SHIP CONSTRUCTION & STABILITY – LEVEL 5

Registration code – NAUT SCS5

Duration – 270 hours

Pre-requisites

- Grade 9 level of mathematics, algebra and geometry
- Basic computer skills
- Ship Construction and Stability, Level 4

Course description

This is a course designed to provide ship's Masters with the knowledge and skill required to safely and efficiently manage the stress and stability of a vessel in both intact and damaged conditions. Topics include; design and construction of various types of vessels, welding techniques, stress of materials, stability calculations for intact and damaged vessel with emphasis on practical skills; use of a ship's stability booklet, perform calculations related to ship's drafts, trim, list and initial stability.

Required for the following certificates of competencies:

- Master, Near Coastal
- Master Mariner

Learning objectives/competencies

TC Subject	TC Knowledge
Understanding of fundamental principles of ship construction and the theories and factors affecting trim and stability and measures necessary to preserve trim and stability	**Shipbuilding Materials** Different types of steel; What is meant by: tensile strength, ductility, hardness, toughness; Strain as extension divided by original length; Ability to sketch a stress-strain curve for mild steel; Ability to explain yield point, ultimate tensile stress and modulus of elasticity; Brittle fracture; Examples where castings or forgings are used in ship construction; Advantages of the use of aluminium alloys in the construction of superstructures; How strength is preserved in aluminium superstructures in the event of fire; Special precautions against corrosion that are needed where aluminium alloy is connected to steelwork. **Welding** The process of manual electric arc welding; The purpose of flux during welding; Description of the automatic welding processes, electro-slag, TIG and MIG; Description of butt, lap, fillet welds; The various preparations of a plate edge for welding; Ability to explain what is meant by a full-penetration fillet weld; Ability to explain what is meant by single pass, multi-pass and back run; Ability to explain how welding can give rise to distortion and describe measures which are taken to minimize it; The use of tack welding; Ability to describe weld faults: lack of fusion, no inter-run penetration, lack of reinforcement, lack of root penetration, slag inclusion, porosity, overlap and undercut; Gas cutting of metals; Electrode type and process of welding high tensile steels; testing of welds: a) visual; b) radiographic; c) ultrasonic; d) magnetic particle and e) dye penetrant **Bulkheads** Differences between watertight, non-watertight and oil-tight or tank bulkheads; Definitions of margin line, bulkhead deck and weather tight; Collision bulkhead; After peak bulkhead; Bulkhead at each end of the machinery space; Additional bulkheads; Construction of a watertight bulkhead and its attachments to sides, deck and tank top; How water tightness is maintained where bulkheads are pierced by longitudinal, beams or pipes; The rules regarding penetrations of the collision bulkhead; How bulkheads are tested for tightness; Examples of non-watertight bulkheads; The purpose of washing bulkheads in cargo tanks or deep tanks; Importance of subdivision: transverse bulkhead and longitudinal bulkhead; Cofferdam, Flat plate and Corrugated bulkhead construction; The use of cross ties in tanker construction.

	Watertight and Weather tight doors Openings in watertight bulkheads; Number of openings in watertight bulkheads of passenger ships; Watertight doors: Class 1 – hinged doors, class 2 – hand-opened sliding doors, class 3 – sliding doors which are power-operated as well as hand opened; All types of watertight doors should be capable of being closed with the ship listed to 15 degrees either way; Ability to describe with sketches the arrangement of a power-operated sliding watertight door; Ability to describe with sketches a hinged watertight door, showing the means of securing it; Characteristic of a hinged watertight door; Frequency of the drills for the operating of watertight doors; Records of drills and inspections. Cargo vessels: Ability to distinguish between ships of Type A and Type B for the purpose of computation of freeboard; what is considered a "one- compartment ship"; Requirements for survivability of Type B ships with reduced freeboard assigned. All ships Openings in watertight bulkheads; Requirements for watertight openings to be closed at sea; procedures for ensuring that all watertight doors are closed; Frequency of operation of all watertight doors in main transverse bulkheads, in use at sea; Frequency of inspection of watertight doors and their mechanisms and indicators, all valves the closing of which is necessary to make a compartment watertight and all valves for damage-control cross-connections; Records of drills and inspections. **Corrosion and its prevention** What is meant by corrosion; What is meant by erosion of metals; Ability to describe the formation of a corrosion cell and to define anode, cathode and electrolyte; The galvanic series of metals in seawater; Given the galvanic series which of two metals will form the anode in a corrosion cell; Ability to explain the differences in surface condition or in stress concentration can give rise to corrosion cells between two areas of the same metal; By what corrosion can be controlled; Ability to explain that cathodic protection can only be used to protect the underwater hull or ballasted tank; Ability to explain what mill scale is; Ability to describe the treatment of steel in a shipyard and the use of holding primers; List common paint vehicles as: drying oils, oleo-resins, alkyd resins, polymerizing chemicals and bitumen. What is the suitability of each various applications; The action of anti-fouling paint; The use of self-polishing anti-fouling paint and the proposed banning of Tributyltin; Ability to describe typical paint schemes for: underwater areas, boot topping, topsides, weather decks, superstructures and tank interiors; The safety precautions when using paint; Ability to describe the system of cathodic protection using sacrificial anodes; The metals and alloys which may be used as anodes; Why anodes of magnesium and of magnesium alloy are not permitted in cargo/ballast tanks and in adjacent tanks in tankers; Why the anodes are insulated from the hull; Ability to describe the impressed-current system of hull protection; Ability to explain as the underwater paintwork deteriorates, higher currents are required for

