Australian Government

MARL039 Apply advanced principles of marine engineering thermodynamics

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 apply advanced principles of engineering thermodynamics to perform calculations and to explain the operation of marine machinery, including internal combustion and gas turbine engines, air compressors, steam condensers and refrigeration units.

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

- 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 Engineer Class 1 (STCW Chief Engineer Unlimited) or Engineer Class 2 (STCW Second Engineer Unlimited) and to 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 Calculate heat mixtures involving water equivalent, change of phase and feed heating	**1.1** Key terms associated with heat transmission are explained
	1.2 Heat transfer is calculated between liquids and solids using water equivalent
	1.3 Flow is differentiated from non-flow heating and cooling processes
	1.4 Effects of superheating and sub-cooling on steam plant efficiency are outlined
	1.5 Enthalpy is applied to heat mixture calculations with or without phase change
	1.6 Enthalpy is applied to calculate resultant conditions of hot wells involving multiple returns
	1.7 Steam conditions in a system when using throttling devices and separators are calculated
	1.8 Entropy is distinguished from enthalpy
	1.9 Entropy values are determined from standard tables
	1.10 Mass balance throughout a steam plant cycle is constructed and effects of pressure and temperature on cycle efficiency are analysed
2 Determine fluid properties of steam	**2.1** Relationship between saturated and superheated steam, including dryness fraction, is explained

		2.2	Tables and/or diagrams are used to find enthalpy and entropy values for liquid, part liquid-part vapour and vapour states
		2.3	Carnot cycle is outlined
		2.4	Rankine cycle is outlined
		2.5	Isentropic efficiency is explained
		2.6	Problems are solved involving the efficiency of steam turbines operating in the Rankine cycle
3	**Calculate boiler efficiency and boiler water density**	**3.1**	Concept of parts per million for density of boiler water is explained
		3.2	Changes in boiler water density due to contaminated feed are calculated
		3.3	How acceptable dissolved solids and water levels may be maintained in a boiler is shown
4	**Apply Dalton's Law of partial pressures to steam condensers**	**4.1**	Dalton's Law is applied to calculate air and condensate extraction from condensers
		4.2	Problems are solved involving cooling water mass flow and cooling water pump work
5	**Apply chemical equations for complete and incomplete combustion**	**5.1**	Atomic and molecular weights and kilogram-mole (kg-mol) are explained
		5.2	Elements and compounds present in fuel and the products of combustion are evaluated
		5.3	Calorific value of a fuel is calculated by chemical formula
		5.4	Mass of air required for stoichiometric combustion is calculated by gravimetric and volumetric analysis
		5.5	Chemical equations for combustion elements and compounds are developed and elements of combustion are analysed
		5.6	Air/fuel ratio, gravimetric and volumetric analysis are explained

		5.7	Air/fuel ratio is determined when supplied with composition of fuel and exhaust gas analysis
		5.8	Bomb calorimeter is used to find calorific value of a fuel
6.	**Calculate thermal expansion**	**6.1**	Coefficient of linear expansion and its significance to different materials is explained
		6.2	Clearances and shrunk fit allowances are calculated
		6.3	Stresses generated with restricted expansion are calculated
		6.4	Volumetric expansion of solid and liquids, and allowance required for fluid expansion in tanks and systems is calculated
7	**Calculate gas conditions, work and thermal efficiency of internal combustion engines**	**7.1**	Compression and pressure ratio is explained and related to combined gas law equation
		7.2	Combined gas law equation is applied to constant volume and constant pressure processes
		7.3	Specific gas constant of a gas or mixture of gases is calculated
		7.4	Universal gas constant from Avogadro's hypothesis is determined
		7.5	Differentiation is made between specific heat of gases, ratio of specific heats, work and change in internal energy
		7.6	Changes in internal energy associated with specific heat of gases, ratio of specific heats and work are calculated
		7.7	First law of thermodynamics is applied to thermodynamic processes in a closed system
		7.8	Second law of thermodynamics is applied to find thermal efficiency of Carnot cycle
		7.9	Mathematical formula is applied to solve problems related to ideal constant volume air standard cycle

