



Australian Government

MARL6002A Apply intermediate principles of marine engineering thermodynamics

Release 1

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Modification History

Release 1

This is the first release of this unit.

Unit Descriptor

This unit involves the skills and knowledge required to apply intermediate principles of marine engineering thermodynamics to perform calculations and explain the operation of marine machinery, including engines, compressors, steam plants, refrigeration and air-conditioning units.

Application of the Unit

This unit applies to the work of a Marine Engineers Class 2 on commercial vessels greater than 3000 kW and forms part of the requirements for the Certificate of Competency Marine Engineer Class 2 issued by the Australian Maritime Safety Authority (AMSA).

Licensing/Regulatory Information

Not applicable.

Pre-Requisites

Not applicable.

Employability Skills Information

This unit contains employability skills.

Elements and Performance Criteria Pre-Content

Elements describe the essential outcomes of a unit of competency.

Performance criteria describe the required performance needed to demonstrate achievement of the element. Assessment of performance is to be consistent with the evidence guide.

Elements and Performance Criteria

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| 1 Calculate heat mixtures involving water equivalent, change of phase, and feed heating | <ul style="list-style-type: none">1.1 Key terms associated with heat transmission are explained1.2 Heat transfer is calculated between liquids and solids using water equivalent1.3 Flow is differentiated from non-flow heating and cooling processes1.4 Effects of superheating and sub-cooling on steam plant efficiency are outlined1.5 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 | <ul style="list-style-type: none">2.1 Relationship between saturated and superheated steam, including dryness fraction, is explained2.2 Regions on a temperature/enthalpy diagram are constructed and identified2.3 Steam tables are used to determine fluid properties2.4 Changes of enthalpy throughout a system are identified2.5 Operating principles and application in steam plants of throttling, separating and combined throttling, and separating calorimeters are explained2.6 Calorimeters are applied to determine dryness fraction of steam |
| 3 Calculate boiler efficiency and boiler water density | <ul style="list-style-type: none">3.1 Efficiency of saturated and superheated steam boilers is calculated3.2 Where loss of efficiency occurs is shown3.3 Concept of parts per million for density of boiler water is explained3.4 Changes in boiler water density due to contaminated feed are calculated3.5 How acceptable dissolved solids and water levels may be maintained in a boiler is shown |

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| 4 Determine steam turbine velocity | <ul style="list-style-type: none">4.1 Principles and differences between pressure and velocity changes in reaction and impulse steam turbines are explained4.2 Velocity diagrams to calculate steam velocity at exit of nozzles and blades are applied4.3 Graphical and mathematical methods to determine blade angle, steam velocity, thrust, power, and efficiency of single stage impulse and reaction steam turbines are applied |
| 5 Calculate calorific value and the air fuel ratio for solid and liquid fuels | <ul style="list-style-type: none">5.1 Elements and compounds present in fuel and the products of combustion are evaluated5.2 Air/fuel ratio, gravimetric and volumetric analysis are explained5.3 Chemical equations for combustion elements and compounds are developed and elements of combustion are analysed5.4 Bomb calorimeter is used to find calorific value of a fuel5.5 Formula to calculate calorific value of a fuel from mass analysis of fuel is applied5.6 Air required for combustion is calculated |
| 6 Calculate thermal expansion | <ul style="list-style-type: none">6.1 Coefficient of linear expansion and its significance to different materials is explained6.2 Clearances and shrink fit allowances are calculated6.3 Stresses generated with restricted expansion are calculated6.4 Volumetric expansion of solid and liquids, and allowance required for fluid expansion in tanks and systems is calculated |
| 7 Apply gas law equations | <ul style="list-style-type: none">7.1 Compression and pressure ratio is explained and related to combined gas law equation7.2 Combined gas law equation is applied to constant volume and constant pressure processes7.3 Specific gas constant of a gas or mixture of gases is |

- calculated
- 7.4 Differentiation is made between specific heat of gases, ratio of specific heats, work and change in internal energy
- 7.5 Changes in internal energy associated with specific heat of gases, ratio of specific heats and work are calculated
- 8 Calculate gas conditions, work and thermal efficiency of internal combustion 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 Thermal efficiency of engine cycles is calculated
- 9 Perform calculations related to refrigeration and air conditioning cycles**
- 9.1 Pressure/enthalpy diagram is applied to describe the refrigeration cycle
- 9.2 Importance of superheating and under-cooling in determining stability and well-functioning of refrigeration systems is explained
- 9.3 Properties and hazards of refrigerants used in refrigeration and air conditioning systems are identified
- 9.4 Refrigeration tables are applied to calculate refrigeration effect, cooling load and coefficient of performance
- 9.5 Basic air conditioning cycles are explained
- 9.6 Wet and dry bulb temperatures are explained
- 9.7 Humidity conditions are determined using psychrometric charts

10 Solve heat transfer problems involving flat plates and thin cylinders

- 10.1 Different *forms of heat transfer* are identified
- 10.2 Heat flow through composite flat plates using thermal conductivity is calculated
- 10.3 Interface temperatures of composite flat layers are calculated
- 10.4 Radial conduction of heat through a thin cylinder is calculated

