Level 3 Diploma in Maritime Defence (Development Knowledge) (4715-03)

Version 2.1 (July 2023)

Qualification Handbook

Qualification at a glance

Subject area	Mechanical
City & Guilds number	4715
Age group approved	16+
Entry requirements	None
Assessment types	Multiple Choice and Centre Devised
Approvals	See page 7 for details
Support materials	Assessment pack
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	GLH	TQT	City & Guilds qualification number	Ofqual accreditation number
Level 3 Diploma in Maritime Defence (Development Knowledge)	529	569	4715-03	603/2426/0

Version and date	Change detail	Section
v1.0 September 2017	Original documentation	
v2.0 August 2018	Update to units 300,301, 307and 308. Additional units 324 to 336	Units
V2.1 July 2023	Guidance on resit opportunities added	Grading

Contents

1 Introduction

This document tells you what you need to do to deliver the qualification:

Area	Description
Who is the qualification for?	It is aimed at anyone over the age of 16 who has an interest in working and progressing in the Maritime Engineering sector. It is designed to be the base to train and qualify the next generation of Maritime Defence Engineers to meet an identified gap in the market and minimise the potential loss of skills and knowledge over the next 5-10 years.
What does the qualification cover?	This qualification allows learners to learn, develop and practise the skills required for employment and/or career progression in the Maintenance and Engineering sector in general.
What opportunities for progression are there?	Upon completion of this qualification, learners will have developed the skills and knowledge required during their development phase of the Apprenticeship and will enable them to progress into full employment.
Who did we develop the qualification with?	This qualification has been developed in collaboration with the Engineering Technician Employer Group which included the following organisations: BAE Systems, Airbus Group, The Institution of Engineering and Technology, British Airways, Rolls- Royce plc, Royal Aeronautical Society, Royal Air Force Cosford, Royal Navy, Institution of Mechanical Engineers, Siemens plc, Jaguar Land Rover, BMW, Toyota Motor Manufacturing (UK) Ltd and Babcock International Ltd. As well as SEMTA and EAL.
Is it part of an apprenticeship framework or initiative?	Yes. This qualification forms part of the mandatory development phase for the on-programme section of the new Engineering Technician Standard. The qualification can also be used for full time students who would like to gain the knowledge and skills that will enable them to progress into further training to become a Marine Engineer.

Structure

Maritime Mechanical Fitter: Learners must complete units 300-303 plus 4 from (307 - 336)

Centres should use the following certification units to claim for the achieved grade
904 Pass
905 Merit
906 Distinction.

Maritime Electrical Fitter: Learners must complete units 300-302,304 plus 4 from (307 - 336)

Centres should use the following certification units to claim for the achieved grade
907 Pass
908 Merit
909 Distinction.

Maritime Pipeworker: Learners must complete units 300-302,305 plus 4 from (307 - 336)

Centres should use the following certification units to claim for the achieved grade
910 Pass
911 Merit
912 Distinction.

Maritime Fabricator: Learners must complete units 300-302,306 plus 4 from (307 - 336)

Centres should use the following certification units to claim for the achieved grade
913 Pass
914 Merit
915 Distinction.

Please see the Grading section for the grading process.

City & Guilds unit number	Unit title	GLH
Mandatory		
300	Engineering maths	60
301	Engineering and environmental health and safety	60
302	Engineering principles	80
Mandatory Pathway		
303	Principles of mechanical engineering	80
304	Principles of electrical and electronic engineering	80
305	Principles of pipework fabrication	80
306	Principles of fabrication and welding	80
Optional		
307	Marine propulsion systems	80
308	Marine auxiliary systems and equipment	80
309	Principles of shipbuilding	68
310	Principles of maintenance, installation and commissioning	80
311	Power generation systems and ancillary equipment	80
312	Generation distribution for electrical power systems	80
313	Platework fabrication of materials	68
314	Sheet metal work fabrication of materials	45
315	Fabrication and erection of structural steel	68
316	Pattern development for fabrication	100
317	Further electrical and electronic principles	80
318	Maintenance of utility systems	80
319	Maintenance of electrical equipment and systems	80
320	Electrical maintenance on ships	80
321	Maintenance of fluid power systems	80
322	Maintenance of hydraulic systems	80
323	Maintenance of pneumatic systems	80
324	Principles of welding	80
325	Principles of fabrication	80

326	Advanced mathematics and science	80
327	Marine internal combustion engines theory and maintenance	145
328	Marine mechanical system and equipment maintenance	52
329	Fitting and machining	300
330	Welding and pipe work processes	303
331	Electrical and electronic cable maintenance and repair	138
332	Electrical submarine systems equipment maintenance	134
333	Marine electrical circuit breakers and static frequency changers	91
334	Marine systems electrical maintenance	114
335	Marine mechanical equipment and system maintenance	133
336	Marine controls systems and diagnostics	81

Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours, which represents an estimate of the total amount of time that could reasonably be expected for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

1) The number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
2) An estimate of the number of hours a Learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but unlike Guided Learning, not under the Immediate Guidance or Supervision of - a lecturer, supervisor, tutor or other, appropriate provider of education or training.

Title and level	GLH	TQT
Level 3 Diploma in Maritime Defence (Development Knowledge)	529	569

2 Centre requirements

Approval

If your centre is approved to offer the following qualifications:

Level 3 Diploma in Engineering (2850-70, 71, 72)

then you will have automatic approval for the new Level 3 Diploma in Maritime Defence (Development Knowledge).

To offer these qualifications, new centres will need to gain both centre and qualification approval. Please refer to the Centre Manual - Supporting Customer Excellence for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualifications before designing a course programme.

Internal quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications.

Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance.

Standards and rigorous quality assurance are maintained by the use of:

- internal quality assurance
- City & Guilds external quality assurance.

In order to carry out the quality assurance role, Internal Quality Assurers must have appropriate teaching and vocational knowledge and expertise. Assessor/Verifier (A/V) units are valued as qualifications for the centre, but they are not currently a requirement for this qualification.

Staff must:

- be familiar with the occupation and technical content covered within the qualification
- be familiar with the Engineering Technician (UK spec) requirements where delivering/assessing Level 3, they will be required to provide a signed declaration confirming they have read and understood the Engineering Technician UK Spec and the evidence requirements to meet the Engineering Technician (UK Spec) criteria.

Resource requirements

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area[s] for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Additionally, those involved in internal quality assurance must:

- have experience in quality management/internal verification
- hold or be working towards an appropriate teaching/training/assessing qualification
- be familiar with the occupation and technical content covered within the qualification.

Centre staff may undertake more than one role, eg tutor and assessor or internal verifier, but cannot internally verify their own assessments. They must:

- be technically knowledgeable in the area(s) for which they are delivering training/assessing, with appropriate qualifications
- be familiar with the Engineering Technician (UK Spec) requirements where delivering/assessing Level 3, they will be required to provide a signed declaration confirming they have read and understood the Engineering Technician UK Spec and the evidence requirements to meet the Engineering Technician (UK Spec) criteria.

Learner entry requirements

City & Guilds does not set entry requirements for these qualifications. However, centres must ensure that candidates have the potential and opportunity to gain the qualifications successfully.

Individual employers will set the criteria, but most candidates will have four GCSEs at grade C (or equivalent) or above on entry (including English, Maths & Science). Employers who recruit learners without English, Maths and Science at Grade C or above, must ensure that the learner achieves this requirement, or an equivalent Level 2, prior to completion of the Apprenticeship.

This qualification is a mandatory component of the on-programme foundation phase of the Engineering Technician Apprenticeship Standard for the following occupational pathways:

Maritime Electrical Fitter
Maritime Mechanical Fitter
Maritime Fabricator
Maritime Pipe worker

The Standard and Assessment plan has been designed by Employers. Centres should make themselves familiar with the Standard, Assessment Plan and Employer Occupational Brief requirements, details of which can be found at:

https://www.gov.uk/government/collections/apprenticeship-standards

Age restrictions

City & Guilds cannot accept any registrations for learners under 16 as these qualifications are not approved for learners under 16.

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs
- support and guidance they may need when working towards their qualifications
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualification, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for these qualifications:

Description	How to access
Assessment pack	www.cityandguilds.com

Recording documents

Candidates and centres may decide to use a paper-based or electronic method of recording evidence.

City & Guilds endorses several ePortfolio systems, including our own, Learning Assistant, an easy-to-use and secure online tool to support and evidence learners' progress towards achieving qualifications. Further details are available at: www.cityandguilds.com/eportfolios.

City & Guilds has developed a set of *Recording forms* including examples of completed forms, for new and existing centres to use as appropriate. Recording forms are available on the City & Guilds website.

Although new centres are expected to use these forms, centres may devise or customise alternative forms, which must be approved for use by the external verifier, before they are used by candidates and assessors at the centre. Amendable (MS Word) versions of the forms are available on the City & Guilds website.

4 Assessment

Summary of assessment methods

Candidates must:

- have completed the relevant assessment for each Mandatory unit
- have completed the relevant assessment for each Optional unit chosen

Available assessments/assignments

City & Guilds has written the following assessments to use with this qualification:

- evolve tests for the unit 302
- externally set assignments for units 300-301 and 303-306
- internally set assignments for units 307-336.

City & Guilds has written guidance for centres to write their own assessments/assignments for the internally set units.

Assessment Types			
Unit	**Title**	**Assessment method**	**Where to obtain assessment materials**
300	Engineering maths	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
301	Engineering and environmental health and safety	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
302	Engineering principles	online multiple choice examination via evolve	www.cityandguilds.com
303	Principles of mechanical engineering	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
304	Principles of electrical and electronic engineering	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
305	Principles of pipework fabrication	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
306	Principles of fabrication and welding	Assignment - SAQ externally set and internally marked	www.cityandguilds.com
307	Marine propulsion systems	Assignment - internally set and marked	www.cityandguilds.com
308	Marine auxiliary systems and equipment	Assignment - internally set and marked	www.cityandguilds.com
309	Principles of shipbuilding	Assignment - internally set and marked	www.cityandguilds.com
310	Principles of maintenance, installation and commissioning	Assignment - internally set and marked	www.cityandguilds.com
311	Power generation systems and ancillary equipment	Assignment - internally set and marked	www.cityandguilds.com
312	Generation distribution for electrical power systems	Assignment - internally set and marked	www.cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
313	Plate work fabrication of materials	Assignment - internally set and marked	www.cityandguilds.com
314	Sheet metal work fabrication of materials	Assignment - internally set and marked	www.cityandguilds.com
315	Fabrication and erection of structural steel	Assignment - internally set and marked	www.cityandguilds.com
316	Pattern development for fabrication	Assignment - internally set and marked	www.cityandguilds.com
317	Further electrical and electronic principles	Assignment - internally set and marked	www.cityandguilds.com
318	Maintenance of utility systems	Assignment - internally set and marked	www.cityandguilds.com
319	Maintenance of electrical equipment and systems	Assignment - internally set and marked	www.cityandguilds.com
320	Electrical maintenance on ships	Assignment - internally set and marked	www.cityandguilds.com
321	Maintenance of fluid power systems	Assignment - internally set and marked	www.cityandguilds.com
322	Maintenance of hydraulic systems	Assignment - internally set and marked	www.cityandguilds.com
323	Maintenance of pneumatic systems	Assignment - internally set and marked	www.cityandguilds.com
324	Principles of welding	Assignment - internally set and marked	www.cityandguilds.com
325	Principles of fabrication	Assignment - internally set and marked	www.cityandguilds.com

Unit	Title	Assessment method	Where to obtain assessment materials
326	Advanced mathematics and science	Assignment - internally set and marked	www.cityandguilds.com
327	Marine internal combustion engines theory and maintenance	Assignment - internally set and marked	www.cityandguilds.com
328	Marine mechanical system and equipment maintenance	Assignment - internally set and marked	www.cityandguilds.com
329	Fitting and machining	Assignment - internally set and marked	www.cityandguilds.com
330	Welding and pipe work processes	Assignment - internally set and marked	www.cityandguilds.com
331	Electrical and electronic cable maintenance and repair	Assignment - internally set and marked	www.cityandguilds.com
332	Electrical submarine systems equipment and maintenance	Assignment - internally set and marked	www.cityandguilds.com
333	Marine electrical circuit breakers and static frequency changers	Assignment - internally set and marked	www.cityandguilds.com
334	Marine systems electrical maintenance	Assignment - internally set and marked	www.cityandguilds.com
335	Marine mechanical equipment and system maintenance	Assignment - internally set and marked	www.cityandguilds.com
336	Marine controls systems and diagnostics	Assignment - internally set and marked	www.cityandguilds.com

Assessment strategy

Mandatory unit 302 is assessed by a multiple-choice online test, which is graded Pass/Merit/Distinction. This is marked by City & Guilds.

