Australian Government

MARL041 Apply advanced principles of trim, stability and stress

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 perform complex naval architectural calculations related to the seaworthiness of commercial vessels, including those dealing with vessel stability, trim, fuel consumption, buoyancy, power and symmetrical flooding vessel strength and vibration.

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	**Apply Simpson's First and Second Rules to calculate areas, volumes and displacement of ship shapes using tonnes per centimetre (TPC) values**	**1.1**	Simpson's (Mid-Ordinate) First Rule and Second Rule, with typical applications, using half and full ordinates is explained and applied to find typical and non-conforming shipboard areas
		1.2	Areas of water planes, transverse sectional areas to determine underwater volumes, 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
		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 and changes in draught associated with fluid density**	**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 freshwater allowance is applied
		3.5	Changes in mean draft due to changes in density and loading are calculated
		3.6	Density correction formula is defined
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 centre of gravity (CG) and linear congruential generator (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 metacentric height (GM) are explained
		5.2	Principles of metacentric data height are explained
		5.3	Application of the second moment of area using parallel axis theorem to obtain free surface moment of inertia and use of density correction between vessel and free surface fluids is explained

		5.4	Calculations are performed to solve problems of liquid free surface for simple compartments, including correction for free surface on GM and fluid mass on CG
		5.5	CG solid is differentiated from CG fluid
		5.6	Second moment of area is applied to obtain free surface moment of inertia and is related to stability criteria for standard conditions
		5.7	Problems of liquid free surface for simple and complex geometry compartments, including variation in filling rates, are solved
		5.8	Wall-sided formula and factors that lead to negative GM creating an angle of loll are explained
		5.9	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 onboard, 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 centre of buoyancy (CB), longitudinal centre of buoyancy (LCB), longitudinal centre of flotation (LCF) and bulkhead area centroids are explained
		7.3	Calculations are performed to determine centroids of shipboard areas and volumes
		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 moment to change trim 1 cm (MCT1cm), longitudinal metacentre height (GML) and longitudinal metacentre radius (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
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 and problems related to symmetrical flooding**	**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
		12.3	Volume lost-volume gained relationship for flooded compartments is explained
		12.4	Modified volume lost by compartment subdivision is explained using horizontal flat
		12.5	Modified volume lost by compartment permeability is explained, including consideration of cargo

			stowage factor and relative density details
		12.6	Problems of symmetrical flooding of simple box-shaped and standard hull forms involving flooding above and below horizontal subdivisions and different permeabilities are solved
13	**Perform rudder structural 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 (Fn), 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 resistance and power 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 are 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), 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 are calculated
		14.7	Problems of resistance and powering for full size vessels and models are solved
15	**Solve propeller and powering problems**	**15.1**	Factors that influence the speed of advance are explained
		15.2	Calculations are performed to solve problems of single screw vessels
		15.3	Relationships between propulsive coefficient,

	quasi-propulsive coefficient and related powers together with typical values of losses for transmission, hull and propeller are explained
15.4	Components of hull resistance are explained
15.5	Calculations are performed to show impact of resistance augmentation and thrust deduction factors on powering of full-size vessels
15.6	Causes, effects and methods of reducing cavitation are explained

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 MARL017 Apply intermediate principles of naval architecture.

This unit replaces and is equivalent to MARL021 Apply advanced principles of naval architecture.

Links

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