Higher National Unit Specification

General information for centres

Unit title: Ship Stability: Theory and Practical Application

Unit code: F0LC 35

Unit purpose: This Unit introduces the theory and practice affecting stability, trim and structural loading for the safe operation of ships. It also covers current national and International Maritime Organisation (IMO) regulations concerning stability and the use of stability and stress calculating equipment. It is primarily aimed at candidates who intend to seek sea-going employment as a Merchant Navy Deck Officer. However it could also be studied by someone with an interest in the subject area.

On completion of the Unit the candidate should be able to:

1 Apply the theories affecting stability and trim and perform stability calculations.
2 Analyse the factors and perform calculations concerning stability at large angles of heel.
3 Analyse and use stability/stress diagrams and stress calculating equipment.

Credit points and level: 1.5 HN Credits at SCQF level 8: (12 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre. However it would be beneficial if candidates had achieved either a *UK MCA 'Officer of the Watch'* Certificate or equivalent, or the HNC Nautical Science, or the HN Unit F0LD 34 *Ship Stability: An Introduction*.

Core Skills: The achievement of this Unit gives automatic certification of the following:

Numeracy at SCQF Level 6

There are also further opportunities to develop the Core Skills of:

Communication: Reading at SCQF level 6
Communication: Written at SCQF level 6
Problem Solving: Critical Thinking at SCQF level 6
Problem Solving: Reviewing and Evaluating at SCQF level 6

General information for centres (cont)

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

Assessment: Outcome 1 and Outcome 2 may be assessed using a single unseen assessment consisting of questions that are administered under supervised open-book conditions. The questions will include a number of numerical calculations and some theoretical questions.

Outcome 3 may be assessed by an unseen assessment consisting of questions under supervised conditions. There will be an assignment on stress/stability as part of this Outcome.

Higher National Unit specification: statement of standards

Unit title: Ship Stability: Theory and Practical Application

Unit code: F0LC 35

The sections of the Unit stating the Outcomes, knowledge and/or skills, and Evidence Requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Apply the theories affecting stability and trim and perform stability calculations

Knowledge and/or skills

- Stability information required to be carried on board ship
- Loading, discharging, shifting weights, effect on a vessel's transverse stability
- Loading, discharging, shifting weights, effect on a vessel's longitudinal stability
- Stability and trim worksheets

Evidence Requirements

Candidates will need to produce evidence to demonstrate their knowledge and/or skills by showing that they can apply the theories affecting stability and trim by a series of calculations:

1 Summarise the stability information required to be carried on board a vessel as per current legislation.

2 Calculate the effect on the transverse stability of a vessel due to the effect of loading, discharging, shifting weights on the vessel's centre of gravity. The calculation will include the effect of free surface.

This can be achieved by sampling **one** of the following calculations:

(a) Calculation of the final angle of list after loading or discharging multiple weights.
(b) Calculating the cargo to load to bring a listed vessel upright.
(c) Calculations involving limiting the angle of list whilst loading or discharging.
(d) Calculations based on the Inclining Experiment.

In every case (a)–(d), above, free surface effects must be included in the calculation.

In the case of (a) –(c) above, the final/initial Metacentric heights (GM) must be determined (as appropriate) to the nearest millimetre.

In the case of (d) the Lightship Displacement and Centre of Gravity (KG) must be determined and free surface effects must be included. The precautions to be observed prior to and during the experiment to achieve an accurate determination of Lightship Displacement and Centre of Gravity (KG) should be noted.

2 Calculate the effect on the longitudinal stability of a vessel due to loading, discharging or shifting weights on board a vessel.

This can be achieved by sampling **one** of the following calculations:

(e) Calculations involving the achievement of a required trim.
(f) Calculation of the final drafts after loading or discharging.
(g) Calculations to keep the draught constant.
(h) Calculations to increase or decrease the draught by a given amount.
(i) Calculation of the cargo to load in order to bring the vessel to an even keel.
(j) Calculation of the vessel's stability during dry-docking.

In the case of (e)–(i) above the final draughts forward and aft must be determined to the nearest millimetre.

In the case of (j) the precautions to be observed prior to and during drydocking must be covered.

In all cases (e)–(i), above, the method of solution must use the method of Moments about the After Perpendicular unless this is not possible, when the appropriate method as recommended by the UK Maritime and Coastguard Agency must be employed. (MCA has issued guidance to all nautical colleges on these matters).

Evidence for 1 and 2 will be based on sampling and a different sample must be used on each assessment occasion.

In the calculation of 1 and 2 MCA Hydrostatic Data sheets must be used in all calculations by candidates to demonstrate their knowledge of the stability information required on board ship.