Mandatory units 300 and 301 are assessed by short-answer question assessments, set by City & Guilds, internally marked by centres and externally verified. These assessments are graded Pass/Merit/Distinction.

Optional units 303-306 are assessed by short-answer question assessments, set by City & Guilds, internally marked by centres and externally verified. These assessments are graded Pass/Merit/Distinction.

Optional units 307-336 are assessed by centre devised assessment and internally marked by centres and externally verified. These assessments are to be graded Pass/Fail only.

Test Specifications

The way the knowledge is covered by each externally marked test is laid out in the tables below:

Assessment title: Engineering Principles
Assessment type: Online Multiple Choice
Assessment conditions: Invigilated examination conditions
Grading: X/P/M/D

	Duration: 70 minutes		
	Learning Outcome	**Number of marks**	**%**
Unit 302	01 Know how to interpret engineering information	11	24.5
	02 Know how to differentiate between common engineering materials	10	22
	03 Know how to perform engineering calculations	10	22
	04 Understand quality control in engineering	14	31.5
	Total	**45**	**100**

5 Grading

Grading of individual assessments

Some individual assessments will be graded Pass/Merit/Distinction.

For a unit to be achieved, candidates must achieve a minimum Pass in the assessment, as per the marking scheme provided.

A Pass reflects the minimum requirements that are expressed in the unit, with Merit and Distinction showing progression in the depth and breadth of the learner's knowledge, as well as in the type of cognitive operations they demonstrate.

Grading of the qualification

Individual assessments will be graded Pass/Merit/Distinction where indicated

The grade boundaries for Pass, Merit and Distinction for each assessment have been set through a judgemental process using technical experts, aimed at defining what the grades for each assessment should mean in practice. The following descriptors are based on that process.

For the units to be achieved, candidates must achieve a minimum of Pass in the assessments. The descriptors given here simply provide a baseline against which Merit and Distinction grades can be understood and should **not** be used for grading/marking the assessments.

Pass

The candidate has a solid understanding of the unit key concepts. Some understanding may be simplistic, narrow or shallow. Individual topics are dealt with separately but understanding is clear. Recall of the unit content is generally accurate, without serious misapprehensions or gaps. Recall may be slow or show signs of difficulty/uncertainty and minor misapprehensions may occur.

Indicators:

- explanations may be a little incoherent or incomplete but the meaning is on the whole accurate
- the use of illustrations/examples are mostly relevant to the explanation
- relationships between concepts are missing
- reasoning shows comprehension of the main facts
- analyses or evaluations are simplistic but relevant
- sources, when used, are limited but relevant
- main facts are stated accurately
- definitions and descriptions are accurate, but somewhat limited
- diagrams, when used, are mostly correctly annotated, with some minor errors eg spelling.

Merit

The candidate has a sound understanding of the breadth/depth of the relevant concepts. Topics are dealt with in relation to each other and communicated clearly. The breadth and depth of the unit content are recalled in an accurate and complete manner. Recall is confident.

Indicators:

- explanations are coherent, complete and accurate
- use of illustrations/examples which accurately and clearly add to/support the explanation
- relationships are made between concepts
- reasoning is plausible and conventional
- analyses and evaluations are methodical and plausible
- information is drawn from a range of appropriate sources and used appropriately
- facts are accurate and cover the breadth and depth of the unit
- definitions and descriptions are clear
- technical language is accurate

Distinction

The candidate has a well-developed understanding of the relevant concepts. Relationships between topics are highly developed and may be set in context; interactions between topics are clearly expressed. There is evidence of understanding of some facts/knowledge, which go beyond the requirements of the unit. Recall is automatic and can be brought together making useful connections.

Indicators

- explanations are well thought out, thorough and well-argued/justified

- well-chosen illustrations/ examples, which accurately and precisely clarify explanations
- relationships are brought together to show an understanding of the bigger picture
- reasoning is justified, well-argued and may be creative
- analyses and evaluations are thorough, well-developed
- sourced information is critically evaluated, showing awareness of its importance or relevance
- evidence of interest beyond the scope of the unit
- descriptions and definitions are detailed
- use of knowledge is consistently high and second nature.

Grading of qualification

The Employer Group has taken the decision to grade this qualification Pass/Merit/Distinction, through the aggregation of the individual assessment graded Pass/Merit/Distinction.

Grading can be of use both as a motivational tool within the learning environment and also to learners presenting evidence of their knowledge to prospective employers.

All assessments must be achieved at a minimum of Pass for the qualification to be awarded. All assessments graded Pass/Merit/Distinction contribute equally to the overall qualification grade. Learners **must** achieve a Pass in assessments graded pass/fail only; however, they do **not** contribute to the overall qualification grade.

Centres will need to calculate the qualification grade as follows:

- Centre will mark and grade each graded assessment using the model answer mark scheme provided by City & Guilds and available on www.cityandguilds.com

- The grade achieved by a learner will need to be converted into points as follows:

Individual assessment grade	Grade points
Pass	1
Merit	2
Distinction	3

- Grade points for each assessment need to be added together and the overall qualification grade determined using the following conversion table:

Total grade points	Overall qualification grade
4 - 6	Pass
7 - 9	Merit
10 - 12	Distinction

- Overall qualification grades must be entered using **one** of the grading modules on the Walled Garden. Please refer to the Structure section.

Example

Learner A has achieved the following:

Assessment	Grade achieved	Grade points
Mandatory		
300	Merit	2
301	Pass	1
302	Pass	1
Mandatory Pathway choice		
303	Distinction	3
Optional		
www	Pass	No grade points, as Pass/Fail only
xxx	Pass	No grade points, as Pass/Fail only
yyy	Pass	No grade points, as Pass/Fail only
zzz	Pass	No grade points, as Pass/Fail only
	Total grade points	**7**
	Overall qualification grade	**Merit**

Opportunities to repeat assessments

The tasks are summative assessments. A candidate should not be allowed to repeat until it is evident that they are ready to undertake the assessment. This is not likely to be less than 10 working days after the original assessment. Please see individual assessment packs for detail of the number of resits allowed for each assessment.

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience, or qualifications, which have already been achieved, to contribute to a new qualification.

RPL is **not** allowed for this qualification.

http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/quality-assurance-documents

6 Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes, which are comprised of a number of assessment criteria

Centres must deliver the full breadth of the range. Specialist equipment or commodities may not be available to all centres, so centres should ensure that their delivery covers their use. This may be covered by a practical demonstration (e.g. video). For the practical assessments for this qualification, centres should ensure that there are sufficient resources to complete the task but are not required to use all the equipment or commodities in the range.

Unit 300 Engineering maths

Unit level:	Level 3
GLH:	60
Unit aim:	The purpose of this unit is for learners to understand the principles of mathematics and apply these to solve engineering problems. They will learn the principles of arithmetic, trigonometry, algebraic methods and statistics and how these can be applied in a range of engineering contexts.

Learning outcome

The learner will:

1 Solve engineering problems using arithmetic

Assessment criteria

The learner can:

1.1 apply arithmetic methods

1.2 apply standard formulae.

Range

(AC1.1)

- addition, subtraction, multiplication, division
- order of operation
- decimal places
- significant figures
- SI units (metric) and prefixes
- ratio, proportions
- transposition
- fractions.

(AC1.2)

- area of simple and compound 2D shapes
- surface area and volume of simple and compound 3D shapes
- calculating density and mass

Learning outcome

The learner will:

2 Solve engineering problems using algebraic methods

Assessment criteria

The learner can:

2.1 solve problems using equations

2.2 solve problems using rules of indices

2.3 solve problems using logarithms.

Range

(AC2.1)
- simplifying equations and functions
- manipulating equations to change the subject.

(AC2.2)
- solve problems using rules of indices

(AC2.3)
- laws of logarithms,
- use of natural logarithms
- changing the base.

Learning outcome

The learner will:

3 Solve engineering problems using trigonometric methods

Assessment criteria

The learner can:

3.1 use trigonometry on right angled triangles

3.2 apply sine and cosine rules to engineering problems

3.3 use **Radian measure.**

Range

(AC3.1) **calculate**:
- length of unknown side from two other side
- length of unknown side from a known angle and length
- unknown angle from two lengths

(AC3.2)
- solution of triangles, by applying of sine and cosine rules.

(AC3.3) **Radian measure**:
- using radians
- convert angles between radians and degrees.

Learning outcome

The learner will:

4 Solve engineering problems using statistics

Assessment criteria

The learner can:

4.1 perform calculation of averages
4.2 carry out central tendency and dispersion.

Range

(AC4.1) **calculate**:

- Mean
- Median
- Mode.

(AC4.2)

- cumulative frequency and variance
- standard deviation.

Unit 300 Engineering maths

Supporting Information

Unit guidance

This is a theoretical unit that is best taught through applied activities related to engineering contexts.

There are many opportunities to link the learning in this unit with practical activities.

Employers can be engaged to support delivery with examples of activities where the theory can be applied eg with engineering drawings or case studies.

Unit 301 Engineering and environmental health and safety

Unit level:	Level 3
GLH:	60
Unit aim:	The aim of this unit is for learners to develop their knowledge of their health and safety responsibilities when working in an engineering business. They will learn about health and safety legislation and how the business' activities could impact on the environment. They will also learn about the types of documentation require to adhere to Health and safety policies.

Learning outcome

The learner will:

1 Understand workplace health and safety responsibilities

Assessment criteria

The learner can:

1.1 state the legislation relating to health and safety in the workplace

1.2 describe the responsibilities of employers and employees arising from health and safety legislation

1.3 state the job roles involved in workplace health and safety

1.4 explain how job roles in health and safety may differ depending on the type of organisation

1.5 state the external organisations involved in workplace health and safety and the actions these organisations can take in specific situations.

Range

(AC1.1, 1.2)

- Health and Safety at Work etc. Act
- Management of Health and Safety at Work Regulations
- Control of Substances Hazardous to Health (COSHH)
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Manual Handling Operations Regulations
- Lifting Operations and Lifting Equipment Regulations (LOLER)
- Noise at Work Regulations
- Vibration at Work Regulations
- Electricity at Work Regulations

- The Health and Safety (Display Screen Equipment) Regulations
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

(AC1.3, 1.4)
- health and safety representatives
- environmental health officers
- Health and Safety Executive Inspectors
- first aiders
- fire marshals/wardens.

(AC1.5)
- Health and Safety Executive (HSE)
- local authorities
- environmental health agency
- fire authority
- trade unions

Learning outcome

The learner will:

2 Understand how to maintain a safe and healthy workplace

Assessment criteria

The learner can:

2.1 state the organisational procedures, reporting requirements and supporting documentation to manage health and safety in the workplace

2.2 explain how to carry out a risk assessment

2.3 describe the hierarchy of control for risks and how it is applied in different situations.

Range

(AC2.1)
- fire prevention
- emergency evacuation
- accidents
- near misses
- machining operations
- maintenance
- storage of materials
- movement of materials.

(AC2.2)
- hazards
- severity
- risks
- risk rating
- control measures
- review process.

(AC2.3)
- elimination
- substitution
- controls

- safe systems of work
- personal protective equipment

Learning outcome

The learner will:

3 Understand the responsibilities of engineering businesses for environmental management

Assessment criteria

The learner can:

3.1 state the main requirements of environmental legislation and standards

3.2 describe how human and environmental factors in the workplace may affect the environment and how these are controlled

3.3 describe the sources of energy and their environmental impact

3.4 describe the potential causes of waste and pollution in the workplace and how these are managed.

Range

(AC3.1)
- Environmental Protection Act
- Pollution Prevention and Control Act
- Clear Air Act
- Radioactive Substances Act
- Waste Regulations
- The Dangerous Substances and Explosive Atmospheres Regulations ISO4001.
- Waste Electric and Electronic Equipment (WEEE) Regulations

(AC3.2)
- human factors (lack of management control and supervision; improper behaviour and dress; inadequate or inappropriate training; experience; fatigue; carelessness; drug-taking; alcohol)
- environmental factors (unguarded or faulty machinery, equipment and tools; inadequate ventilation; inadequate lighting; untidy, dirty or overcrowded workplace).

(AC3.3)
- renewable and non-renewable sources, fossil fuels, nuclear, solar, tidal, wind, biomass

(AC3.4)
- types and likely causes of industrial emissions and methods used for mitigation
- requirements for the safe disposal and recycling of waste
- procedures required for energy audits and implications of findings.

Unit 301 Engineering and environmental health and safety

Supporting Information

Unit guidance

This is a theory unit that provides opportunities for learners to input on their own experiences when working in an engineering environment. The use of case studies from a range of different types of business would enable learners to grasp the scale and scope that health and safety has on the industry. Case studies can also be used to consider the impact of an engineering activities on the environment.

Gaining an understanding of health, safety and the environment can be developed through practical activities where learners complete documentation.

There are opportunities to work with employers who can provide case studies of how policies and procedures have prevented incidents. They can also provide examples of real documentation used in their business.

