



Australian Government

MARL021 Apply advanced principles of naval architecture

Release: 1

MARL021 Apply advanced principles of naval architecture

Modification History

Release 1. New unit of competency.

Application

This unit involves the skills and knowledge required to perform complex calculations related to the seaworthiness of commercial vessels, including those dealing with vessel stability, trim, fuel consumption, buoyancy, vessel strength and vibration.

This unit applies to the work of a Marine Engineer Class 1 on commercial vessels of unlimited propulsion power and forms part of the requirements for the Certificate of Competency Marine Engineer Class 1 issued by the Australian Maritime Safety Authority (AMSA).

No licensing, legislative or certification requirements apply to this unit at the time of publication.

Pre-requisite Unit

Not applicable.

Competency Field

L – Marine Engineering

Unit Sector

Not applicable.

Elements and Performance Criteria

Elements describe the essential outcomes.

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

1 Apply Simpson's First and Second Rules to calculate areas, volumes and displacement of ship shapes using TPC values	1.1	Simpson's (Mid-Ordinate) First Rule and Second Rule, with typical applications, using half and full ordinates is explained
	1.2	Areas of water planes, bulkheads and elemental areas are calculated
	1.3	Problems of immersed hull volume, appendage volumes and non-standard tank volumes are solved
	1.4	Archimedes Principles of buoyancy are explained

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| | 1.5 | TPC with application of Simpson's Rules to find displacement is explained |
| | 1.6 | Change in draught with mass addition and removal using TPC to give parallel sinkage or rise is explained |
| | 1.7 | Problems of vessel displacement given water plane areas or TPC values are solved |
| | 1.8 | TPC curves and displacement curves for given values are constructed |
| 2 | Apply ship form coefficients | |
| | 2.1 | Ship form coefficients and their uses are defined |
| | 2.2 | Coefficients are calculated given underwater form particulars |
| | 2.3 | Problems of ship form coefficients following change in length and draught are solved |
| 3 | Calculate changes in draft due to fluid density | |
| | 3.1 | Load line freeboard measurement and markings required for change in fluid density are explained |
| | 3.2 | Formula for change in mean draft due to change in density is derived |
| | 3.3 | Change in draft between fluids of two densities are calculated |
| | 3.4 | Formula to derive fresh water allowance is applied |
| | 3.5 | Changes in mean draft due to changes in density and loading are calculated |
| 4 | Solve stability problems | |
| | 4.1 | Calculations are performed to solve problems associated with adding, removing and transferring masses on ships |
| | 4.2 | Centre of gravity of a suspended mass is explained |
| | 4.3 | Calculations are performed to solve problems associated with suspended masses |
| | 4.4 | How KG and LCG can be obtained from stability information is explained |
| | 4.5 | Creation of overturning moments by mass addition, removal or transfer transversely, including cargo shift or loss is explained |
| | 4.6 | Calculations are performed to solve problems of small angle transverse stability |

	4.7	Purpose of inclining experiments, weighing tests and roll period tests to determine stability characteristics are explained
	4.8	Calculations are performed to solve problems associated with inclining experiments and roll period tests
5 Calculate loss of transverse stability due to fluid free surface	5.1	Principles of free surface loss of GM are explained
	5.2	KG solid is differentiated from KG fluid
	5.3	Second moment of area is applied to obtain free surface moment of inertia and is related to stability criteria for standard conditions
	5.4	Problems of liquid free surface for simple and complex geometry compartments including variation in filling rates are solved
	5.5	Wall-sided formula and factors that lead to negative GM creating an angle of loll are explained
	5.6	Problems involving correction of loll angle are solved
6 Calculate large angle transverse static and dynamical stability	6.1	How GZ and KN righting levers are obtained from cross curves of stability is explained
	6.2	KN values are converted to GZ
	6.3	Dynamical stability is explained
	6.4	IMO requirements for intact and damaged stability cases as well as different vessel types, using typical values from stability files are applied
	6.5	Problems of large angle transverse stability, including changes due to redistribution of mass on board are solved and results against IMO requirements are evaluated
	6.6	Graphical solutions to large angle transverse stability problems identifying key points are prepared
7 Solve problems of hydrostatics	7.1	Importance of area and volume centroids is explained
	7.2	Methods of determining KB, LCB, LCF and bulkhead area centroids are explained
	7.3	Calculations are performed to determine centroids of shipboard areas and volumes

