SQA Advanced Unit Specification

General information

Unit title: Ship Stability: Theory and Practical Application (SCQF level 8)

Unit code: HW77 48

Superclass: XQ

Publication date: November 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This unit is designed to enable learners to develop their knowledge and understanding of 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 used on board ships. It is primarily aimed at learners 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. It is a mandatory unit in SQA Advanced Diploma in Nautical Science.

Outcomes

On completion of the unit the learner should be able to:

1 Apply the theories affecting ship stability, trim and stability calculations.
2 Analyse the factors and 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 SQA Credits at SCQF level 8: (12 SCQF credit points at SCQF level 8)

Recommended entry to the unit

Access to this unit is at the discretion of the centre. However, it would be beneficial if learners had achieved either a UK Maritime and Coastguard Agency (MCA) 'Officer of the Watch' Certificate or equivalent, or the SQA Advanced Certificate in Nautical Science, or the SQA Advanced Unit *Ship Stability: An Introduction*.

Core Skills

Achievement of this unit gives automatic certification of the following Core Skills component:

Complete Core Skill	Numeracy at SCQF level 6
Core Skill component	Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this unit specification.

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.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

SQA Advanced Unit Specification: Statement of standards

Unit title: Ship Stability: Theory and Practical Application (SCQF level 8)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

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. Learners must 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 ship's stability, trim and 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

Outcome 2

Analyse the factors and 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 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

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 for this unit

Written and/or recorded oral evidence is required for Outcomes 1–3 under open-book supervised conditions. Outcomes 1 and 2 should be combined for assessment and should last no longer than three hours. Assessment for Outcome 3 will last no longer than two hours.

Learners should have access to hydrostatic stability data sheets as provided to learners in MCA examinations.

All knowledge and skills are assessed within the three outcomes, however there is sampling within each of the knowledge and skills. On each assessment occasion a different sample should be used.

Outcome 1

Learners will need to produce written and/oral recorded evidence to demonstrate their knowledge and/or skills of 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 loading, discharging, shifting weights on the vessel. 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 while 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 centimetre.

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.

3 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 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 centimetre (MCA requires three decimal places).

In the case of (j) the precautions to be observed prior to and during dry-docking 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 MCA must be employed.

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 learners to demonstrate their knowledge of the stability information required on board ship.

Outcome 2

Learners will need to produce written and/or oral recorded evidence to demonstrate their knowledge and/or skills.

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 for learners to show that they have a full understanding of the calculation of volumetric heeling moments.

— To achieve this part of the outcome learners 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 Using a minimum of three items from the examples given below, explain the effects on a GZ curve:

(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:

— Learners 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 Calculate and explain one from the following:

(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 learner must mention the effect of free and fixed trim on GZ values obtained from KN curves and the use of the wall sided formula.

For (b) above the learner must explain the current regulations pertaining to damage stability for the 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 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.

Outcome 3

Analyse and use stability/stress diagrams and stress calculating equipment

Learners will need to produce evidence to demonstrate their knowledge and/or skills by showing a minimum of one of the following that they can correctly:

1 Explain the types of stresses caused by:

(a) Ship stresses in still water and sea going conditions.
(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.

Learners 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. Learners should be given the initial dimensions of the box shaped vessel and 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.

MCA approved formula sheets should be made available to all learners during assessment.

SQA Advanced Unit support notes

Unit title: Ship Stability: Theory and Practical Application (SCQF level 8)

Unit support notes are offered as guidance and 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 a UK MCA Chief Mate Certificate of Competency and accordingly reflects the content of International Maritime Organisation's Standards of Training Certification and Watchkeeping (STCW '78 as amended).

The unit is primarily intended for learners 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 learners 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 '78 as amended) at Management level aboard ship.

Completion of the unit will also ensure that the learner complies with all the requirements laid down by the UK 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 and 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

Learners 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. Learners 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.

Learners 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.

Outcome 2

This outcome develops the learner's knowledge of the stability of a vessel at large angles of heel and the importance of the wall sided formula for calculation of GZ values at large angles of heel.