Unit 302 Engineering principles

Unit level:	Level 3
GLH:	80
Unit aim:	This unit is concerned with those engineering principles that enhance the performance of engineering operations. This includes the extraction, interpretation and use of a range of technical information sources. It includes the use of basic calculations and engineering science that enables the leaner to better understand the behaviour and properties of engineering materials in order that appropriate materials may be selected to satisfy specifications. The identification and application of quality control measures that are relevant to engineering activities are also covered.

Learning outcome

The learner will:

1 Know how to interpret engineering information

Assessment criteria

The learner can:

1.1 explain the relevance of **engineering information**

1.2 describe the difference between the **abbreviations and notation** used on various standard engineering drawings, circuit diagrams or piping layouts

1.3 interpret the information that can be extracted from **reference charts, tables, graphs and BS EN standards**

1.4 explain the use of CAD systems to produce engineering drawings

1.5 explain the use of databases and spreadsheets to display information

1.6 explain the basic principles of **document control**

1.7 interpret **drawings, dimensioning and labelling**

1.8 describe how to use charts, tables, graphs and BS EN standards

1.9 describe how to extract information from drawings

1.10 describe how to use engineering drawings to produce material lists

1.11 describe how to use engineering drawings to determine quality requirements.

Range

(AC1.1) • **engineering information**: BS EN standards, instruction manuals, technical handbooks, tables, charts (including: flow, Gantt, tally), graphs (including histograms, scatter diagrams), Ishikawa diagrams (fishbone diagrams or cause-and-effect diagrams), data sheets, text books and reference materials, computer applications

(AC1.2) • **abbreviations and notation**: symbols and abbreviations, application to: engineering drawings, machining, welded joints, circuit diagrams and piping layouts

(AC1.3) • **reference charts, tables, graphs and BS EN standards**: tapping sizes and threads, feeds and speeds, cable sizing, PIN configurations, component ratings, welding symbols, machining symbols and tolerances, piping components

(AC1.6) • **document control**: where documents are obtained from, how distribution and use of documents is controlled, the relevance of document issue numbers, document approval and authorisation procedures, procedure to be adopted if documents are lost or damaged

(AC1.7) • **drawings**, **dimensioning and labelling**: projections (orthographic [first angle, third angle], isometric [including exploded], oblique); reference points, lines, edges and surfaces, continuous dimensions, baseline dimensions

Learning outcome

The learner will:

2 Know how to differentiate between common engineering materials

Assessment criteria

The learner can:

2.1 describe the difference between a range and form of **supply of materials** commonly used in engineering

2.2 describe the difference between **characteristics** of metallic and non-metallic materials used in engineering

2.3 describe how carbon and alloying elements affect the properties of carbon and low alloy steels

2.4 describe how **heat treatments** can affect the properties of carbon and low alloy steels

2.5 explain the causes of **corrosion** in materials

2.6 state the **defects** that can occur in materials/products and explain the importance of controlling them

2.7 select materials to meet specification requirements in a typical engineering environment.

Range

(AC2.1) • **supply of materials**: ferrous metals (low, medium and high carbon steels; low alloy steels; stainless steels; cast irons), non-ferrous metals (aluminium and aluminium alloys, copper, brass, bronze, nickel, lead, titanium), non-metallic (hard and soft woods, composites, plastics: thermoplastic, thermosetting), ceramics, reinforcing materials (glass fibre, carbon fibre, aramid fibre)

(AC2.2) • **characteristics**: selection of materials for engineering applications, strength, rigidity, temperature stability (heat resistance, thermal conductivity, electrical conductivity and insulation), wear resistance, acoustic absorption, shock absorption, corrosion resistance, influence of physical properties of materials on processing techniques (cutting, forming, joining), identification* of engineering materials (colour, surface texture, appearance, density, magnetic/non-magnetic, spark test).

Additional Guidance: factors influencing the choice of materials (properties, cost, testing of materials (non-destructive: visual, penetrant [dye and fluorescent], magnetic particle [dye and fluorescent], radiography, ultrasonic; destructive: tensile, shear, hardness [Brinell, Vickers, Rockwell], toughness [Charpy, Izod], creep, fatigue, bending.

(AC2.4) • **heat treatments**: iron-carbon thermal equilibrium diagram, annealing, normalising, hardening, tempering

(AC2.5) • **corrosion**: pitting, intergranular, galvanic, leaching, oxidation

(AC2.6) • **defects**: critical, major, minor or non-critical

Learning outcome

The learner will:

3 Know how to perform engineering calculations

Assessment criteria

The learner can:

3.1 express numerical solutions to a **degree of accuracy** that is appropriate to the value being calculated

3.2 use a calculator to raise a number to a power and determine square roots

3.3 use formulae to complete **transpositions** and solve problems

3.4 use **algebraic expressions**

3.5 plot and interpret **straight line graphs**

3.6 apply Pythagoras' Theorem

3.7 explain how to use **Sine, Cosine and Tangent** to solve typical engineering problems

3.8 define density and relative density and solve related problems using formula

3.9 define **moments of a force** and solve related problems using formula

3.10 define **work, power and energy** and solve related problems using formula

3.11 define **friction** and solve related problems using formula

3.12 describe the relationship between **temperature** changes and changes in length

3.13 define types of **heat** and solve related problems using formula.

Range

(AC3.1)
- **degree of accuracy**: correct to three significant figures, correct to two decimal places, express a decimal fraction in standard form, express tolerance in terms of limits of sizefixings (tack welding)

(AC3.3)
- **transpositions**: involving addition, subtraction, multiplication and division in any combination using a maximum of three terms, for example Ohm's Law solve problems: substitution of known values

(AC3.4)
- **algebraic expressions**: represent numerical quantities using symbols, apply laws of precedence in the use of precedence (BODMAS)arc welding (MMA)

(AC3.5)
- **straight line graphs**: determining suitable scales from given data, defining and correctly labelling axes, determine the gradient, determine the intercept, prove the law of the straight line graph is y = mx + c

(AC3.7)
- **Sine, Cosine and Tangent**: state their ratios for angles up to 90°, determine their values for given angles up to 90°, solve simple problems)

(AC3.9)
- **Moments of a force**: define and apply the 'Principle of Moments', define the meanings of the terms 'torque' & 'couple'.
- **solve problems**: associated with levers and couples work, power and energy define work done in terms of force and distance moved.

(AC3.10)
- **work, power and energy**: explain what is meant by energy; state that the unit of energy is the joule (J), the unit of power is the watt (W) and the unit of work is the joule (J); define power in terms of voltage/current and work done per second, perform calculations for work, power and energy**.**

(AC3.11)
- **friction**: definition, explain coefficient of friction, explain how friction can be reduced, select materials that will rotate, or slide together with low frictional value, perform calculations for friction

(AC3.12)
- **temperature:** define coefficient of expansion, solve numerical problems to determine the change in length due to temperature.

(AC3.13)
- **heat:** define: specific heat capacity, specific latent heat (fusion, evaporation) solve numerical problems associated with specific heat capacity, specific latent heat of fusion, specific latent heat of evaporation

Learning outcome

The learner will:

4 Understand quality control in engineering

Assessment criteria

The learner can:

4.1 state what is meant by the term **quality** and apply quality to contexts/perceptions

4.2 define the terms **inspection** and **quality control**

4.3 explain the principles of quality control and inspection

4.4 explain the need for materials and components, **inward inspection** and correct documentation

4.5 state the function of an incoming raw materials inspection department

4.6 explain the need for **validating and calibrating** test and measuring equipment

4.7 explain how to **check equipment is approved** for use and how to take appropriate action to return/report equipment that has passed its approval date

4.8 explain the use of engineering standards in determining the fitness of purpose of items/equipment used in engineering production, construction and maintenance

4.9 describe the appropriate **action** to take when required standards of performance are not met

4.10 explain limits of authority in respect of re-working, adjusting or scrapping a component/product

4.11 explain the need to inform a responsible person of the variation from the stated standard

4.12 state the need to document all actions agreed upon and taken

4.13 explain the importance of **quality records** and the type of inspection records needed

4.14 explain the purpose of the ISO 9000 series of standards

4.15 describe how to complete quality documents/records of work carried out and record test/inspection results

4.16 interpret results from quality measurements and compare them with stated parameters

4.17 make recommendations whether to re-work, adjust or scrap items/components.

Range

(AC4.1)
- **quality**: components, products or services being fit for purpose, customer expectation, product, component or service reliability, the need for interchangeability with regard to supplying spare parts, product life cycle.

(AC4.2, 4.3)
- **quality control and inspection**

  inspection: covering the examination, measurement, testing and judgement of a product for conformation to a predetermined requirement i.e. fitness for purpose.

  quality control: activities embracing all stages of manufacture from initial design, raw material and finished products, principles of inspection (random sampling, sampling frequency).

(AC4.4)
- **inward inspection**: dimensional accuracy, correct documentation for incoming goods/materials, importance of release and advice notes, faults that may arise in documentation and storage of incoming goods, methods of checking for faults in documentation, spot checks, random checks; sampling (quarantine inspection) in terms of: importance of release and advice notes, the reason for clear, identification of materials with relevant batch numbers, procedures to be followed before batch material is released into stores in accordance with storage recommendations – tests to be applied, identification of acceptance/rejection criteria and the recording procedures involved, remedial action to be taken when components/materials prove defective

(AC4.6)
- **validating and calibrating**: need for regular and controlled calibration and validation of measuring equipment, need for traceable records of calibration checks, use of international standards.

(AC4.7)
- **check equipment is approved**: Equipment such as: torque wrenches, lifting equipment, pressure gauges, micrometers, vernier instruments.

(AC4.9)
- **action**: re-work, adjust, scrap

(AC4.13)
- **quality records**: record all test results, record all inspections carried out, procedures to be taken upon completion of task (place into stores, pass it to another department, mark it for re-work, adjust, mark it for scrap or salvage welding.

Unit 303 Principles of mechanical engineering

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the leaner to understand the underlying principles for mechanical engineering as well as those that apply to all common machine tool systems, covering the alignment of machine tools, power transmission, an evaluation of the application of CNC to machine tools and the understanding of maintenance requirements for machine tool systems. Within the unit leaners are expected to prepare a maintenance programme, prepare a lubrication chart, produce a CNC part-programme and critically compare CNC machining to non-CNC machining

Learning outcome

The learner will:

1 Understand the fundamentals of engineering science

Assessment criteria

The learner can:

1.1 identify the primary units of the SI system; length, mass, time, temperature, capacity

1.2 identify the derived units of the SI system; force, stress, density, conductivity, power, current, voltage and resistance

1.3 demonstrate an understanding of the effects of heat

1.4 demonstrate an understanding of the elementary strength of materials

1.5 demonstrate an understanding of forces

1.6 demonstrate an understanding of the laws of friction

1.7 demonstrate an understanding of work and power transmission

1.8 demonstrate an understanding of basic electrical principles

1.9 carry out calculations involving heat, strength of materials, forces, friction work and power

1.10 carry out a tensile test on various materials to determine the ultimate tensile strength, yield point, limit of proportionality, elastic limit, ultimate load, breaking load, percentage elongation and percentage reduction in area

1.11 carry out calculations involving work done and power

1.12 solve problems involving electromotive force and resistance.

Learning outcome

The learner will:

2 Understand how to determine the alignment of machine tools

Assessment criteria

The learner can:

2.1 describe the range of **machine tools** available in terms of size, capacity, accuracy and production capability

2.2 explain the **structural requirements** of a range of common machine tools

2.3 explain the common methods of **mounting** machine tools

2.4 explain the importance of **alignment** in machine tools and methods to achieve it.

Range

(AC2.1)
- **machine tools**: lathes (centre), milling machines (vertical), drilling machines (pedestal, radial arm, multi- spindle, special purpose), grinding machines (surface [horizontal spindle], cylindrical [plain, universal]), electro machining (electrodischarge machining [EDM] {ram feed, wire feed}, ultrasonic machining [USM], electrochemical machining [ECM], computer numerical control (CNC). presses (gap, flywheel). die casting machines (hot and cold chamber).

