses
- industry standards for drawing symbols/layouts for schematic diagrams
- instrument process and control terms
- machinery space monitoring alarm and control systems
- marine electrotechnology
- measurement and test equipment used for fault finding electronic apparatus
- mechanical and electrical sensors
- meters, including:
 - rotometer
 - target meter
- methods of testing transmitter outputs, including:
 - MA test point
 - MV test point
 - no test points
- open and closed loop systems
- operation of hydraulic governors
- operation of pneumatic 3-term controller and controller adjustment procedures
- operation of PLCs
- operational safety of HV installation
- proportional-integral-derivative (PID) electronic controllers
- pneumatic and electrical instrumentation transmitters
- principles and operation of pneumatic control element and systems
- principles of:
 - basic electronic circuits
 - basic pneumatic systems and action of pneumatic instruments
 - process control
- safety devices, alarms and monitoring systems
- sensing and transmitting elements
- signal transmissions systems used for monitoring, controlling and shutting down machinery
- tests and procedures required to meet UMS requirements
- WHS/OHS legislation, policies and procedures.

Assessment Conditions

Assessors must hold credentials specified within the Standards for Registered Training

Organisations current at the time of assessment.

Assessment must satisfy the Principles of Assessment and Rules of Evidence and all regulatory requirements included within the Standards for Registered Training Organisations current at the time of assessment.

Assessment processes and techniques must be appropriate to the language, literacy and numeracy requirements of the work being performed and the needs of the candidate.

Practical assessment must occur in a workplace, or realistic simulated workplace, under the normal range of workplace conditions.

Simulations and scenarios may be used where situations cannot be provided in the workplace or may occur only rarely, in particular for situations relating to emergency procedures and adverse weather conditions where assessment would be unsafe, impractical or may lead to environmental damage.

Resources for assessment must include access to:

- relevant documentation, including workplace procedures, regulations, codes of practice and operation manuals
- tools, equipment, materials and relevant personal protective equipment (PPE) that replicate and are currently used in industry.

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