11 Solve problems related to single and multi stage air compression

- 11.1 Pressure–volume diagram is applied to describe operating cycle of reciprocating compressors
- 11.2 Work done by constant pressure, isothermal processes and polytropic processes in reciprocating compressors is calculated
- 11.3 Effect of clearance volume on efficiency of reciprocating compressors is explained
- 11.4 Volumetric efficiency and free air discharge in reciprocating compressors is calculated
- 11.5 Volume, mass flow and temperature are calculated at completion of each process in reciprocating compressors
- 11.6 How inter-cooling and after-cooling affects overall efficiency of reciprocating compressors is explained
- 11.7 Quantity of cooling water required by reciprocating compressors is calculated

12 Perform calculations related to engine power and heat balances

- 12.1 Indicator and timing diagrams for internal combustion engines are plotted
- 12.2 Formula is applied to solve problems related to indicated power of internal combustion engines
- 12.3 Formula is applied to solve problems related to brake power of internal combustion engines
- 12.4 Morse test is applied to determine the indicated power of internal combustion engines
- 12.5 Tabular and graphical heat balance diagrams are applied to calculate mechanical, thermal and overall efficiencies of internal combustion engines

Required Skills and Knowledge

This section describes the skills and knowledge required for this unit.

Required Skills:

- Assess own work outcomes and maintain knowledge of current codes, standards, regulations and industry practices
- Explain basic principles of marine engineering thermodynamics
- Identify and apply relevant mathematical formulas and techniques to solve basic problems related to marine engineering thermodynamics
- Identify and interpret numerical and graphical information, and perform basic mathematical calculations related to marine engineering thermodynamics, such as gas expansion and contraction, heat transfer, and thermal efficiency
- Identify, collate and process information required to perform basic calculations related to marine engineering thermodynamics
- Impart knowledge and ideas through verbal, written and visual means
- Read and interpret written information needed to perform basic calculations related to marine engineering thermodynamics
- Use calculators to perform mathematical calculations

Required Knowledge:

- Air compressor:
 - 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
- Enthalpy
- Expansion and compression of gases
- Gas laws
- Internal combustion engines:
 - second law of thermodynamics
 - heat engine cycles
 - operating principles of two stroke and four stroke internal combustion engines
 - performance characteristics
 - improvements

- Principles of:
 - heat transfer
 - refrigeration
- Refrigeration and air conditioning cycles
- Steam plants
- System International (SI) units
- Thermal efficiency calculations
- Thermodynamic principles
- Work health and safety (WHS)/occupational health and safety (OHS) requirements and work practices

Evidence Guide

The evidence guide provides advice on assessment and must be read in conjunction with the performance criteria, the required skills and knowledge, the range statement and the Assessment Guidelines for the Training Package.

Critical aspects for assessment and evidence required to demonstrate competency in this unit

The evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the Elements, Performance Criteria, Required Skills, Required Knowledge and include:

- making accurate and reliable calculations
- solving problems using appropriate laws and principles.

Context of and specific resources for assessment

Performance is demonstrated consistently over time and in a suitable range of contexts.

Resources for assessment include access to:

- industry-approved marine operations site where intermediate principles of marine engineering thermodynamics can be applied
- diagrams, specifications and other information required for performing intermediate calculations related to marine engineering thermodynamics
- technical reference library with current publications on intermediate marine thermodynamics
- tools, equipment and personal protective equipment currently used in industry
- relevant regulatory and equipment documentation that impacts on work activities
- range of relevant exercises, case studies and/or other simulated practical and knowledge assessments
- appropriate range of relevant operational situations in the workplace.

In both real and simulated environments, access is required to:

- relevant and appropriate materials and equipment
- applicable documentation including workplace procedures, regulations, codes of practice and operation manuals.

Method of assessment

Practical assessment must occur in an:

- appropriately simulated workplace environment and/or
- appropriate range of situations in the workplace.

A range of assessment methods should be used to assess practical skills and knowledge. The following examples are appropriate to this unit:

- direct observation of the candidate applying intermediate

principles of marine engineering thermodynamics

- direct observation of the candidate applying relevant WHS/OHS requirements and work practices.

Guidance information for assessment

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended.

In all cases where practical assessment is used it should be combined with targeted questioning to assess Required Knowledge.

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

Range Statement

The range statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording, if used in the performance criteria, is detailed below.

Key terms may include:

- Enthalpy of fusion
- Evaporation
- Sensible heat
- Transfer of heat energy

Processes may include:

- Adiabatic
- Isothermal
- Polytropic

Fluid properties include:

- Density
- Dryness fraction
- Enthalpy of water
- Pressure
- Saturated steam
- Specific volume
- Superheated steam
- Temperature

Forms of heat transfer may include:

- Conduction
- Convection
- Radiation

Unit Sector(s)

Not applicable.

Competency Field

Marine Engineering