(AC2.2)
- **structural requirements**: strength, rigidity, stability, control of movement, materials (cast iron, cast steel, steel plate), structures (box column, rib and box bed, fabricated base)

(AC2.3)
- **mounting**: cork pad, adjustable mounting, rag bolt, expanding bolt
weld bead

(AC2.4)
- **alignment**:
slideways: flat, vee, dovetail, cylindrical, comparison of their capabilities, main features, accuracy of movement, means of adjustment, lubrication, protection
stick-slip: definition, recirculating ball leadscrews, hydrostatic slides
typical checks: coaxial alignment between main spindle axis, coaxial alignment between two spindles, alignment of spindle to guideway, squareness of slideways movement, concentricity and end float of spindle, squareness of planes to spindle, setting of guards, stops and automatic safety cut-outs
bearings: plain bush (radial, radial and axial) ball (radial, axial, radial and axial) roller (radial, axial, radial and axial)
methods of alignment: standard tests, straight edge, precision level, autocollimator and reflector, roundness measuring machine)

Additional Guidance

Sand casting

Learning outcome

The learner will:

3 Understand the properties of engineering materials

Assessment criteria

The learner can:

3.1 demonstrate an understanding of the term atomic structure – the atom, electron, proton and neutron. The arrangement of atoms defining a substance; solid, liquid or gas

3.2 demonstrate an understanding of the forms of bonding: covalent, ionic and metallic

3.3 demonstrate an understanding of the crystalline structure of metals; lattice structures: body-centred cubic, face-centred cubic and close-packed hexagonal

3.4 demonstrate an understanding of how lattice and grain structures arise; solidification and growth of dendrites

3.5 demonstrate an understanding of the term recrystallisation

3.6 demonstrate an understanding of the effects of heat treatment and hot and cold working on the crystal structure

3.7 demonstrate an understanding of the relationship between the solidification process and a cooling curve

3.8 recognise the cooling curves for a pure metal and an alloy

3.9 recognise an equilibrium diagram

3.10 demonstrate an understanding of the structure, properties, and uses of steels (to include plain carbon steel, alloy steels such as; structural Steel, tool steel and stainless steel)

3.11 demonstrate an understanding of the principal methods of testing for hardness; Brinell; Vickers; Rockwell; Shore

3.12 demonstrate an understanding of the structure of polymers; polymer chains and their effect on the polymer

3.13 demonstrate an understanding of the effects of temperature on the mechanical properties of polymers

3.14 demonstrate an understanding of the properties and uses of common polymers; thermoplastics; thermosetting polymers; elastomers

3.15 carry out a hardness test.

Learning outcome

The learner will:

4 Understand how to evaluate the application of CNC to machine tools

Assessment criteria

The learner can:

4.1 explain the **operating principles** of computer numerically controlled machine tools

4.2 describe how to produce a **part-programme** to demonstrate the relative work/tool movement of a CNC machine tool

4.3 describe how to prove the part-programme using simulation software

4.4 **critically compare** CNC machine tools against non-CNC machine tools

4.5 describe how to evaluate **cutting tools materials** for given applications (CNC and non-CNC).

Range

(AC4.1)
- **operating principles**: open loop system, closed loop system, control systems (closed loop servo motors and associated transmission, stepper motors and associated transmission), types and function of position transducers (rotary type, optical gratings), digital control

(AC4.2)
- **part-programme**: co-ordinate positioning (absolute, incremental), use of sub routines, macros and canned cycles, role of CADCAM

(AC4.4)
- **critically compare**: production (mass, flow, batch, single items/job), ease of programming, repeatability, prototypes, skill levels and other factors

(AC4.5)
- **cutting tools materials**: high carbon steel (HCS), high speed steel (HSS) tungsten carbide, ceramic

---

Learning outcome

The learner will:

5 Understand the maintenance requirements for machine tool systems

Assessment criteria

The learner can:

5.1 describe the differences between **types of maintenance** carried out on machine tools

5.2 describe a **maintenance programme** for a typical machine tool

5.3 describe what would be included in a **lubrication chart** for a typical machine tool workshop

5.4 classify **coolants and lubricants** applicable to machine tool systems

5.5 classify the methods of application for common surface coatings

5.6 explain the **commissioning/maintenance procedures** carried out on machine tools.

Range

(AC5.1)
- **types of maintenance**: running, preventive, breakdown, routine

(AC5.2)
- **maintenance programme**: inspection, lubrication, adjustment, rectification, overhaul

(AC5.3)
- **lubrication chart**: machine designation, types of lubricant, quantities of lubricant, frequency

(AC5.4) • **coolants and lubricants**: types of coolant pump, strainers and filtration methods (including separating tanks and magnetic drum), filters, lubrication of headstock/gearbox assemblies of splash and pressurised feed (lead and feed screws, separation of coolant from lubricants in the lathe cross slides/carriage assemblies)

(AC5.6) • **commissioning/maintenance procedures**: checks, operational function, compare checks and operational functions with manufacturers' or production departments requirements, complete reports and job sheets, submit report

Additional Guidance

Commissioning/maintenance procedures: checks (alignment and levels, electrical power supplies/insulation, safety switches/devices and interlocking, security of pipes and couplings, oil levels), operational function (run at light load: check, oil temperature, oil pressure, cooling/coolant system as appropriate; run at full load and carry out the same checks again), compare checks and operational functions with manufacturers' or production departments requirements, complete reports and job sheets (work carried out to commission/restore machine tool to operational condition, complete maintenance schedule, report and recommendation on system condition), submit report.

Unit 304 Principles of electrical and electronic engineering

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the learner to understand the underlying principles that apply across electrical and electronics engineering. The unit covers supply systems, protection and earthing, the function of electrical and electronic components, electronic measurement, a.c. circuits and the relationship between magnetic materials and inductance.

Learning outcome

The learner will:

1 Understand electrical supply systems, protection and earthing

Assessment criteria

The learner can:

1.1 explain electricity **supply systems**

1.2 explain the function of **transformers** and switchgear

1.3 explain the purpose of **earthing systems**

1.4 explain **protection systems.**

Range

(AC1.1) • **supply systems**:from generation to utilisation, generation, transmission and distribution voltages, star and delta connections, single and three phase power. (tack welding)

(AC1.2) • **transformers**: principle of operation, input, output and losses, transformer rating in kVA, autotransformer; Low voltage (LV) and High voltage (HV) switchgear.

(AC1.3) • **earthing systems**: human safety, overvoltage protection (lightning, transient voltages).

(AC1.4) • **protection systems**: short circuits, overloads, under voltage, earth leakage, fuses, circuit breakers, residual current devices, residual current breakers (RCD's) with overload (RCBO).

Learning outcome

The learner will:

2 Understand the function of electrical and electronic components

Assessment criteria

The learner can:

2.1 define electrical **units**

2.2 describe **resistors**

2.3 describe **batteries**

2.4 describe **inductive components**

2.5 describe **capacitors**

2.6 describe **circuit properties** connected to d.c. supplies

2.7 describe **circuit properties** connected to a.c. supplies

2.8 describe the function of **electronic circuits**

2.9 describe applications of **components** in electronic circuits.

Range

(AC2.1) • **units**: Energy, current, charge, voltage, power and resistance

(AC2.2) • **resistors**: types, construction, material resistivity, tolerances, colour coding, applications (series/parallel connections)

(AC2.3) • **batteries**: construction, charging, discharging, chemical process

(AC2.4) • **inductive components**: types, construction, properties, applications

(AC2.5) • **capacitors:** types, construction, properties, applications (series/parallel connections)

(AC2.6) • **circuit properties**: circuits with Inductors (L) and Capacitors (C) connected in series, charge and discharge, time constants

(AC2.7) • **circuit properties**: circuits with Resistors (R), Inductance (L) and Capacitance (C) connected in series / parallel, power, power factor, kW, kVA & kVAr. (PA)

(AC2.8) • **electronic circuits**: amplifier, oscillator, filter, linear power supply

(AC2.9) • **components:** photocell, photodiode, transistors (Bipolar/FET), zener diodes, diodes, thyristors.

Learning outcome

The learner will:

3 Understand the behaviour of magnetic materials and their effect on inductance

Assessment criteria

The learner can:

3.1 explain the relationship between common magnetic **terms**

3.2 explain the **properties** of magnetic materials undergoing cyclic magnetisation

3.3 explain the relationship between the shapes of hysteresis loops of **materials** in magnetic circuits

3.4 explain electromagnetic behaviour **laws.**

Range

(AC3.1) • **terms**: magnetomotive force (m.m.f.); Magnetic field strength; flux density; total flux; reluctance

(AC3.2) • **properties**: coercivity; remanence; saturation; permeability

(AC3.3) • **materials**: magnetically soft and magnetically hard

(AC3.4) • **laws**: Faraday's law; Lenz's law; Flemings rule.

Learning outcome

The learner will:

4 Understand single and three-phase a.c. circuits

Assessment criteria

The learner can:

4.1 describe the principles of rotating **electrical machines** used in a.c. circuits

4.2 describe the function of **induction motors** used in three-phase circuits

4.3 describe the function **motors** used in single-phase a.c. circuits

4.4 determine three-phase circuit **quantities.**

Range

(AC4.1) • **electrical machines:** generators, interdependence of frequency, speed, pole pairs, EMF and field strength, synchronous and asynchronous machines

(AC4.2) • **induction motors:** cage rotor, wound rotor

(AC4.3) • **motors:** series universal, split phase, permanent capacitor, capacitor start/ run

(AC4.4) • **quantities:** line and phase values (current and voltage) in star and delta configurations.

Learning outcome

The learner will:

5 Know how to carry out electronic measurement

Assessment criteria

The learner can:

5.1 describe how to use **multimeters** to measure current, voltage and resistance

5.2 describe how to use **oscilloscopes** in different modes

5.3 describe how to use electronic instruments for **component testing** and prepared circuits

5.4 describe how to use electronic instruments as **signal sources** for prepared circuits

5.5 describe the use of **computers** in component testing.

Range

(AC5.1)
- **multimeters:** auto range, data capture and transfer, correct range settings.

(AC5.2)
- **oscilloscopes**: use to carry out a range of tests and measurements, real time and storage. Advantages and disadvantages of oscilloscopes.

(AC5.3)
- **component testing:** transistors, a series RLC circuit: a resistor, inductor and capacitor (L,C & R), power gain or loss in dB, voltage/current gain.

(AC5.4)
- **signal sources:** signal generators, function generators (include sine wave, square wave and saw tooth), signal injection probes.

(AC5.5)
- **computers:** diagnostic information, technical information, websites, use and function as digital multimeter, oscilloscope, spectrum analyser.

Unit 305 Principles of pipework fabrication

Unit level:	Level 3
GLH:	80
Unit aim:	The aim of this unit is for learners to develop an understanding of pipe and tube fabrication. The understanding is used extensively within the sector and allow learners to select the most suitable materials, techniques, methods and protection required.

Learning outcome

The learner will:

1 Know how to interpret and evaluate pipework drawings, specifications and sources of regulations

Assessment criteria

The learner can:

1.1 identify **production requirements** from drawings

1.2 calculate **data** for pipework fabrication from drawings

1.3 extract relevant **information** from drawings.

Range

(AC1.1)
- **production requirements**: Materials, cutting methods and equipment, pipe protection methods, pipe fittings.

(AC1.2)
- **data**: Calculation of cutting, joining and bending allowances, angles of cut, neutral line concept.

(AC1.3)
- **information**: Material cutting lists, parts and fittings lists, pipe layouts, templates, flowcharts.

Learning outcome

The learner will:

2 Know how to evaluate pipe materials and components for a range of applications

Assessment criteria

The learner can:

2.1 describe the **constructional features** of different types of pipework systems

2.2 describe applications of different types of **pipework materials.**

Range

(AC2.1)
- **constructional features**: Pressure and vacuum pumps, fans and blowers, compressors, circulation and lift pumps, valves.

(AC2.2)
- **pipework materials**: Metals: cast iron, steel (carbon, alloys and stainless), copper/ copper alloys, nickel/nickel alloys, aluminium/aluminium alloys. Non-metals: PVC, polythene, rubber/rubber components.)

Learning outcome

The learner will:

3 Understand a range of piped systems and the methods of testing and cleaning

Assessment criteria

The learner can:

3.1 describe requirements for **testing** pipe systems

3.2 describe pipe system **cleaning methods.**

Range

(AC3.1)
- **testing**: Hydrostatic testing, air pressure testing, gas pressure testing

(AC3.2)
- **cleaning methods**: Mechanical and chemical descaling, deterging, pickling, special requirements for grease and bacteria free piping, the use of “pigs” for cleaning and inspection.

Learning outcome

The learner will:

4 Understand assembly, joining and inspection methods to pipe and tube fabrications

Assessment criteria

The learner can:

4.1 describe joining **methods** for the assembly of pipe and tube fabrications

4.2 describe types of fitting appropriate for the joining method

4.3 describe **installation requirements** for pipe and tube fabrications

4.4 describe **inspection techniques** to check pipe and tube fabrications against specification

4.5 explain the implications of **defects** identified during inspection

4.6 explain how to avoid **defects** in joining and assembly of pipe and tube fabrications.

Range

(AC4.1) • **methods**: Threaded, welded, adhesive bonded, hot air welded, soldered, brazed compression.

(AC4.3) • **installation requirements**: Pipe supports, lagging, surface protection, ins-service conditions.

(AC4.4) • **inspection techniques**: Visual inspection, hydrostatic testing, thread insertion check.

(AC4.5, 4.6) • **defects**: Crushed bore, puckering, split tube, misalignment, wall thinning, weld defects.