		7.10	Mathematical formula is applied to solve problems related to diesel and dual cycles
8	**Calculate performance of internal combustion and gas turbine engines**	**8.1**	Processes associated with expansion and compression of gases are explained
		8.2	Gas conditions and index of compression at end of each process are determined
		8.3	Work formula is derived for each process and derived formula is applied to calculate work and power per cycle
		8.4	Air standard cycle is applied to determine amount of fuel consumed and work produced by an internal combustion engine
		8.5	Differentiation is made between air standard efficiency and thermal efficiency
		8.6	Pressure/volume (P/V) and out-of-phase engine indicator diagrams are analysed
		8.7	Work, power, mean effective pressure and thermal efficiency of internal combustion engine cycles are calculated
		8.8	Heat transfer to jacket cooling systems is calculated
		8.9	Open and closed systems for gas turbines are outlined
		8.10	Temperature/entropy diagrams are applied to illustrate gas turbine cycles
		8.11	Power, isentropic efficiencies, thermal efficiency, work and fuel consumption for gas turbine cycles are calculated
		8.12	Methods to increase efficiency of gas turbines are specified
		8.13	Reheaters and intercoolers and how they improve efficiency is explained
9	**Analyse air compressor performance**	**9.1**	Compressor types are classified

		9.2	P/V diagram is applied to describe operating cycle of reciprocating compressors
		9.3	Work done by constant pressure, isothermal processes and polytropic processes in reciprocating compressors is calculated
		9.4	Effect of clearance volume on efficiency of reciprocating compressors is explained
		9.5	Volumetric efficiency at free air conditions is explained
		9.6	Volume, mass flow and temperature are calculated at completion of each process in reciprocating compressors
		9.7	Intercooling and after-cooling effects on overall efficiency of reciprocating compressors is explained
		9.8	Heat transfer to air or cooling water from an air compressor is calculated
		9.9	Work is calculated for isothermal and adiabatic compression, and effect of clearance for reciprocating compressor
		9.10	Formula to calculate work and efficiency of centrifugal compressors is derived
		9.11	Pressure ratio for compressor types is analysed
10	**Analyse vapour compression refrigeration cycles**	**10.1**	Design parameters for a vapour compression cycle are explained
		10.2	Pressure/enthalpy diagram is prepared for a refrigeration cycle
		10.3	Heat rejected, work done and coefficient of performance (COP) for a basic cycle is calculated
		10.4	Effect of subcooling and superheating is shown on a temperature/entropy diagram
		10.5	COP is calculated with evaporators operating at two different pressures

		10.6	Properties and hazards of refrigerants used in refrigeration and air conditioning (RAC) systems are identified
		10.7	Basic air conditioning cycles are explained
11	**Apply psychrometric principles to solve air conditioning problems**	**11.1**	Comfort conditions for air conditioning systems are defined
		11.2	Key parameters used in defining air condition are illustrated on a psychrometric chart
		11.3	Cooling loads are calculated
		11.4	Problems associated with air delivering and distribution methods are analysed
		11.5	Methods of controlling noise and vibration in air conditioning systems are analysed
12	**Analyse different methods of heat transfer**	**12.1**	Different forms of heat transfer are identified
		12.2	Heat flow through composite divisions is calculated
		12.3	Insulation dimensions and interface temperatures are determined
		12.4	Problems relating to radiated energy are solved by applying Stefan-Boltzmann Law
		12.5	Relative efficiency of contra-flow heat exchange is determined
		12.6	Problems in heat exchangers are solved by applying log mean temperature difference
		12.7	Radial conduction of heat through a thin cylinder is calculated
13	**Perform calculations related to engine power and heat balances**	**13.1**	Formula is applied to solve problems related to indicated power of internal combustion engines
		13.2	Formula is applied to solve problems related to brake power of internal combustion engines

		13.3	Morse test is applied to determine the indicated power of internal combustion engines
		13.4	Tabular and graphical heat balance diagrams are applied to calculate mechanical, thermal and overall efficiencies of internal combustion engines
14	**Determine steam velocity**	**14.1**	Principles and differences between pressure and velocity changes in reaction and impulse steam turbines are explained
		14.2	Velocity diagrams to calculate steam velocity at exit of nozzles and blades are applied
		14.3	Graphical and mathematical methods to determine blade angle, steam velocity, thrust, power, and efficiency of single stage impulse and reaction steam turbines are applied
15	**Use nozzles**	**15.1**	Convergent nozzles are compared to convergent-divergent nozzles
		15.2	Steady flow equation is used to determine nozzle exit speed in terms of enthalpy
		15.3	Conditions for maximum mass flow through a nozzle are established

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 MARL015 Apply intermediate principles of marine engineering thermodynamics.

This unit replaces and is equivalent to MARL019 Apply advanced principles of marine engineering thermodynamics.

Links

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