



Australian Government

MARL039 Apply advanced principles of marine engineering thermodynamics

Release: 1

MARL039 Apply advanced principles of marine engineering thermodynamics

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

Elements describe the essential outcomes.

1 Calculate heat mixtures involving water equivalent, change of phase and feed heating

PERFORMANCE CRITERIA

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

- 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
- 2.1** 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

2 Determine fluid properties of steam

		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

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| 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 |

10	Analyse vapour compression refrigeration cycles	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
		10.1	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

11	Apply psychrometric principles to solve air conditioning problems	10.7	Basic air conditioning cycles are explained
		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
12	Analyse different methods of heat transfer	11.5	Methods of controlling noise and vibration in air conditioning systems are analysed
		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
13	Perform calculations related to engine power and heat balances	12.7	Radial conduction of heat through a thin cylinder is calculated
		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>

Assessment Requirements for MARL039 Apply advanced principles of marine engineering thermodynamics

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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:

- assessing own work outcomes and maintaining knowledge of current codes, standards, regulations and industry practices
- communicating knowledge and ideas through verbal, written and visual means
- explaining advanced principles of engineering thermodynamics
- identifying and applying relevant mathematical formulas and techniques to solve advanced problems related to engineering thermodynamics
- identifying and interpreting numerical and graphical information, and performing advanced mathematical calculations related to engineering thermodynamics, such as calculation of power, isentropic efficiencies, thermal efficiency, and work and fuel consumption for gas turbine cycles
- identifying, collating and processing information required to perform advanced calculations related to engineering thermodynamics
- reading and interpreting written information needed to perform complex calculations related to engineering thermodynamics
- solving problems using appropriate laws and principles
- using calculators to perform accurate, reliable and complex mathematical calculations.

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:

- air compressors, including:
 - components
 - faults and hazards
 - first law of thermodynamics
 - operating cycle of reciprocating air compressors
 - performance characteristics
 - property diagrams
 - types

- uses
- working principles of reciprocating compressors
- atomic and molecular weights and the kilogram-mole (kg-mol)
- basic gas expansion and contraction, heat transfer
- basic principles of engineering thermodynamics
- Daltons Law of partial pressures
- enthalpy
- expansion and compression of gases
- fluid properties, including:
 - density
 - dryness fraction
 - enthalpy of water
 - pressure
 - saturated steam
 - specific volume
 - superheated steam
 - temperature
- gas laws
- gas turbines
- heat cycles, including:
 - marine diesel engine
 - marine steam boiler and steam turbine
 - marine gas turbine
- heat transfer, including:
 - forms:
 - conduction
 - convection
 - radiation
 - methods
 - principles
- internal combustion engines, including:
 - heat engine cycles
 - improvements
 - operating principles of two-stroke and four-stroke internal combustion engines
 - performance characteristics
 - second law of thermodynamics
- internal combustion engine cycles
- key terms, including:
 - enthalpy of fusion
 - evaporation

- sensible heat
- transfer of heat energy
- laws of thermodynamics
- methods, including:
 - duct attenuators
 - duct lining
 - lined duct splitters
 - lined plenums
 - natural attenuation
 - sound absorbing materials/placement
 - vibration isolators
 - white noise
- noise and vibration control, including:
 - fundamentals of sound
 - noise and vibration problems
 - methods of control
 - operating cycle of reciprocating air compressors
- operating principles of two-stroke and four-stroke internal combustion engines
- parameters, including:
 - adiabatic saturation or constant enthalpy
 - humidifying or dehumidifying
 - latent heat
 - sensible heat
- principles of refrigeration, including:
 - processes:
 - adiabatic
 - isothermal
 - polytropic
- Rankine cycle
- refrigeration and air conditioning (RAC) cycles and systems
- steam plants
- International System of Units (SI)
- tables and/or diagrams, including:
 - pressure-enthalpy
 - pressure-specific volume
 - specific enthalpy-specific entropy
 - temperature-pressure
 - temperature-specific enthalpy
 - temperature-specific entropy
- thermodynamic and heat transmission, including:

- air conditioning combustion
- gas cycles/engine analysis
- heat transfer
- properties and vapours
- refrigeration
- steam cycles
- thermodynamic principles
- thermodynamic processes, including:
 - adiabatic
 - isobaric
 - isochoric
 - isothermal
 - polytropic
- thermal efficiency calculations
- work health and safety (WHS)/occupational health and safety (OHS) requirements and work practices.

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) currently used in industry.

Links

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<https://vetnet.gov.au/Pages/TrainingDocs.aspx?q=772efb7b-4cce-47fe-9bbd-ee3b1d1eb4c2>