Learning outcome

The learner will:

5 Understand the need for the protection and insulation of pipelines

Assessment criteria

The learner can:

5.1 explain the **purpose** of pipe insulation

5.2 describe methods and materials used for the **external protection of pipework**

5.3 describe methods and materials used for the **internal protection of pipework**

5.4 explain **factors** consider before insulating a pipeline.

Range

(AC5.1) • **purpose**: Avoidance of heat loss, prevention of surface condensation, fire proofing, sound proofing.

(AC5.2) • **external protection of pipework:** Dipping, spraying, hand painting, bituminous coating, impregnated tapes.

(AC5.3) • **internal protection of pipework:** Rubber, cement, resin, synthetic linings, metal linings.

(AC5.4) • **factors:** Operating temperatures, clearance between pipes, accommodating pipe supports and brackets, clearance between adjacent walls and equipment.

Unit 306 Principles of fabrication and welding

Unit level:	Level 3
GLH:	90
Unit aim:	This unit enables the leaner to understand the underlying principles of fabrication and welding, without focusing on specific fabrication disciplines or welding processes. Fabrication materials, joining using non-thermal methods, weld symbols, joint design, distortion, weld defects and testing: non-destructive (NDT) and destructive (mechanical) are included.

Learning outcome

The learner will:

1 Understand materials technology relating to fabrication and welding

Assessment criteria

The learner can:

1.1 critically compare **materials** from a range found in fabrication engineering

1.2 explain the commercial **forms of supply** of materials available

1.3 state the **criteria** used to select materials for a given application

1.4 explain the different material **structures**

1.5 explain the variation in properties that result from different types of **metallic structures**

1.6 explain the requirement for the **heat treatment** of metals

1.7 describe typical causes of **material failure**

1.8 explain the impact of metallic corrosion

1.9 describe methods of surface protection.

Range

(AC1.1)
- **materials**: metallic (low-carbon steel, low alloy steels, high yield steels, austenitic stainless steels, clad and coated materials [galvanised steel, tin plated steel, plastic coated steel, clad steels, anodised aluminium], aluminium/aluminium alloys, copper/copper alloys, titanium/ titanium alloys), polymers (thermoplastics, thermosetting), composites (glass fibre, carbon fibre, aramid fibre).

(AC1.2)
- **forms of supply :**sheet, plate, section (RSJ, channel, column, beam, tee, angle (equal leg, unequal leg), hollow section (square, rectangular, round [tubular]), pipe, fibre reinforcing materials (FRP).

(AC1.3) • **criteria :**strength/weight ratio, resistant properties (heat, corrosion, wear), cost, weldability, formability, machinability, appearance, availability.

(AC1.4) • **structures:** crystalline, chain molecules, amorphous.

(AC1.5) • **metallic structures**: fine grained structure, coarse grained structure, effect of grain size upon working properties.

(AC1.6) • **heat treatment:** annealing (steels, stainless steels, non-ferrous metals), normalising of steels, hardening of steels, tempering of steels, precipitation hardening of aluminium alloys.

(AC1.7) • **material failure**: brittle and ductile fractures, Fatigue failure , Yielding due to overloading of remaining cross section, Instability (buckling), Creep failure.

(AC1.9) • **protect metals:** materials supplied with protective layers, preventing damage during fabrication and transportation. Protection against contamination, surface damage, corrosion and arcing during welding.

Learning outcome

The learner will:

2 Know how to apply welding symbols to joint preparations

Assessment criteria

The learner can:

2.1 describe the difference between **features** of welded joints

2.2 describe how to apply BS EN 22553 to **types of joints**

2.3 describe how to apply **weld dimensions** to weld symbols.

Range

(AC2.1) • **features:** face, toes, root, HAZ (heat affected zone), convex fillet profile, concave fillet profile, mitred fillet profile, root face, root gap, root radius (‘U’ butt profile), land (‘U’ butt profile), bevel angle, included angle, weld width, throat thickness, leg length(s), fusion zone (depth of fusion), excess weld metal, penetration, fusion line (boundary).

(AC2.2) • **types of joints:** Welded, brazed and soldered joints — symbolic representation on drawings, symbols for the communication of the designation of welded joints; types of joint (butt, tee, lap, corner); types of weld preparation (square butt [open], square butt [closed], flanged butt, single-vee butt, double-vee butt, single ‘U’ butt, double ‘U’ butt, fillet, single-bevel butt, double-bevel butt, single ‘J’ butt, double ‘J’ butt, spot, seam, projection, surfacing, plug, edge, surface, inclined, fold); application of types of weld preparation (arrow line, reference line, identification line, symbol, non-symmetrical welds, symmetrical welds); supplementary and complimentary symbols (finished flush by grinding, finished flush by machining, convex, concave, backing [sealing] run, permanent backing strip, removable backing strip, toes blended smoothly, peripheral welds, field or site welds, numerical indication of welding process [EN 24063 — Welding,

brazing, soldering and braze welding of metals — nomenclature of processes and reference numbers for symbolic representation on drawings].

(AC2.3) • **weld dimensions:** leg length, throat thickness, fillet welds, square butt welds, root gaps, intermittent fillet welds, staggered intermittent fillet welds.

Learning outcome

The learner will:

3 Know the difference between non-thermal joining methods

Assessment criteria

The learner can:

3.1 classify **bolting** methods from a range found in fabrication engineering

3.2 classify **mechanical fastenings** applied to thin plate fabrication engineering

3.3 explain the reasons for and the methods available to protect metal surfaces prior to and after assembly

3.4 classify **joint configurations** from a range found in fabrication engineering

3.5 explain the **benefits of using jigs and fixtures**

3.6 explain the use of **adhesive bonding** in the joining of fabricated assemblies

3.7 calculate **joining allowances.**

Range

(AC3.1) • **bolting :** black bolts, high strength friction grip (HSFG), close tolerance bolts, fitted bolts, load indicating bolts, torshear, importance of cleanliness of contact surfaces, correct tensioning, hole diameters, tolerances and alignment of holes to produce satisfactory bolted connections.

(AC3.2) • **mechanical fastenings**: bolts, captive nuts, studs, self-tapping screws, special thin plate fastenings, solid and tubular rivets, blind rivets (pop rivets).

(AC3.4) • **joint configurations**: self-secured, lap joints, flanged joints, thermal/mechanical bonded, grooved seams, double grooved seams, knocked up, panned down, slip joints, flexible joints, threaded joints.

(AC3.5) • **benefits of using jigs and fixtures**: position of component(s), joint alignment, mass production/repetitive work, distortion control/dimensional accuracy, economy of operation.

(AC3.6) • **adhesive bonding:** methods available (heat activated, solvent activated, impact activated), preparation of surfaces, applications, health and safety considerations, failure types.

(AC3.7) • **joining allowances :** self-secured joints, joints joined by: riveting, bolting, adhesive bonding.

Learning outcome

The learner will:

4 Understand the effects of distortion and residual stresses due to welding

Assessment criteria

The learner can:

4.1 explain the **reasons for distortion** due to welding

4.2 classify **types of distortion**

4.3 explain the methods of **controlling distortion**

4.4 explain the methods of **rectifying distortion**

4.5 explain the **residual stress** effects of welding.

Range

(AC4.1) • **reasons for distortion :** uneven expansion and contraction, degree of restraint.

(AC4.2) • **types of distortion:** longitudinal, transverse, angular, buckling, bowing, dishing, twisting).

(AC4.3) • **distortion control:** presetting, pre-bending, weld sequencing, skip welding, back-stepping, balanced welding, intermittent welding, tack welding, pre and post weld heat treatment, joint design, chills, restraint (clamping, jigs, back-to-back assembly).

(AC4.4) • **distortion rectification:** mechanical methods (peening, jacking, pressing, bending, rolling, hammering, planishing); thermal methods (use of heat strips, use of heat triangles); combination of mechanical and thermal methods (hot working).

(AC4.5) • **residual stress:** causes (restraint due to uneven expansion and contraction [natural], restraint due to distortion control methods [clamping, jigs, back-to-back assembly, balanced welding]), effects (pattern across joint cross-section [areas of tension, areas of compression], influence upon mechanical properties in service), stress relieving methods (normalising, thermal stress relief).

Learning outcome

The learner will:

5 Know how to determine the integrity of welded joints.

Assessment criteria

The learner can:

5.1 classify the types of **weld defects** (EN 26520) and identify possible causes and remedial action

5.2 explain the application of **visual examination** methods to welded joints

5.3 explain the application of **penetrant testing** methods to welded joints

5.4 explain the application of **magnetic particle testing** methods to welded joints

5.5 explain the application of **radiography** methods to welded joints

5.6 explain the application of **ultrasonic testing** methods to welded joints

5.7 explain the application of **mechanical testing** methods to welded joints

5.8 explain the methods of **container testing.**

Range

(AC5.1)
- **weld defects:** cracks (longitudinal, transverse, edge, HAZ, crater, centreline, fusion zone, underbead), lack of fusion (root, side wall, inter-run), porosity (scattered, cluster, isolated pore, root, blow holes, worm holes), piping (craters), solid inclusions (slag, copper, tungsten, oxide), lack of penetration, undercut, oxidation, excessive weld metal (including penetration), underfill, concavity, overlap, burn-through, possible causes, remedial action.

(AC5.2)
- **visual examination:** applications, requirements (equipment, personnel) benefits, limitations

(AC5.3)
- **penetrant testing:** dye, fluorescent, test procedure, applications, equipment requirements, limitations.

(AC5.4)
- **magnetic particle testing :** magnetic flow (types of magnet [horseshoe, yoke]), current flow (a.c. [skin effect], d.c., types of magnetisation [prods, bar, coil, tubular, kettle element]), test procedure, applications, equipment requirements, benefits, limitations).

(AC5.5)
- **radiography :**sources of radiation (x-ray, gamma ray), principle, applications, equipment requirements, benefits, limitations, radiation hazards (effects of radiation on the human body, radiation monitoring, personal monitoring, radiation enclosures, precautions for site radiography), radiographic techniques (plate, pipe [single wall – single image {including panoramic}, double wall – single image, double wall – double image [ellipse, superimposed]).

(AC5.6)
- **ultrasonic testing:** applications, procedure, applications, equipment requirements (ultrasonic testing set [cathode ray tube {oscilloscope}, controls, calibration], probes [normal, angle, probe index, selection criteria, beam spread, far zone, near zone, dead zone], leads, calibration blocks, couplant), benefits, limitations, techniques (thickness testing, lamination testing, transmission method, reflection method), determination of geometry (beam angle, skip distance), procedures for reporting and recording flaws in welded components.

(AC5.7)
- **mechanical testing:** impact tests (izod, charpy), bend tests (root, face, side), tensile (determination of tensile strength, determination of yield stress, determination of percentage elongation, transverse, all weld metal, tensile/shear [application to lap joints, application to double lap joints]), fracture (nick break), macro examination (specimen preparation, magnification), micro examination (specimen preparation, magnification), hardness surveys (weld zone, HAZ, parent metal, location of indents, testing methods (Vickers, Brinell, Rockwell), testing of spot welded joints (peel test, tensile/shear, cross tensile, 'U' tensile, twist or torsion.

(AC5.8)
- **container testing:** hydraulic pressure, pneumatic pressure, by filling, by immersion, health and safety considerations).

Learning outcome

The learner will:

6 Understand the principles of metallic corrosion and methods of surface protection.

Assessment criteria

The learner can:

6.1 describe the types of **corrosion** affecting different metals

6.2 describe the **factors** affecting the rate of surface corrosion

6.3 describe the **need** for corrosion prevention

6.4 describe commonly used **surface coating methods of protection**

6.5 describe surface protection by **electro-chemical** means.

Range

(AC6.1) • **corrosion:** dry chemical corrosion (oxidation), electrolytic corrosion, galvanic series.

(AC6.2) • **factor:** Structural design, applied and internal stresses, environmental, metal composition, electrolyte concentration, temperature

(AC6.3) • **need:** cost implications of corrosion, avoidance of material/ component malfunction, techniques and reagents used for removing corroded parts

(AC6.4) • **surface coating methods of protection:** hot dipping, galvanising, tin plating, terne plating, electroplating, cladding, metal/ceramic spraying, sheradisings

(AC6.5) • **electro-chemical: a**nodising, chromating, phosphating, cathodic protection, anodic protection (sacrificial protection), inhibitors e.g. paints, varnishes, lacquers, oils.

Learning outcome

The learner will:

7 Understand the principles of metallic corrosion and methods of surface protection.

Assessment criteria

The learner can:

7.1 state the types of testing procedures used within fabrication & welding

7.2 describe the use of **visual inspection** techniques

7.3 describe the **process and applications of dye-penetrant testing**

7.4 describe the **process and applications of magnetic particle testing**

7.5 describe the **process and applications of radiographic testing**

7.6 describe the **process and applications of ultrasonic testing**

7.7 describe the **principles and applications of tensile testing**

7.8 describe the **principles and applications of fracture toughness (impact) testing**

7.9 describe the **principles and applications of hardness testing procedures**

7.10 describe the **principles and applications of fatigue testing**

7.11 describe the **principles and applications of creep testing**

7.12 carry out a hardness testing assessment on sample materials pre and post heat treatment.