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| | 7.4 | Impact of hydrostatic pressure and load on vertical and horizontal surfaces is explained |
| | 7.5 | Methods of calculating pressure, load, shear force and bending moment diagrams for typical tank structures are applied |
| | 7.6 | Problems are solved in hydrostatics relating to pressure and loads on ship structures, including graphical solution of shear force diagrams of rectangular bulkheads and their elemental stiffeners |
| | 7.7 | Effective weld area of bulkhead attachment is calculated |
| 8 | | Perform trim and draft calculations |
| | 8.1 | Meaning of trim and how trim occurs is explained |
| | 8.2 | Standard trimming moments resulting from mass addition, removal, transfer, flooding or combinations of these factors are explained |
| | 8.3 | Change of trim is calculated using MCT1cm, GML and BML |
| | 8.4 | Problems of applied trimming moments to determine final vessel draughts are solved |
| | 8.5 | True mean draft is differentiated from apparent mean draft by applying correction for layer |
| | 8.6 | Calculations are performed to solve problems associated with true mean draft |
| | 8.7 | Problems of combined trim and transverse stability from typical fluid transfer in both a longitudinal and transverse direction are solved |
| 9 | | Calculate voyage and daily fuel consumption |
| | 9.1 | Problems of fuel consumption are solved using the admiralty coefficient for various speed indexes |
| | 9.2 | Optimum vessel speed for combined propulsive and auxiliary fuel consumptions is determined |
| | 9.3 | Calculations are performed to show relationships between fuel consumption and displacement |
| | 9.4 | Calculations are performed to show relationships between daily fuel consumption and speed |
| | 9.5 | Calculations are performed to show relationships between voyage consumption, speed and distance travelled |

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| 10 Apply principles of loading to ship structures to determine strength characteristics | 10.1 | Distribution of concentrated and point masses, buoyancy, load, shear force and bending moments are explained using simple loaded beam principles |
| | 10.2 | Calculations and diagrams are used to solve problems involving loaded conditions of simple box-shaped vessels, identifying location and value of maximum shear force and bending moments |
| | 10.3 | Empirical formula is applied to solve problems involving bending and direct stress in beams |
| 11 Apply empirical formula to solve vibration problems | 11.1 | Causes and adverse effects of ship vibration are explained |
| | 11.2 | Natural hull vibration is explained |
| | 11.3 | Schlick formula is applied to determine natural frequency of ship hull vibrations |
| | 11.4 | Ways of preventing or reducing local vibration are identified |
| 12 Solve buoyancy problems | 12.1 | Calculations are performed to solve problems of lost buoyancy and sinkage into homogeneous mud due to tide fall with insufficient under keel clearance |
| | 12.2 | Calculations are performed to solve problems of simple box-shaped and standard hull forms involving change in trim due to flooding end compartments |
| 13 Perform rudder calculations | 13.1 | Types of rudders in use on ships are outlined |
| | 13.2 | Reasons for using balanced rudders are identified |
| | 13.3 | Application of force acting normal to a rudder surface (F_n), its components and the influence of Propeller Race Effect is explained |
| | 13.4 | Rudder Centre of Effort for ahead and astern conditions is obtained to determine torque on rudder stock for conventional rudders or equivalent twisting moment (ETM) for spade rudders |
| | 13.5 | Calculations are performed involving simple and complex rudder shapes to calculate speed limitations ahead and astern for stated safety factor and material properties |
| | 13.6 | Calculations are performed involving simple and complex rudder shapes to determine rudder stock and coupling bolt diameters |