	protection; What is the result of a too high current. **Surveys and Dry-docking** The frequency of classification society surveys; Possibility of extending the intervals between dry-dockings; Hull survey; Special surveys; ; Harmonized system of ship survey and certification; Condition Assessment Scheme (CAS) for oil tankers and Condition Assessment programme (CAP); Ability to list the items inspected at annual survey; Ability to list the items to examine in dry-dock; Ability to describe the examinations to be made of the items listed above; Ability to describe the cleaning, preparation and painting of the hull in dry-dock; Ability to calculate paint quantities. **Inclining Experiment** Purpose of the experiment; practical details of the procedure and resulting calculations; precautions to be observed to ensure a reliable and accurate result. **Stability** Approximate Calculation of areas and volumes; Effects of density; Stability at moderate and large angles of heel: Simplified Stability Data: Trim and List; Dynamical Stability; Definition and understanding of the relationship between dynamical and statical stability; the development of Moseley's formula for dynamical stability and calculations of dynamical stability at a specified angle of inclination by using the stability curve; Approximate GM by means of rolling period tests; Recommendation on Intact stability for Passenger and Cargo ships under 100 metres in length; Intact stability requirements for the Carriage of grain; Rolling of ships; Dry-docking and grounding; Shear Force, bending moments and torsional stress. **Effect of Beam and Freeboard on Stability** Effect of increase or decrease of beam, considered in isolation, on initial value, maximum value, range and shape of the stability curve; effect of increase or decrease of freeboard, considered in isolation, on initial value, maximum value, range and shape of stability curve; effect of beam, block coefficient and speed on squat. **Pressure in Liquids** Calculation of total pressure on an immersed plane surface of a regular geometric form that is oriented parallel to, vertical to, or at an angle to the surface of the liquid; and the development of the formula locating the centre of pressure of the surface, with related calculations.
Knowledge of the effect on trim and stability of a ship in	**Effect of flooding on transverse stability and trim.**

the event of damage to and consequent flooding of a compartment and countermeasures to be taken	Passenger vessel What is meant by "floodable length"; Definition of margin line, bulkhead deck and permeability of a space; What is meant by "permissible length of compartments" in passenger ships; Significance of the Criterion of Service Numeral; The significance of the factor of subdivision; With reference to the factor of subdivision, the extent damage which a passenger ship should withstand; The provisions for dealing with asymmetrical flooding; The minimum residual stability requirements in the damaged condition with the required number of compartments flooded; The use of the damaged stability information required to be provided to the master of a passenger vessel. Cargo ships The extent of damage that a Type A ship over 150 m in length should be able to withstand; The equilibrium conditions regarded as satisfactory after flooding; Damage to compartments may cause a ship to sink as a result of what. **Calculation of vessel condition after flooding** Calculate the permeability of cargo, given its density and its stowage factor; Calculate the increase in mean draught of a ship, given the TPC and the dimensions of the flooded space, using: *Increase in draught = volume of lost buoyancy / Area of intact waterplane* To explain why the BM of a ship is generally less when bilged that when intact, Use the formula *BM = I/V* . Explain why the GM usually decreases where: I. there is a large loss of intact waterplane; 2. there is intact buoyancy below the flooded space; 3. the flooded surface has a high permeability.