Range

(AC7.2)
- **visual inspection:** surface defects, casting distortion, welded joints, use of visual examination aids (torch, magnifying glass, probes and welding gauges), volumetric testing (size, length and profile)..

(AC7.3)
- **process and applications of dye-penetrant testing:** Health and safety when handling, using and storing penetrant fluids, principles of dye penetrant testing, principles of capillary action, suitability for surface and surface breaking defects, types of fluids used; fluorescent dye, non-fluorescent dye, cleaner, developer, procedures for use; application, soak times, removal, developer, interpretation of results, use of ultra violet light with fluorescent dye, applications and limitations of penetrant testing.

(AC7.4)
- **process and applications of magnetic particle testing:** Health and safety when handling, using and storing magnetic particle materials, principles of magnetic particle testing procedures, sSuitability for ferro-magnetic materials, types of magnetic field and the effect of discontinuities on the field, suitability for surface and immediate sub surface defects, detection media; powders, inks, fluorescent inks, types of magnets; permanent and electro, procedures for use; materials preparation, selection and application of detection media, interpretation of results, applications and limitations of magnetic particle testing.

(AC7.5)
- **process and applications of radiographic testing:** Health and safety when handling, using and storing radioactive materials, principles of radiographic testing procedures, types of radiation (Gamma and X-ray), sources and generation of suitable radiation, suitability for sub surface defects, use of image quality indicators, procedures for using

equipment, development of x ray films and interpretation of results, applications and limitations of radiography.

(AC7.6) • **process and applications of ultrasonic testing:** Principles of ultrasonic testing procedures, method of operation of equipment, testing of welded joints, types and use of couplants, calibration of equipment, interpretation of results, applications and limitations of ultrasonic testing.

(AC7.7) • **principles and applications of tensile testing:** Principles of tensile testing procedures, typical applications and use of tensile testing, types of tensile testing equipment used, standardisation of test specimen dimensions, interpreting stress-strain curves for low carbon steel, cast iron and aluminium, yield points.

(AC7.8) • **principles and applications of fracture toughness (impact) testing:** Principles of testing resistance to impact, types of impact testing equipment, difference in Charpy and Izod tests, principles of Crack Opening Displacement testing (COD), comparison of impact values for common materials, visual examination of fracture faces, typical applications and uses of testing, examples of brittle fracture.

(AC7.9) • **principles and applications of hardness testing procedures:** Principles of testing resistance to indentation/scratching, operation of portable testing equipment (hand held scratch test; Shore Scleroscope), procedures for using testing equipment, Brinell, Vickers and Rockwell testing procedures, interpretation of indentation results.

(AC7.10) • **principles and applications of Fatigue testing:** Principles of fatigue testing procedures, interpretation of S-N curves for LCS & non-ferrous alloys, factors affecting fatigue failure, examples of typical fatigue failures.

(AC7.11) • **principles and applications of Creep testing:** Principles of creep testing procedures, examples of creep in materials/component, interpretation of creep test results, applications of creep testing.

Unit 307 Marine propulsion systems

GLH	80
Unit aim:	This unit enables the learner to have an understanding of the layout and the operating systems of the various propulsion units used within naval vessels. The learner will understand the reasons for selecting a particular propulsion system and the major components that go to make up a propulsion system. They will also gain knowledge of the main defects that occur in propulsion systems and the maintenance activities that need to take place.

Learning outcome

The learner will:

1 Understand the range of the main propulsion systems used within the marine industry both by commerce and by the military.

Assessment criteria

The learner can:

1.1 describe the **main propulsion plants** used in maritime vessels

1.2 explain the need for **Gearboxes and clutches** and the types in use

1.3 understand the function of the **main ancillary equipment**

1.4 explain the **main components** that go to make up the shaft line on a propulsion system

1.5 produce layout diagrams for at least **two main propulsion systems.**

Range

(AC1.1)
- **Main propulsion plants:** Diesel-Electric; Internal Combustion Engines; Electric Propulsion Motors; Gas Turbines; Steam Turbines (align to nuclear propulsion plant); Water Jet Drives; Fuel Cell

(AC1.2)
- **Gearboxes and Clutches**: Reduction Gearboxes, Ratios, Multi Input Gearboxes, Single and Double Helical gears, Spur Gears, Epicyclic gears, Parallel Offset Gearbox, Concentric Drive Gearbox. Dry and Wet clutches, Hydraulic Clutches, Air Operated Clutches (radial and axial), SSS Clutches, Plate Type Clutch, Dog Clutch.

(AC1.3)
- **Main ancillary equipment:** Heat Exchangers (condensers, coolers, preheaters),Types of Pumps used for different fluid systems, Starter motors, Turbo Blowers, Generators, Air Ejectors, Nuclear Propulsion (Reactor Pressuriser, Steam Generator), Bow Thrusters.

(AC1.4) • **Main Components:** Thrust blocks; Plummer Blocks; Flexi Couplings; Shaft brakes; Bulkhead glands; Stern Seals; Stern Tubes;SKF couplings; Flanged Couplings; Muff Coupling; 'P' Brackets; 'V' Brackets; Controllable Pitched Propeller Systems; Propellers, Propulsors. WaterJet Buckets/Deflectors**.**

(AC1.5) • **Two main propulsion systems:** Diesel; Diesel Electric; Gas Turbine; Combined Diesel Electric and Gas (CODLAG);Nuclear Propulsion Plant;

Learning outcome

The learner will:

2 Understand the major systems required to support a Marine Propulsion Plant.

Assessment criteria

The learner can:

2.1 describe the functions of a fuel supply system, understanding its layout and the **major components of the system**

2.2 describe the functions of a lubrication oil system, understanding its layout and **the major components within the system**

2.3 describe the functions of a fresh water cooling system, understanding its layout and the **major components within the system**

2.4 describe the functions of a sea water cooling system, understanding its layout and the **major components within the system**

2.5 describe the functions of a Controllable Pitch Propeller (CPP) system, understanding its layout and the **major components within the system**

2.6 produce layout drawings of the systems related to at least **two major propulsion plants.**

Range

(AC2.1) • **Major components of the system:** On engine fuel systems. Pumps, Heat Exchangers, Filters, Coalecers, Centrifuge, Relief Valves, Methods of storing fuel. Water compensated fuel tanks, transfer pumps.

(AC2.2) • **Major components within the system:** On engine and gearbox systems. Types of Pumps, Relief Valves, Filters, Centrifuge, Heat Exchangers.

(AC2.3) • **Major components within the system:** On Engine Fresh water Coolant Systems, Header Tanks, Pumps, Heat Exchangers, Thermostatic Valves.

(AC2.4) • **Major components with the system:** Duplex Strainers, Filters, Pumps, Valves (hull, relief, isolation), Heat exchangers.

(AC2.5) • **Major components with the system:** Oil Transfer Box, Hubs, Pistons, Prop Blades, Transfer Tubes, Lip seals, Types of Pump, Header tank, Hydraulic Oil Sump.

(AC2.6) • **Two major propulsion plants:** systems required on a Nuclear/Steam propulsion Plant. Systems required on a Diesel propulsion Plant. Systems required on a Diesel Electric Propulsion Plant. A CPP System.

Learning outcome

The learner will:

3 Understand the main defects/faults that occur on the Marine propulsion Systems

Assessment criteria

The learner can:

3.1 explain the cause and effects of common malfunctions on a **diesel** engine propulsion system

3.2 explain the cause and effects of common malfunctions on a **gas turbine** propulsion system

3.3 explain the cause and effects of common malfunctions on an **electric motor propulsion** system

3.4 explain the cause and effects of common malfunctions on a **steam propulsion** system.

Range

(AC3.1) • **Diesel:** Diesel Blocked intake filters, (misfiring, difficult starting, black smoke). Noisy cylinder (valve timing). High cylinder temperature, (injectors, cooling jacket). Lubricating oil dilution, (water or diesel. Leaking seals/gaskets, worn piston rings). Low oil pressure (blocked filters, low oil level, pump defect, closed valve). Low fuel pressure (blocked filters, pump defect). High lub oil temperature (heat exchanger problem, thermostat, warm seas). High Coolant temperature (heat exchanger problem, thermostat, warm seas) Running to fast/to slow (governor problem).

(AC3.2) • **Gas Turbine:** Gas Turbine Engine hunting (blocked intake filters, water in fuel)). Power/efficiency drop off (blade fouling, optimisation and tuning)). Excessive Vibration (turbine blade damage, uneven warm through) High combustion temperature (blocked burners). High bearing temperature (oil leaks). Control system failure (defective speed sensors, PCB failure, leaks on fuel or air system) Out of spec emissions (poor combustion, white smoke, water in fuel).

(AC3.3) • **Electric Propulsion Motor:** Electric Propulsion Motor. Burnt out windings. Overheating motor (cooling fans not running, blocked air intake filters). AC to DC converter malfunction.

(AC3.4) • **Steam Propulsion:** Steam Propulsion Water hammer (wet steam) High Vibration (uneven warm through). Poor feedwater quality (chemical dosing). Feedwater contamination (leaking heat exchanger). High/Low lube oil temperatures (cooler problems, faulty thermostat). Blade impingement (wet steam, foreign object damage). Steam leaks (joint failure). Relief valves lifting (set up wrong, sudden drop in steam take off).

Learning outcome

The learner will:

4 Understand how to diagnose malfunctioning systems and components on marine propulsion systems

Assessment criteria

The learner can:

4.1 describe the **methods used** to diagnose malfunctioning systems and components

4.2 describe the methods used to obtain and interpret **diagnostic information**

4.3 identify the **tools and equipment** required for fault diagnosis

4.4 recognise the **hazards and precautions** to take when working with marine propulsion systems.

Range

(AC4.1)
- **Methods used:** Methods used: Normal running. Operator feedback. Sea Trials. Measuring equipment. Fault code analysis.

(AC4.2)
- **Diagnostic information:** The learner should cover the following: Historical analysis of data (log books, maintenance records, service schedules). Flow rates. Temperature ranges. Pressure ranges. Leakage. Vibration analysis. System Knowledge. Combustion gas analysis

(AC4.3)
- **Tools and equipment**: Test equipment (computer software), Measuring devices (dial gauges, feeler gauges,) Vibration meters. Gas analysers. Electric test meters

(AC4.4)
- **Hazards and precautions**: The learner should be familiar of the hazards and precautions in relation to: Rotating machinery. Reciprocating machinery. Lifting equipment, High voltage systems. High pressure systems. Excessive noise Lubricants. Fuels. Fire risks. The learner should also cover the following in relation to the subject matter: Correct PPE. Awareness of appropriate H&S regs. Awareness of access and egress routes from compartments, safe systems of work. System isolation.

Unit 308 Marine Auxiliary Systems and Equipment

GLH	80
Unit aim:	This unit enables the learner to have an understanding of the main auxiliary systems and equipment that go into and support the operation of maritime vessels. The learner will get to understand the general mechanical make up of this equipment, the reasons for its installation on vessels and be able to produce system lay out drawings of the general arrangement. The learner will also get to understand the main defects and malfunctions that can occur on auxiliary systems and equipment whilst in operation.

Learning outcome

The learner will:

1 Understand the general arrangement and the major functions of the components that go to make up the main auxiliary equipment on a vessel.

Assessment criteria

The learner can:

1.1 explain the power generation and distribution arrangements used on maritime vessels

1.2 explain how high pressure (HP) and low pressure (LP) air compressors function, their general arrangement and the functions of the **main components**

1.3 explain main types of **steering gear and stabiliser arrangements** used on vessels, their general arrangement and understand the functions of the main components

1.4 explain the functions of the refrigeration and chilled water systems, their general arrangement and the functions of the main components

1.5 explain how a sewage treatment plant works, the types in use and the functions of the main components that go to make up the system

1.6 explain how a water making plant works, the types that are in use and the functions of the main components that go to make up the system.

Range

(AC1.1)

- The following are examples of what the learner might cover: Diesel Generators. Steam Generators. Gas Turbine Generators. Transformers. Main and secondary Switchboards. Bus Bars. Static Frequency Changers. Inverters. Circuit Breakers. Auto/Manual Change over switches. High Voltage. 440V. 240V, 115V,60hz, 400hz. Equipment and Services supplied. Motor Generators. Shore supply. DC Batteries. Alternate supplies. Segregation of supplies. Fuses. Earth monitoring. Redundancy. Load shedding.