Assessment guidelines

Evidence for 1 and 2 above may be generated by carrying out combined list/trim calculations using the MCA worksheet, 'Trim and Stability'. If this option is selected then questions should be structured such that the final list is asked for. Information as to the transverse position of weights must be included in the question and all supporting working should be available. Where required by the calculation draughts and GM should be determined to the nearest millimetre.

Outcome 1 and Outcome 2 may be assessed as a single assessment event. Outcome 1 will be assessed on a sample basis by means of an assessment under supervised open-book conditions with access to MCA Hydrostatic Data sheets.

Higher National Unit specification: statement of standards (cont)

Unit title: Ship Stability: Theory and Practical Application

Outcome 2

Analyse the factors and perform calculations concerning stability at large angles of heel

Knowledge and/or skills

- Compliance with IMO (International Maritime Organisation) Intact Stability requirements and Loadline Rules
- Compliance with IMO (International Maritime Organisation) Grain Code requirements
- Factors affecting GZ curves
- Changes in stability at large angles of heel
- Effect of damage and flooding on stability
- Effect of turning on a vessel's stability
- Effect of rolling and synchronous rolling on a vessel's stability

Evidence Requirements

Candidates will need to produce evidence to demonstrate their knowledge and/or skills by showing that they can:

1 Using information supplied either:

(a) Produce a GZ curve and hence determine if the vessel complies with the specified stability criteria contained in the Loadline Rules; **or**
(b) Produce a GZ curve and hence determine if the vessel complies with the specified stability criteria contained in the IMO Grain Code.

The minimum information to be supplied, in 1 above, is the vessel's displacement and the initial KG. In the case of the IMO Grain Code full data on the grain cargo carried must be given as per the MCA Hydrostatic data sheets. At least one cargo compartment must be partly full in order for candidates to show that they have a full understanding of the calculation of Volumetric Heeling Moments.

- To achieve this part of the Outcome candidates must clearly show how GZ values have been obtained and how the various features of the GZ curve comply with the loadline requirements.
- Simpson's Rules should be used to determine areas under the curve.

2 Explain the effect on a GZ curve of a sample of **three** from the following:

(a) Changes in beam.
(b) Changes in freeboard.
(c) Changes in stability on the voyage.
(d) Vessel with an initial list.
(e) Vessel with angle of loll.
(f) Vessel with zero initial GM.
(g) Shift of cargo/solid ballast.
(h) Wind heeling moments.

(i) Angle of loll and effective GM at angle of loll and the dangers of and methods of correcting an angle of loll.

When making an assessment decision assessors should ensure:

- Candidates have clearly explained why there are differences between the normal GZ curve and that for the condition chosen. Answers should include a sketch indicating the main differences in terms of:

  — Initial GM
  — Angle of Deck Edge Immersion
  — Area under the GZ Curve
  — Range of Positive Stability

3 Explain **one** from the following sample:

(a) The changes in stability at large angles of heel.
(b) The effect of damage and flooding on stability.
(c) The effect of turning on a vessel's stability.
(d) The effect of beam winds on a vessel's stability.
(e) The effect of rolling and synchronous rolling on a vessel's stability.
(f) The effect of bilging a compartment.

For (a) above the candidate must mention the effect of free and fixed trim on GZ values obtained from KN Curves and also the use of the Wall Sided Formula.

For (b) above the candidate must explain the current regulations pertaining to Damage Stability for the particular type of vessel quoted.

For (c) above, in the case of turning a calculation must be given in which the final angle of heel due to turning must be determined and also the increase in draft.

For (f) above the compartment must either be an amidships, end or side compartment, however in the case of the latter two there must be no consideration of permeability and in the case of the former two it would be possible to consider a compartment bounded by a horizontal watertight flat.

Evidence for 1, 2 and 3 above should be generated by an assessment under supervised open-book conditions and candidates should have access to Hydrostatic Stability data sheets as provided to candidates in MCA examinations.

Where sampling is used a different sample must be used on each assessment opportunity.

Assessment guidelines

Outcome 2 will be assessed on a sample basis by means of an assessment under supervised open-book conditions with access to MCA Hydrostatic Data sheets.

The assessment of Outcome 2 may be combined with the assessment for Outcome 1.

Higher National Unit specification: statement of standards (cont)

Unit title: Ship Stability: Theory and Practical Application

Outcome 3

Analyse and use stability/stress diagrams and stress calculating equipment

Knowledge and/or skills

- Types of ship board stress
- Shear force and bending moments curves for box shaped vessels
- Stress calculating equipment

Evidence Requirements

Candidates will need to produce evidence to demonstrate their knowledge and/or skills by showing that they can correctly:

1 Explain the causes of stresses by sampling **one** of the following:

(a) Ship stresses in still water.
(b) Shear forces.
(c) Bending moments.
(d) Torsion stresses.