Explain why the bilging of empty double bottom tanks or of deep tanks that are wholly below the waterline leads to an increase in GM.

Explain why the bilging of empty double bottom tanks or of deep tanks that are wholly below the waterline leads to an increase in GM.

Calculate the reduction in BM resulting from lost area of the waterplane, given the following corrections:

a) second moment of lost area about its centroid/displaced volume;

for a rectangular surface $LB^3/12V$

where: L is length of the lost area

b is breath of the lost area

V is displaced volume = displacement/ density of water

b) $\frac{\text{original waterplane area}}{\text{intact waterplane area}} \times \text{lost area} \times \frac{(\text{distance from centerline})^2}{\text{displaced volume}}$

this is: $\frac{\text{original waterplane area}}{\text{intact waterplane area}} \times 1bd^2/V$

c) for a rectangular surface, where d is the distance of the centre of the area from the centerline

Calculate the shift (F) of the centre of flotation (CF) from the centerline, using:

$$F = \frac{a \times d}{A - a}$$

	Where: a is the lost area of waterplane A is the original waterplane area d is the distance of the centre of lost area of waterplane from the centerline Show that the heeling arm is given by: $$\text{heeling arm} = \frac{\text{lost buoyancy (tonnes)}}{\text{displacement}} \times \text{transverse distance from new CF}$$ Construct a GZ curve for the estimated GM and superimposes the heeling arm curve to determine the approximate angle of heel; Use wall sided formula to determine GZ values; Use wall sided formula to calculate angle of heel; Explain how lost area of waterplane affects the position of the centre of flotation. **Effect of flooding on trim** Calculate the movement of the centre of flotation (CF) given: $$\textit{Movement of CF} = \frac{\textit{moment of lost area about original CF}}{\textit{intact waterplane area}}$$ Explain how the deduction in intact waterplane reduces the MCT 1 cm; Calculate the reduction of BML, given the following corrections: a) second moment of lost area about its centroid/displaced volume;

This is $\frac{bL^3}{12V}$ for a rectangular surface

where: L is length of lost area

B is breadth of lost area

V is displaced volume = $\frac{\text{displacement}}{\text{density of water}}$

b) $\frac{\textit{original waterplane area}}{\textit{intact waterplane area}} \times \textit{lost area} \times \frac{(\textit{distance from CF})^2}{\textit{displaced volume}}$

this is $\frac{\textit{original waterplane area}}{\textit{intact waterplane area}} \times bld^2/v$

c) for a rectangular surface, where d is the distance of the center of area from the original centre of flotation

Calculate the reduction of MCT 1 cm, given,

reduction of MCT 1 cm = $\frac{\textit{displacement} \times \textit{reduction of GM}}{100 \times \textit{ship's length}}$

Given the dimensions of a bilged space and the ship's hydrostatic data, calculate the draughts in the damaged conditions; describe measure which may be taken to improve the stability or trim of a damaged ship.

Theories affecting Trim and stability

The static and dynamic effects on stability of liquids with a free surface; Ability to identify free surface moments and show its application to dead-weight moment curves; Ability to interpret changes in stability which take place during a voyage; Effect on stability of ice formation on super structure; The effect of water absorption by deck cargo and retention of water on deck; Stability requirements for dry docking.