(AC1.2) • **Main component: Reciprocating.** Centrifugal. Multi Staged. Intakes. Intercoolers. Lub oil Coolers. Filters. Driers. Air Receivers. Relief valves. Bursting Discs. Oil Separators. Blow Down Valves. Scrubbers. Air Banks**.**

(AC1.3) • **Stearing gears and stabiliser arrangements:** Rudder Stocks. Rudders. Forward and Stern Planes Hydraulic. Electro-Hydraulic. Telemotor. Hydraulic pumping stations. Header tanks. Rams, Crossheads, Tie Bars. Rotary Vane Type. Secondary systems. Manual emergency control. Bow and Stern Thrusters. Stabilisers. Gyros. Hydraulic Cleanliness.

(AC1.4) • Compressors (reciprocating, screw type), Condenser. Evaporator. Oil Separator. Drier. Receiver. Types of Gas Used. Cool room Cold room. Thermostatic Regulating Valve. Chilled water ring main. Air Treatment unit. Chillers. Chilled water pumps. Weapons electronic equipment cooling. Air Conditioning. Machinery space cooling.

(AC1.5) • Maritime Regulations (MARPOL). **Biological Systems**. Aeration Chamber. Settling Tanks. Disinfection Chambers. Chlorination. UV radiation**. Vacuum Systems**. Vacuum pumps. Grey water. Black Water. Macerators. Transfer Pumps. Holding Tanks. **Physical-Chemical Systems.**

(AC1.6) • **Evaporators** (single and multi- stage). Heat Source (steam, hot water), Creating a vacuum), heat Exchangers (re-heaters, condensers). Demisters/separators. Pumps. Brine system. Distillate system. Reverse Osmosis Plants. Filtration arrangements. RO membranes. Pressure pumps. Ultraviolet and chemical treatment.

Learning outcome

The learner will:

2 Be able to produce schematic drawings of a vessels main auxiliary systems and equipment and the services supplied.

Assessment criteria

The learner can:

2.1 produce a schematic drawing of a **vessel's Power Generation and Distribution system** and the services supplied

2.2 produce a schematic drawing of a vessel's **High pressure or Low pressure air system** and the services supplied

2.3 produce a schematic drawing of a vessel's **Steering Gear System**

2.4 produce a schematic drawing of a vessel's Refrigeration or **Chilled Water System** and the services supplied

2.5 produce a schematic drawing of a vessel's **Sewage Treatment Plant**

2.6 produce a schematic drawing of a vessel's **Water Making** Plant and the services supplied.

Range

(AC2.1) • Generators Transformers. Main and secondary Switchboards. Bus Bars. Circuit Breakers. Auto/Manual Change Over Switches. High Voltage. Motor Generators. Equipment and Services supplied. Circuit protection (fuses, earth leakage) Earth monitoring. Auto

Voltage Regulators. Static Frequency Changers. Rectifiers/production of DC. Battery backup.

(AC2.2) • Compressor. Intakes. Intercoolers. Lub oil Coolers. Filters. Driers. Air Receivers. Relief valves. Bursting Discs. Oil Separators. Blow Down Valves. Scrubbers. Air Banks. Equipment and Services supplied

(AC2.3) • Pumps. Header Tanks. Filters. Rudder Stocks. Rudders. Forward and Stern Planes. Hydraulic. Electro-Hydraulic. Telemotor. Rams, Crossheads, Tie Bars. Rotary Vane Type. Secondary systems. Manual emergency control.

(AC2.4) • Compressor Condenser. Evaporator. Oil Separator. Drier. Receiver. Types of Gas Used. Cool room Cold room. Thermostatic Regulating Valve. Chilled water ring main. Air Treatment unit. Chillers. Chilled water pumps. Services Supplied (Weapons electronic equipment cooling. Air Conditioning. Machinery space cooling)

(AC2.5) • **Biological System**: Aeration Chamber. Settling Tanks. Disinfection Chambers.. UV radiation. **Vacuum System**. Vacuum pumps. Grey water. Black Water. Macerators. Transfer Pumps. Holding Tanks. **Physical-Chemical System** Aeration tank, settling tank, air compressor, pumps, Chlorination.

(AC2.6) • Evaporators (single and multi- stage). Heat Source (steam, hot water), Creating a vacuum), heat Exchangers (re-heaters, condensers). Demisters/separators. Pumps. Brine system. Distillate system. **Reverse Osmosis Plants**. Filtration arrangements. RO membranes. Pressure pumps. Ultraviolet and chemical treatment. Drinking Water. Distilled water. Sanitation.

Learning outcome

The learner will:

3 Understand the Main defects/faults that occur when operating a vessel's main auxiliary systems and equipment.

Assessment criteria

The learner can:

3.1 explain the cause and effects of common malfunctions on a Power generation and Distribution System

3.2 explain the cause and effects of common malfunctions on a High Pressure and Low Pressure Air plant and system

3.3 explain the cause and effects of common malfunctions on Steering Gear and Stabiliser plant and system

3.4 explain the cause and effects of common malfunctions on Refrigeration and Chilled water plant and systems

3.5 explain the cause and effects of common malfunctions on Sewage Treatment Plant

3.6 explain the cause and effects of common malfunctions on Water Making Plant.

Range

(AC3.1) • Generator Failure. Overspeed/Underspeed. Overloaded Generator. Overloaded Breakers. Motor Generator bearing failure. Salt water contamination of motor windings.

Short circuits. Earths. Lack of synchronisation. Commutator/brush failure/carbon build up. Circuit protection.

(AC3.2)
- Blocked Intakes. Low output pressure. Water in Sump Oil. Oil carry over into air system. Heat Exchanger Failure. Ruptured Bursting Disc. Combine oil/water pump impeller degrades. Blocked Driers. Drier exhaust valve failure. Defective inter-stage valves. Piston ring failure. Bearing failure. Carbon build up. Incorrectly set relief valves. High running temperatures. Loss of cooling water. System leaks. Flexi Hose Failure. Motor bearings.

(AC3.3)
- Hunting. Hydraulic oil contamination. Wrong grade of Oil. Low hydraulic fluid level. Worn stock bearings. Stock packing failure. Fluid leakage. Pump failure. Overheating system. Heat exchanger failure. Loss of cooling water. System leaks. Shaft scoring. Distorted Rams. Loss of clearances. Worn Crosshead. Flexi hose failure. Motor bearing failure.

(AC3.4)
- Loss of refrigerant gas. Incorrect refrigerant gas. Defective sensors. Mechanical seal failure. Pump failure. Heat Exchanger failure. Loss of cooling water. Thermostatic reducing valve.

(AC3.5)
- System blockage/ build-up of solids. Blocked screens. Pump failure. Loss of vacuum. Bacteria has died off (inadequate aeriation, chemical contamination). Incorrect dosing. Defective UV lamps. Defective macerator. System leakage. Sticking vacuum valves. Internal corrosion of pipework.

(AC3.6)
- Loss of vacuum. Low water or steam temperature. Scale build up on tube nests. Defective heat exchangers. Pump failure. Plastic pipework failure. Membrane failure. Poor water quality.

Unit 308 Marine Auxiliary Systems and Equipment

Supporting Information

Unit guidance

For LO 2 it is expected that the learner has knowledge of all the international symbols for producing the drawings and has many opportunities to practise with systems familiar and unfamiliar to their working environment.

Unit 309 Principles of shipbuilding

Unit level:	Level 3
GLH:	68
Unit aim:	This unit provides the understanding required to work within a shipbuilding/ship repair establishment and is concerned with ship design the identity of types in typical forms and major components linked to design features.

Learning outcome

The learner will:

1 Understand shipbuilding technical drawings and computer aided engineering.

Assessment criteria

The learner can:

1.1 explain the **terminology** used on marine industry drawings and specifications

1.2 interpret **abbreviations** used on marine industry technical drawings and data

1.3 interpret shipbuilding technical **drawings, plans and tables**

1.4 interpret lines plans and offset tables

1.5 explain the duties carried out in **mould loft** operations

1.6 explain the purpose of **templates**

1.7 explain computer aided engineering **(CAE)** techniques used and their application in shipbuilding

1.8 critically compare the benefits and limitations of computer aided engineering (CAE) to conventional techniques.

Range

(AC1.1)
- **terminology:** outboard of, inboard of, in way of, scantlings, length (overall, between perpendiculars and on summer load waterline), forward and after perpendiculars, breadth and depth (moulded and extreme), draught, freeboard, freeboard marks, displacement, deadweight, rise of floor, camber, flare, bilge, bilge radius, bilge keel, flat of bottom, tumblehome, superstructure, forecastle, tank top, stringer, floor, bulkhead, shell, frame/frame station, deck, deckhead, longitudinal, transverse, butt seam, gross, net and displacement tonnage.

(AC1.2)
- **abbreviations**: PSFA, LOA, LBP, LBP, (L), FP, AP, B, D, SLWL, TF, F, T, S, W, WNA.

(AC1.3)
- **drawings, plans and tables**: role of shipbuilding detail and assembly drawings, block plans and location drawings, listed plans and tables (body plans, lines plans, sheer profile, off-set tables), relationship between listed plans and tables
- **lines plans and offset tables**: lines plan, displacement stations, frame stations and their relationship; tables of offsets to produce ship shapes, illustrating fairing of form in three dimensions: frames, waterlines, buttocks; shell expansion plans; draught and freeboard markings.

(AC1.5)
- **mould loft**: full scale lofting, scale lofting, numerical control (computer) lofting.

(AC1.6)
- **templates:** avoidance of repetitive marking and measuring, material optimisation, checking angles, contours etc., guidance for repetitive profile cutting, nesting, materials suitable for templates.

(AC1.7, AC1.8)
- **CAE**: computer aided design, computer aided draughting, computer aided manufacture, Industrial robots; productivity, quality, competitiveness, profit, storage space, impact upon working practices, impact upon society, security of data; application in mould lofts (purpose, benefit of computer aided lines fairing, various stages in the production of tapes to control cutting and forming machinery, benefits of numerical control compared to the production and use of templates).

Learning outcome

The learner will:

2 Know structural principles of major components of a ship

Assessment criteria

The learner can:

2.1 critically compare **ship types** in terms of applications, forms and profiles

2.2 describe **design features** of ships

2.3 describe **major components** of ships

2.4 explain **fore and after end construction.**

Range

(AC2.1)
- **ship types:** cargo (general, bulk carrier, oil tanker, container, liquefied natural gas, refrigerated), naval vessels (aircraft carrier, troop carrier, submarine, fleet oiler), passenger vessels (passenger liner, ferry, cruise liner, roll on – roll off), service craft (oil support vessel, tug, ice breaker), FPSO.

(AC2.2)
- **design features**: cargo (double bottom arrangements, decks, bulkheads, engine room space, cargo spaces, fore and after peaks, accommodation spaces), naval vessels (watertight sub –divisions, accommodation spaces, armament and equipment spaces, operations area), passenger vessels (loading and unloading arrangements, accommodation areas, recreation areas, crew accommodation, access routes) service craft, (divisions for: engines, operations, crew, storage, etc.), evacuation craft.

(AC2.3)

- **major components**: cargo space, double bottom tanks, peak tanks, engine rooms, accommodation spaces, deep tanks, cofferdams, pump rooms, chain locker, cargo access arrangements, cargo handling equipment.

- **lines plans and offset tables**: lines plan, displacement stations, frame stations and their relationship; tables of offsets to produce ship shapes, illustrating fairing of form in three dimensions: frames, waterlines, buttocks; shell expansion plans; draught and freeboard markings.

(AC2.4)

- **fore and after end construction**: fore peak construction (collision bulkhead, floors, types of stem, bulbous bows, deep tanks: construction and usage, chain locker and hawse pipes, bow thrust units and supporting structure, access and egress from fore peak), after peak construction (stern construction [types]; flats, floors and wash plates; steering gear flat, construction and supporting structure; stern frame connections; function, construction and operation of rudders; types of rudder), propellors.

Learning outcome

The learner will:

3 Know how to identify the principal structural components of a ship.

Assessment criteria

The learner can:

3.1 describe the **factors influencing the strength of a ship's structure**

3.2 explain the **structural principles of major components** of a ship.

Range

(AC3.1)

- **factors influencing the strength of a ship's structure:** main forces acting on a ship's structure, the variation of liquid pressure with head and its effect on a ship's structure, forces on submerged surfaces (calculations of: internal loads from cargo, fuel oil; external loads from sea), reaction of the ship to applied forces (hogging and sagging, panting, racking).

(AC3.2)

- **structural principles of major components**: double bottoms, tank top, framing, bulkheads, transverses, shell, pillars and girders, superstructure, decks deckhouses, forecastle, bridge, poop, workshop flats; transverse, longitudinal and combined framing systems of ships; components of transverse and longitudinal framed double bottoms: watertight, plate and bracket floors, bottom and tank top stiffening and connections, centre and side girders, margin plate, tank top; shell structure for transversely and longitudinally framed ships, connections to deck and bottom structure; components of deck structure, pillars and girders, deck openings; constructional features of different types of transverse and longitudinal bulkheads; hatches and doors, function and methods of construction (deck openings and supporting structure, side and end hatch coamings, hatch closing arrangements, oil tanker hatches, watertight hatches and doors fitted in naval vessels); constructional features and methods of attachment to the hull of bulwarks and guard rails; methods of obtaining continuity of strength, the avoidance of abrupt changes in contour.