14 Perform rudder calculations

- 14.1 Frictional resistance to motion of a vessel given the empirical formulae for frictional coefficient 'f' of the form is determined
- 14.2 Froudes Laws of Comparison is explained
- 14.3 Meaning of the term 'corresponding speed' is explained
- 14.4 Law of comparison is applied to determine residuary resistance of a ship if residuary resistance of a scale model of vessel is known or can be determined
- 14.5 Differentiation is made between effective power (naked), P_{SEP} effective power and ship correlation factor
- 14.6 Effective power requirements of a full sized ship given total resistance to motion measured on a scale model of vessel towed at corresponding speed is calculated
- 14.7 Problems of resistance and powering for full size vessels and models are solved

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.

Ship form coefficients include one or more of the following:

- block coefficient
- midship section area coefficient
- prismatic coefficient
- waterplane area coefficient

Key points include one or more of the following:

- maximum GZ value and angle of occurrence
- points of vanishing stability
- range of positive stability

Causes include one or more of the following:

- action of the sea
- fluctuating forces on propeller
- operation of deck machinery
- out-of-balance forces in main or auxiliary machinery
- propeller-hull interaction

Adverse effects include one or more of the following:

- discomfort to passengers and crew
- failure of equipment
- structural failure

Unit Mapping Information

This unit replaces and is equivalent to MARL6008A Apply advanced principles of naval architecture.

Links

Companion Volume implementation guides are found in VETNet -

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

Assessment Requirements for MARL021 Apply advanced principles of naval architecture

Modification History

Release 1. New unit of competency.

Performance Evidence

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

- assessing own work outcomes and maintaining knowledge of current codes, standards, regulations and industry practices
- identifying and applying relevant mathematical formulas and techniques to solve complex problems related to speed, fuel consumption and stability of commercial vessels
- identifying and interpreting numerical and graphical information, and performing mathematical calculations related to shipboard areas and volumes, vessel displacement, ship dimensions, centre of gravity, vessel speed, fuel consumption and hydrostatic pressure
- identifying, collating and processing information required to perform calculations related to speed, fuel consumption and stability of commercial vessels
- imparting knowledge and ideas through verbal, written and visual means
- reading and interpreting written information needed to perform calculations related to seaworthiness of commercial vessels
- 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, performance criteria and range of conditions and include knowledge of:

- advanced principles of naval architecture
- buoyancy
- centre of gravity – KG, VCG and LCG
- centre of gravity calculations
- density correction formula
- dynamical stability
- fuel consumption calculations
- hydrostatic pressure
- principle of displacement

- principle structural members of a ship and the proper names of the various parts
- rudders
- ship:
 - displacement
 - measurements
 - resistance
 - stability
 - stability calculations
- shipboard:
 - areas
 - volumes
- ship form coefficients
- Simpson's Rules
- stability problems
- tonnes per centimetre immersion (TPC)
- trim and stress tables, diagrams and stress calculating equipment
- vessel speed calculations
- vibration
- work health and safety/occupational health and safety (WHS/OHS) requirements and work practices.

Assessment Conditions

Assessors must satisfy National Vocational Education and Training Regulator (NVR)/Australian Quality Training Framework (AQTF) assessor requirements.

Assessment must satisfy the National Vocational Education and Training Regulator (NVR)/Australian Quality Training Framework (AQTF) standards.

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.

Assessment must occur in workplace operational situations or where these are not available, in an industry-approved marine operations site where advanced principles of naval architecture can be applied.

Resources for assessment include access to:

- applicable documentation including workplace procedures, regulations, codes of practice and operation manuals
- relevant regulatory and equipment documentation that impacts on work activities
- technical reference library with current publications on naval architecture
- tools, equipment and personal protective equipment currently used in industry

- vessel diagrams and specifications and other information required for mathematical calculations related to shipboard areas and volumes, vessel displacement, ship dimensions, centre of gravity, vessel speed, fuel consumption and hydrostatic pressure.

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

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