	Understanding of angle of loll; Precautions to be observed in correction of angle of loll; The dangers to a vessel at an angle of loll; Effects of wind and waves on ships stability; Virtual gravity and virtual upright and their relationship to true gravity and upright; The main factors which affect the rolling period of a vessel; Synchronous and parametric rolling and the dangers associated with it; The actions that can be taken to stop synchronous and parametric effects.
Knowledge of IMO recommendations concerning ship stability	**Responsibilities under the International Conventions and Codes** Minimum stability requirements required by Load Line Rules 1966; The minimum stability requirements and recommendations of the Intact Stability Code; Correct use of IMO Grain Regulations; How grain heeling moment information is used; The requirements for passenger ship stability after damage.
Stability and trim diagrams and stress calculating equipment	**Shear forces, bending moments and torsional moments** The use of typical cargo loading instruments and the information obtainable from them; Ability to interpret the information regarding stress limits provided to the ship; Maximum permissible values of shear force and bending moment in harbour and at sea; Maximum torsional moments; Ability to plan the loading and discharge of ship to ensure that maximum allowable stress limits are not exceeded. Compliance with the minimum freeboard requirements of the Load Line Regulations Ability to use the chart of zones and seasonal areas to determine the load lines which apply for all stages of a particular passage; Ability to plan the loading, discharge, and consumption of deadweights items to determine the minimum departure freeboards and maximum quantities to load in one or more loading ports to ensure that the vessel is not overloaded at any stage of a voyage through multiple loading zones and seasonal zones. Use of Automatic Data Based (ADB) equipment Provide an understanding of information obtained from ship stress indicators and loading programmes; Use of stress indicators and loading programmes in planning for the safe carriage of dry and liquid cargoes; Advantages and limitations of analogue and digital stability and loading programmes.
Effect of trim and stability of cargoes and cargo operations	**Draught, Trim and Stability** Given the draughts forward, aft and amidships, ability to calculate the draught to use with the deadweight scale, making allowance for trim, deflection and density of the water; Given a ship's hydrostatic data, the weight and the intended disposition of cargo,

	stores, fuel and water, ability to calculate the draughts, allowing for trim, deflection and water density; Ability to calculate the changes of draught resulting from change in distribution of masses; Ability to calculate changes of draughts resulting from change in water density; Ability to calculate the quantity of cargo to move between locations to produce a required trim or maximum draught after loading; Ability to calculate how to divide a given mass between two given locations to produce a required trim or maximum draught after loading; Ability to calculate the locations at which to load a given mass so as to leave the after draught unchanged; Given a ship's hydrostatic data and the disposition of cargo, fuel and water, ability to calculate the metacentric height(GM); Ability to calculate the arrival GM from the conditions at departure and the consumption of fuel and water; Ability to identify when the ship will have the worst stability conditions during the passage; Ability to calculate the maximum weight which can be loaded at a given height above the keel to ensure a given minimum GM; Ability to construct a GZ curve for a given displacement and KG and check that the ship meet the minimum intact stability requirements; Ability to determine the list resulting from a change in distribution of masses; Ability to determine the expected maximum heel during the loading or discharging of a heavy lift with the ship's gear; Ability to calculate the increased draught resulting from the heel; Ability to plan the loading and movement of cargo and other deadweight items to achieve specified draughts and/or stability conditions in terms of required statical and dynamic stability.
Limitation on strength of the vital constructional parts of a standard bulk carrier and interpret given figures for bending moments and shear forces	Hull girder stress; Causes of the longitudinal bending; Ship's torsional strength; Upper deck plating; Transverse bulkheads; Types of cracking in the upper deck; High cyclical stress; Damage to hatch covers; Causes of corrosion; Visual inspection; Cargo hold inspection; The common damage/defects that may occur on watertight transverse bulkheads situated at the ends of dry cargo holds of a bulk carrier; Fractures that may occur in the deck plating at hatches and in connected comings; Causes of cracking in way of no. 1 cargo hold; The damages caused by cargoes in cargo holds, especially to tanktop plating and side: • at loading and unloading ports for coal or iron ore, large grab buckets, high-capacity cargo; • loaders, bulldozers and pneumatic hammers may be employed for cargo-handling operations; • large grab buckets may cause considerable damage to tank top plating when being dropped to grab cargo; • use of bulldozers and pneumatic hammers may also be harmful to cargo hold structures and may result in damage to tank tops, bilge hoppers, hold frames and end brackets; • lumber cargoes may also cause damage to the cargo hold structures of smaller bulkers that are employed in the carriage of light bulk cargoes and lumbers. • Cracking on large bulk carriers; Ballast tanks. Ability to interpret given figures for bending moments and shear forces.
Methods to avoid the detrimental effects on bulk carriers of corrosion, fatigue and inadequate cargo handling	Principal factor in the loss of many bulk carriers; Corrosive effects of cargoes; Causes of improper cleaning during hold cleaning; Causes of corrosion due to ballast exchange; Prevention of corrosion; Vulnerable aspects of a bulk carrier operation; Damages to bow plating; Causes of hatch cover dislodgment; Metal fatigue; What can weaken the vessel's structural capacity; Areas that are prone to fatigue cracks in the cargo holds; Causes of carriage of high density cargoes; Damages to side shell.