Where sampling is used a different sample must be used on each assessment opportunity.

2 Construct simple shear force and bending moments curves for box shaped vessels.

- Candidates should show clearly how a curve of loads is used to produce curves of shear forces and bending moments. All three curves should be produced on each assessment opportunity. Candidates should be given the initial particulars of the box shaped vessel and also the proposed loading plan.

3 Explain the use of stress calculating equipment to assess the outcome of proposed cargo/ballast distribution during operations and for final still water and sea going conditions.

Evidence for 1, 2 and 3 above should be generated by an assessment under supervised closed-book conditions.

Assessment guidelines

Outcome 3 may be assessed either by short answer questions under supervised conditions and/or an assignment on stability and stability/stress calculating equipment.

Evidence for the above may be reproduced by the candidate using typical stability software packages to investigate a proposed loading plan for the vessel in question. Alternatively candidates could be asked what the input/output parameters are for typical stability software packages.

If the latter is used the candidates should be given the opportunity to produce evidence as to the significance of harbour and seagoing conditions supplied in the output parameters.

Administrative Information

Unit code: F0LC 35

Unit title: Ship Stability: Theory and Practical Application

Superclass category: XQ

Original date of publication: August 2006

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History of Changes:

Version	Description of change	Date
02	Core Skills Section Updated	June 2007

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Ship Stability: Theory and Practical Application

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 60 hours.

Guidance on the content and context for this Unit

The content of this Unit forms part of the underpinning knowledge for an UK MCA *Chief Mate Certificate of Competency* and accordingly reflects the content of International Maritime Organisation's *Standards of Training Certification and Watchkeeping (STCW).*

The Unit is primarily intended for candidates who are new entrants to the Merchant Navy via one of the Merchant Navy Training Board (MNTB) approved deck cadet training schemes or for seafarers who are enrolled on a Chief Mate/Master course. Ideally candidates would have already accrued some shipboard experience prior to attempting this Unit, although this is not a prerequisite.

The knowledge and skills contained within the Unit cover all the requirements as laid down by Standards for Training and Certification of Watchkeepers (STCW) 95 at Management level aboard ship.

Completion of the Unit will also ensure that the candidate complies with all the requirements laid down by the UK Maritime and Coastguard Agency (MCA) for the issue of a Chief Mate Unlimited Certificate of Competency as a Deck Officer. The required knowledge and skills for MCA certification can be found in a document detailing the requirements for the issue of an Education and Training Certificate (C & D), which is available from the MNTB.

The following notes give additional information on the knowledge and skills for each of the three Outcomes.

Outcome 1

Candidates will understand the effect on a vessel's transverse and longitudinal stability of loading, discharging and shifting of weights. They will be shown how to carry out typical calculations involving list, trim, dry-docking and the inclining experiment. Candidates should be able to explain the precautions and procedures to be observed when loading and discharging cargoes, including heavy lift operations, dry-docking and carrying out the inclining experiment, to ensure that the vessel has adequate stability.

Candidates will then apply this basic knowledge in different scenarios which will enable them to determine the final and maximum angles of list, final draughts, KG and GM for a vessel on completion of loading or discharging operations.

When calculations are carried out they should be of a similar standard to those set in MCA written examinations.

Higher National Unit specification: support notes (cont)

Unit title: Ship Stability: Theory and Practical Application

Outcome 2

This Outcome develops the candidate's knowledge of the stability of a vessel at large angles of heel and in particular the importance of the Wall Sided Formula for calculation of GZ values at large angles of heel.

It also allows the candidate to understand the basic theories behind the derivation and interpretation of GZ curves. Candidates will be shown how to produce GZ curves using KN tables and also Cross Curves of Stability. The IMO and Loadline regulations regarding Intact stability will be introduced and candidates will be shown how to use a GZ curve to check that a vessel complies with these regulations using graphical and numerical methods including the application of Simpson's rules for calculating areas.

The difference between Statical and Dynamical Stability will be explored.

The effect on the shape of a GZ curve of changing various criteria will be explored and the effect on the vessel's stability examined. Candidates will be shown how the curve for a normal vessel is changed in each of the situations listed in Section 2) of the knowledge and skills.

The stability of a vessel in a damaged condition will be investigated and the relevant regulations for various types of vessel examined.

The concept of an angle of loll will be developed and the correct procedures for identifying and correcting this condition will be examined.

The stability requirements for the carriage of certain types of cargo will also be explored, in particular carriage of grain cargoes and also the additional stability requirements for vessels likely to be affected by strong beam winds and ice accretion.