It also allows the learner to understand the basic theories behind the derivation and interpretation of GZ curves. Learners will be shown how to produce GZ curves using KN tables and cross curves of stability. The IMO and loadline regulations regarding intact stability will be introduced and learners 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. Learners 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; carriage of grain cargoes, 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. Learners 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 learners should be given practical experience of using this software applications to solve typical loading/discharging problems. The significance of results obtained for harbour and seagoing conditions will be examined.

Guidance on approaches to delivery of this unit

This unit contains knowledge and skills which are critical to the safe management of stability of any vessel.

The unit could be delivered by combination of class teaching, tutorial work and practical application cargo loading equipment.

It is therefore vital that all learners 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.

Learners will benefit most if it is delivered in conjunction with the SQA Advanced Unit *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 learners have some seagoing experience the contents of Outcome 1 may be familiar as they will have witnessed the concepts at first hand while loading and unloading the ship and may have carried out some of the practical work as part of their on board training.

Those learners 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 Information and Communication Technology (ICT) delivery would be of great benefit.

Use of stability calculation software. Various scenarios on loading software in the cargo handling simulators to see the effect as the changes can be shown almost instantaneously and learners can see for themselves how changes can affect the stability of the vessel in both numeric and diagrammatic formats. The learner can apply their theoretical knowledge and analyse the practical application of ship's stability and trim calculations in various seagoing conditions of intact and damage stability of the ship.

It is recommended that the hydrostatic data supplied to learners taking the MCA written examinations at Chief Mate level be used in all calculations, in order that all learners are fully conversant with the contents. MCA approved formula sheets should be made available to all learners 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 learner towards the ability to be able to determine the stability of the vessel at the completion of either loading or discharging.

Guidance on approaches to assessment of this unit

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.

Written and/or recorded oral evidence is required for Outcomes 1–3 under open-book supervised conditions. Outcomes 1 and 2 should be combined for assessment and should last no longer than three hours. Assessment for Outcome 3 will last no longer than two hours. Access to MCA hydrostatic data sheets should be provided.

All knowledge and skills are assessed within the three outcomes, however there is sampling within each of the knowledge and skills. On each assessment occasion a different sample should be used.

Where required by the calculation draughts and GM should be determined to the nearest millimetre.

Evidence for the above may be reproduced by the learner using typical stability software packages to investigate a proposed loading plan for the vessel in question. Alternatively, learners could be asked what the input/output parameters are for typical stability software packages. If these software packages are used evidence may be produced in the form of spreadsheets and screenshots.

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

Since this is a safety subject indicated by MCA for Certificate of Competency, it is suggested that the pass mark for assessments on this unit is 60%.

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by ICT, such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

This unit has the Core Skill of Numeracy embedded in it, so when learners achieve this unit their Core Skills profile will be updated to show that they have achieved Numeracy at SCQF Level 6. Using Number through calculations involving several variables and multiple interdependent steps, and Using Graphical Information by constructing graphs to obtain information that will be used in calculations or alternatively use numerical data to construct graphs and then use the graph to analyse the stability of a vessel and check that the vessel complies with minimum stability requirements prior to sailing.

This unit has the Critical Thinking component of Problem Solving embedded in it. This means that when learners achieve the unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6.

There are opportunities to develop the following Core Skills in this unit, although there is no automatic certification of Core Skills or Core Skills components.

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

History of changes to unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for learners

Unit title: Ship Stability: Theory and Practical Application (SCQF level 8)

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 identify 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 IMO.

On completion of the unit you will have developed the skills necessary to determine the final stability condition of a vessel 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 determine 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 centre may assess some elements of Outcome 3 on cargo loading equipment software packages. If software packages are used you will be required to submit spreadsheets and screenshots as evidence for assessment.

This unit has the Core Skill of Numeracy embedded in it, so when you achieve this unit your Core Skills profile will be updated to show that you have achieved Numeracy at SCQF Level 6

This unit also has the Critical Thinking component of Problem Solving embedded in it. This means that when you achieve the unit, your Core Skills profile will also be updated to show you have achieved Critical Thinking at SCQF level 6.