



Australian Government

MARL043 Apply basic principles of marine engineering thermodynamics

Release: 1

MARL043 Apply basic 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 basic principles of engineering thermodynamics to perform calculations and to explain the operation of marine machinery, including engines, compressors, steam plants, and refrigeration and air conditioning (RAC) units.

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

- Engineer Watchkeeper (STCW Engineer Watchkeeper 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 Watchkeeper (STCW Engineer Watchkeeper Unlimited) 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.

PERFORMANCE CRITERIA

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

1 Explain common thermodynamic principles

- 1.1** Desired International System of Units (SI) applicable to thermodynamic calculations are developed
- 1.2** Basic properties of fluids are outlined
- 1.3** Gauge pressure is distinguished from absolute pressure
- 1.4** Temperature is defined and temperature scales are outlined
- 1.5** Calculations are performed by applying formulae for work, power and efficiency

2 Calculate properties of gas during expansion and compression

- 2.1** Calculations are performed by applying Boyle's, Charles's and combined gas laws
- 2.2** Gas equation is derived and applied to gas process calculations
- 2.3** Specific heat of gases and the relationship between constant pressure (C_p), constant volume (C_v), gas constant R and Gamma (γ) are defined
- 2.4** Heat transfer is calculated for C_p and C_v processes
- 2.5** Isothermal, adiabatic and polytropic processes are outlined and properties of gases after expansion and compression, including the effects of turbocharging, are calculated
- 2.6** Work required to compress gases is illustrated and calculated

3 Explain methods of heat transfer

- 3.1** Different forms of heat transfer and their application to marine systems are explained

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| | 3.2 | Heat transfer through flat layers is calculated |
| | 3.3 | Purpose of insulation is explained |
| 4 | Explain enthalpy and apply to mixture calculations | |
| | 4.1 | Heat energy is defined |
| | 4.2 | Fundamental formula for heat energy transfer is developed |
| | 4.3 | Specific heat and its application are identified |
| | 4.4 | Enthalpy and change of phase are outlined |
| | 4.5 | Heat mixture problems involving water equivalent, ice, water and steam are solved |
| | 4.6 | Specific heat of materials are calculated |
| | 4.7 | Latent heat and dryness fraction are identified |
| | 4.8 | Steam tables are used to find values of enthalpy for water, saturated and superheated steam and dryness fraction |
| | 4.9 | Temperature/enthalpy diagram is constructed from steam table data |
| 5 | Explain steam plants and calculate thermal efficiency | |
| | 5.1 | Basic steam plant cycles are sketched and function of each component is outlined |
| | 5.2 | Steam cycles on a temperature/enthalpy diagram are illustrated |
| | 5.3 | Effects of superheating and under-cooling are clarified |
| | 5.4 | Calculations are performed for heat supplied, rejected, work and thermal efficiency of a steam plant |
| | 5.5 | Methods of improving cycle efficiency are outlined |
| 6 | Explain operation of internal combustion engine cycles | |
| | 6.1 | Operating principles of two-stroke and four-stroke internal combustion engines are outlined |
| | 6.2 | Differentiation is made, by use of a pressure/volume diagram, between Otto, diesel and dual combustion cycles |

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| | 6.3 | Mean effective pressure is calculated from an indicator diagram |
| | 6.4 | Indicated power formula is developed and related calculations are solved |
| | 6.5 | Specific fuel consumption is defined and calculated |
| | 6.6 | Ideal cycle and air standard efficiency is defined |
| 7 | Explain operating cycle of reciprocating air compressors | |
| | 7.1 | Pressure/volume diagram is used to describe operating cycle of single stage reciprocating air compressors |
| | 7.2 | Mass of air delivered by single stage reciprocating air compressors is calculated |
| | 7.3 | Clearance volume and its effect on volumetric efficiency is outlined, and volumetric efficiency is calculated |
| | 7.4 | Work per cycle for isothermal and polytropic processes is calculated |
| 8 | Explain operating cycle of RAC plant | |
| | 8.1 | Principle of refrigeration is outlined |
| | 8.2 | Temperature/enthalpy and pressure/enthalpy diagrams are compared |
| | 8.3 | Refrigerants used in RAC machines are identified |
| | 8.4 | Refrigeration effect and plant capacity are defined |
| | 8.5 | Refrigeration tables are used to calculate refrigeration effect and condition of vapour after expansion |
| | 8.6 | Operating cycle of self-contained and centralised air conditioning systems are outlined and compared |
| | 8.7 | Relative humidity is defined and key features of a psychrometric chart are outlined |
| 9 | Apply linear, superficial and volumetric expansion equations to calculate expansion of liquids and metals | |
| | 9.1 | Expansion processes for metals is defined |
| | 9.2 | Coefficient of linear expansion is outlined |

- 9.3** Linear expansion is applied to calculate machinery clearances and to shrink fit allowances
- 9.4** Superficial and volumetric expansion of solids is calculated and recorded
- 9.5** Apparent expansion of liquids in tanks is calculated and recorded

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 equivalent to MARL011 Apply basic 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 MARL043 Apply basic 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:

- identifying and applying relevant mathematical formulas and techniques to solve basic problems related to engineering thermodynamics
- identifying and interpreting numerical and graphical information, and performing basic mathematical calculations related to engineering thermodynamics, such as gas expansion and contraction, heat transfer, thermal efficiency, and the expansion of liquids and solids
- identifying, collating and processing information required to perform basic calculations related to engineering thermodynamics
- maintaining knowledge of current codes, standards, regulations and industry practices
- performing accurate and reliable mathematical calculations using a calculator
- reading and interpreting written information needed to perform basic calculations related to engineering thermodynamics
- solving problems using appropriate laws and principles.

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:

- basic principles of engineering thermodynamics
- enthalpy
- expansion processes for metals (conduction, convection and radiation)
- forms of heat transfer (conduction, convection and radiation)
- gas laws
- heat, including relationship between temperature, heat energy and heat transfer
- internal combustion engine cycles
- methods of heat transfer
- operating cycle of reciprocating air compressors
- operating principles of two-stroke and four-stroke internal combustion engines
- principles of refrigeration
- properties of fluids (density, mass, pressure, specific volume, temperature)
- relationships between forms of energy, work and power

- International System of Units (SI)
- steam plants
- thermodynamics, including:
 - energy change
 - heat transfer
 - ideal gases
 - thermodynamic energy
 - thermodynamic principles
 - thermodynamic processes
 - thermodynamic properties
 - thermodynamic systems
 - vapours
 - work transfer
- thermal efficiency calculations.

Assessment Conditions

Assessors must satisfy applicable regulatory requirements, which include requirements in 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:

- applicable documentation, such as legislation, regulations, codes of practice, workplace procedures and operational manuals
- diagrams, specifications and other information required for performing basic calculations related to engineering thermodynamics
- tools, equipment, machinery, materials and relevant personal protective equipment (PPE) currently used in industry.

Links

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