The effect of prescribed damage and bilging of compartments will also be investigated.

Outcome 3

This Outcome covers the various types of stresses experienced by a vessel in either still water or a seaway. Candidates will be shown how these stresses arise and how to calculate curves of Loads, Shearing Forces and Bending Moments for simple box shaped vessels.

Examples of typical stability software applications can be used to quickly determine the above for ship shaped vessels and the typical input and output information used will be discussed.

Wherever possible candidates should be given practical experience of using these software applications to solve typical loading/discharging problems. The significance of results obtained for harbour and seagoing conditions will be examined.

Higher National Unit specification: support notes (cont)

Unit title: Ship Stability: Theory and Practical Application

Guidance on the delivery and assessment of this Unit

This Unit contains knowledge and skills which are critical to the safe operation of any vessel. It is therefore vital that all candidates are thoroughly familiar with the principles detailed above. It is suggested that the delivery follows the sequence of the Outcomes as they develop the required knowledge and skills in a sequential order.

Candidates will benefit most if it is delivered in conjunction with the HN Unit F0LX 35 *Management of Vessel Operations*. They should also be able to draw on the knowledge gained from the qualifications or Units recommended as prior knowledge as well as experience gained from service at sea.

Where candidates have some seagoing experience the contents of Outcome 1 may be familiar as they will have witnessed the concepts at first hand whilst loading and unloading the ship and may have carried out some of the practical work as part of their on board training.

Those candidates with no prior seagoing experience would benefit from practical demonstrations, where applicable, of the various concepts. This may be possible using models or simple beams showing the effect of transferring weights in a ship. Wherever possible diagrams should be used in explaining concepts regarding movement of weights and the use of presentations and ICT delivery would be of great benefit.

Use of stability calculation software can also be used to good effect as the changes can be shown almost instantaneously and candidates can see for themselves how changes can affect the stability of the vessel in both numeric and diagrammatic formats.

It is recommended that the hydrostatic data supplied to candidates taking the MCA written examinations at Chief Mate level be used in all calculations, in order that all candidates are fully conversant with the contents. MCA approved formula sheets should be made available to all candidates during assessment.

The knowledge and skills developed within the Unit should be applied in the context that will be encountered aboard ship, ideally leading the candidate towards the ability to be able to determine the stability of the vessel at the completion of either loading or discharging.

Assessment of the Unit may be carried out Outcome by Outcome, however it would be advantageous if candidates were able to comply with the paragraph above on completion of the Unit. Consideration may be given to combining the Outcomes into a single assessment so that sampling of the skills and knowledge in each Outcome would include a practical ship loading exercise.

Higher National Unit specification: support notes (cont)

Unit title: Ship Stability: Theory and Practical Application

Opportunities for developing Core Skills

The achievement of this Unit gives automatic certification of the following:

Numeracy at SCQF Level 6

The Unit also provides the opportunity to develop the Core Skill of Problem Solving at SCQF level 5. Problem Solving can be developed by assessment of a candidate on the correct method of determining whether a vessel has adequate stability given initial information.

Open learning

This Unit is not suited to delivery by distance learning because it requires candidates to be observed and questioned by a qualified practitioner to meet the criteria for the award of a Certificate of Competency.

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.

General information for candidates

Unit title: Ship Stability: Theory and Practical Application

This Unit is designed to provide you with the knowledge and skills required to assess the stability of a vessel in terms of the IMO requirements for Intact Stability. It will also further develop the concept of longitudinal stability which was introduced in an earlier Unit.

You will be required to portray numerical data in graphical format and will be required to use graphical information to analyse various conditions of loading of a ship to ensure that it complies with the minimum stability requirements as laid down by the International Maritime Organisation (IMO).

On completion of the Unit you will have developed the skills necessary to determine the final stability condition of a vessel prior to sailing with respect to the transverse and longitudinal stability and should be able to determine the final KG of a vessel, including allowance for the effect of free surfaces, the curve of statical stability and the final draughts forward and aft in water of any density.

Stability at large angles of heel and in a damage scenario will be considered in this Unit.

The assessment of the Unit will require you to produce evidence of your ability to extract information from different sources and solve problems involving movement of weights within the vessel causing list and trim.

You will be required to assess the effects of the distribution of weight within the vessel and determine the final stability of the vessel. The Unit also considers the special stability requirements for certain types of vessel and the additional information that the Master may be required to produce to Authorities prior to loading and/or sailing.

The assessment of the remaining knowledge and skills may take the form of a final assessment covering Outcomes 1, 2 and 3 or you may be assessed on each individual Outcome, depending on the centre offering the Unit.