Learning outcome

The learner will:

4 Understand the assembly and erection of ship parts

Assessment criteria

The learner can:

4.1 explain the importance of **accuracy and alignment** throughout the ship's construction cycle

4.2 explain the need for **inspection**

4.3 explain the main procedure for **erection**

4.4 describe the **lifting procedures and safety precautions** for fabricated units

4.5 explain the methods used to secure the sections in the initial position

4.6 explain the purpose and operation of self-propelled modular transporters (SPMT)

4.7 describe structural behaviour of assemblies and sub-assemblies evidenced from case studies and historical records.

Range

(A4.1)
- **accuracy and alignment:** structure, methods of avoiding accumulation of error, personal responsibility for accuracy, carry out alignment checks using levelling equipment (laser, dumpy level).

(AC4.2)
- **inspection**: function of a datum surface and datum line; standard measuring equipment; define tolerance with regard to accuracy; methods of checking accuracy of dimensions, alignment, form, squareness and freedom from twist or distortion.

(AC4.3)
- **erection:** equipment and instruments necessary for fairing, joining, plumbing and levelling, sequence of erection and methods used to temporary fasten and maintain shape, need for continual alignment checks.

(AC4.4)
- **lifting procedures and safety precautions**: lift large fabricated units considering centre of gravity, safe working loads, swinging loads; importance of determining centre of gravity of regular and irregular shaped units; problems associated with the lifting of large units; health and safety hazards associated with the lifting of large fabricated units SPMT: types, capacity, operation, communication, power.

Unit 310 Principles of maintenance, installation and commissioning

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the leaner to understand the underlying principles that apply to all commonly used processes and elements that are essential to most maintenance, installation and commissioning activities. It takes into account the fact that some industries and organisations employ engineering personnel that perform both of these activities, whereas others, particularly specialist contractors for installation and commissioning, may only cover a limited range. The content of this unit can be applicable to both situations as it is considered essential for all learners to have a wide range of engineering knowledge and experience. It covers the maintenance, installation and commissioning requirements, including equipment and lubrication that are commonly associated with the maintenance, installation and commissioning of plant and machinery and the ways in which they are used or applied. Leaners are not expected to have an in-depth understanding of all maintenance and installation and commissioning strategies, but they should become familiar with the events, terminology and practices that they will need as part of their normal work.

Learning outcome

The learner will:

1 Understand how to plan maintenance, installation and commissioning activities

Assessment criteria

The learner can:

1.1 explain the reasons for carrying out **maintenance activities**

1.2 explain the methods and **procedures** necessary to make an area safe

1.3 describe the contents of a **maintenance plan**

1.4 explain how to carry out **installation activities**

1.5 describe the contents of a **report** completed following maintenance or installation activities

1.6 describe the difference between **symptoms and the causes of faults**

Range

(AC1.1)
- **maintenance activities:** upholding or improving safety standards, maintaining production output at the required levels and quality, maximising the useful working life of engineering assets, increasing production efficiency (reduction of rejected work or downtime), activities include: carrying out routine servicing schedules or planned preventative maintenance, repair and replacement following breakdowns, monitoring and performance testing.

(AC1.2)
- **procedures:** using barriers and/or tapes, placing warning signs in appropriate positions, informing any persons who may be affected, isolating power or pressure sources, obtaining official clearance (permit to work), cleaning work areas after spillage, leakage or contamination (absorbent substances, detergents and solvents, approved waste disposal methods).

(AC1.3)
- **maintenance plan:** tools and equipment, materials and spares (minimising downtime [avoid loss of production, avoid poor customer relations {internal and external}], estimate the length of time needed for maintenance.

(AC1.4)
- **installation activities:** installing machinery and systems into new sites or locations, replacement of machinery and equipment following or extending facilities, monitoring and performance testing, factors to consider: site conditions and locations, storage of parts and materials, tools and equipment, provision of services – gas, communication, electricity, compressed air, water and drainage, minimising disruption to adjacent work areas, how to estimate the length of time needed for the installation and commissioning.

(AC1.5)
- **report:** work undertaken, location(s), dates/times (commencement, completion and handover), parts and consumables used, test data, permit to work or certification references.

(AC1.6)
- **symptoms and the causes of faults: Diagnostic and fault location techniques:** fault location techniques (half-split, input-to-output, function testing, unit substitution, equipment self-diagnostics).evaluation using sensory information, diagnostic techniques, fault location techniques. Aids: manuals, flow charts, troubleshooting guides, maintenance records, barcodes, catalogue numbers**.**

Additional guidance

diagnostic and fault location techniques: evaluation using sensory information (sight, sound, smell, touch), diagnostic techniques (fault reports, visual checks, measurement, movement and alignment checks, testing) Drawings, dimensioning and labelling: projections (orthographic [first angle, third angle], isometric [including exploded], oblique); reference points, lines, edges and surfaces, continuous dimensions, baseline dimensions.

Learning outcome

The learner will:

2 Know how to install and commission instruments and components

Assessment criteria

The learner can:

2.1 explain the applications of **instruments** used for testing and monitoring the condition of systems and machinery

2.2 explain the methods used to **set-up and align components**

2.3 describe how to perform installation and commissioning operations of instruments and/or components.

Range

(AC2.1)
- **instruments**: terms: range, sensitivity, response, accuracy, repeatability, analogue and digital signals, transducers and amplifiers; pressure: manometers, Bourdon tube based instruments; temperature: expansion types, electrical resistance types and thermocouples, thermal paints and crayons; flow: direct (bellows and piston types), inferential (rotameters, venturi and orifice plates, and turbine types); rate and speed: tachometers (mechanical and electrical), stroboscopes, pulse counters; content: direct (dipsticks and sight glasses), indirect (load cells and electrical transducers); electrical multimeters (Ohmmeters, insulation resistance testers); vibration, data recorders; need for regular calibration of instruments and the methods used; methods of mounting instruments and the ways in which they can be protected from: external damage or unauthorised interference, excess loads and surges (use of snubbers and reservoirs), heat and vibration.

(AC2.1)
- **set-up and align components**: straight edges and squares, feeler gauges and test indicators, plumb lines and spirit levels, taut wire, optical and laser based instruments.

Learning outcome

The learner will:

3 Understand how to evaluate methods to overcome friction and corrosion

Assessment criteria

The learner can:

3.1 explain the nature of surfaces and the effects of these on **friction**

3.2 explain the purpose of **lubrication** to reduce the effects of friction

3.3 explain the **nomenclature** used to describe lubricant properties

3.4 evaluate types of **oils** and **greases** for given applications

3.5 explain the nature and causes of **corrosion** and methods of minimising the effects.

Range

(AC3.1, 3.2)
- **friction:** actual surface contact area (on 'peaks') and hence causes of 'cold welding', surface wear (breaking of 'peaks'), generation of heat, forces required to overcome friction (static and dynamic); reducing the adverse effects by use of: low friction materials, material combinations that control wear to only one of the two contacting elements, partial lubrication, full film lubrication.

(AC3.2)
- **lubrication:** hydrodynamic wedge principle – requirements: bearing types and design, clearances, points of oil admission; lubrication methods: total loss, recirculatory (construction and component parts of reservoirs, filtration methods and positioning, heat exchangers, pressure controls and warning devices), splash, grease guns and nipples, self lubricating (cast iron and impregnated metals).

(AC3.3)
- **nomenclature**: viscosity, viscosity index, emulsions, foaming, compatibility (with other oils, seals and bearing material), pour and flash points, additives.

(AC3.4)
- **oils:** mineral, animal and vegetable, synthetic; properties (load, temperature) environmental considerations, reasons for deterioration (excess heat, oxidation, contamination, breakdown of structure due to prolonged overloading, poor storage conditions). **Greases**: the base (matrix), lubricants, methods of application, including the need to prevent over-packing and churning: mineral, animal and vegetable, synthetic; properties (load, temperature) environmental considerations, reasons for deterioration (excess heat, oxidation, contamination, breakdown of structure due to prolonged overloading, poor storage conditions).

(AC3.5)
- **corrosion:** types: oxidation, electrolytic; methods of minimising effects: selection of materials to suit conditions, insulation of dissimilar metals, use of sacrificial anodes, use of protective coatings, paint, galvanising and anodising, plating and coating; methods of releasing corroded nuts (release and penetrating oils, application of heat, nut splitters or similar techniques).

Learning outcome

The learner will:

4 Know how to evaluate connection methods

Assessment criteria

The learner can:

4.1 explain the purposes of **bearings** and their applications

4.2 explain the methods available for **removal and fitting** of bearings

4.3 explain the purposes of **threaded joints** and their applications.

Range

(AC4.1)
- **bearings**: plain bearings, roller bearings, ball bearings, shielded and sealed forms of roller and ball.

Additional Guidance
bearings: plain bearings (materials used [including non-ferrous alloys, non-metallic], split and solid forms and their housing methods, shell and white-metalled types), roller bearings (cylindrical, tapered, double row, spherical, needle), ball bearings (single row deep groove and angular contact, double row deep groove and angular contact, self-aligning).

(AC4.2)
- **removal and fitting**: onto shafts and into housings. methods of removing and fitting bearings (special extractors and mandrels, hand (mandrel) and hydraulic presses, appropriate lubricants or grease.

(AC4.3)
- **threaded joints:** thread forms (pitch and lead, major and root diameters, truncation), identification using screw pitch gauges and charts, applications, methods of insertion and extraction of studs, dealing with sheared studs (extractors, drilling and re-tapping), use of shield anchor bolts (rawlbolts) and ragbolts for masonry and concrete (hole preparation and fitting, health and safety aspects in relation to reinforced concrete.

Unit 311 Power generation systems and ancillary equipment

Unit level:	Level 3
GLH:	80
Unit aim:	This unit is concerned with power generation and associated systems, in terms of planning and preparation, components, carrying out inspections, maintenance and installation tasks and commissioning the system.

Learning outcome

The learner will:

1 Know how to identify the components and features of utilities

Assessment criteria

The learner can:

1.1 identify the components and sub-systems needed for **power generation** units from drawings that use standard symbols

1.2 identify the **function of the essential components** needed for power generation plant or sub-systems

1.3 select **components** or equipment to meet specified functions in terms of required volumes (fuel, air and steam), pressures and temperatures using manufacturers' catalogues or other data.

Range

(AC1.1)
- **power generation**: principles of combustion of hydrocarbon fuels and the products of combustion, need for the correct proportions of air and fuel for complete combustion, ways in which energy forms can be achieved (chemical to heat, heat to mechanical, kinetic to mechanical); principles and factors affecting heat transfer by conduction, convection and radiation, basic four stroke, two stroke cycle for spark, compression ignition (CI) systems, valve timing diagrams (for all types) defining lead, lag and overlap, ignition and combustion requirements [obtaining the correct air pressures and temperatures, uniform mixtures of air and fuel in the required proportions, effects of incorrect mixtures, use of pressure/volume and crank angle/pressure diagrams to show the stages in combustion process].

(AC1.2)
- **function of the essential components**: general layouts of the following types of engine (in-line, vee, engine capacity in terms of bore, stroke and number of cylinders, meaning

of torque and its relationship with engines speed and power produced, factors affecting the efficiency of power generating systems, systems for supplying fuels to power units (from storage point to engine, by carburettors, venture, throttle control, main and idling jets, injection pumps, injectors [types and spray patterns] gas flow regulating valves]) methods of supplying air to IC engines (normally aspirated, under pressure [supercharged and turbo-charged[,construction and positioning of chargers, need for correct operating procedures to avoid damage during start up and shut down, air filtration [wet and dry types]), main features of electrical systems (coil ignition and components-switch, coil, condensers, contact breakers, distributors, spark plug types, suppressors, magneto-rotating armature, rotating magnet, contact breakers and mechanisms, a.c. alternators and generators and including voltage regulators, d.c. batteries-checking of condition and recharging)

(AC1.3)

- **components** :parts of cooling water supply systems (closed circulation via heat exchangers [radiators], pump types, temperature control methods [thermostats], water treatment for preventing scaling, corrosion and freezing, relationship between pressure and boiling point and resultant dangers), parts of lubricating systems – (pressurised: pump types, filters, pressure control and warning systems, oil coolers), splash methods of lubricating cylinder walls and valve mechanisms, types of oil and grease (and additives) used specifically for IC engines, starting methods for IC engines (electric, compressed air, hydraulic, manual, starting aids, volatile gas injection, heater plugs, excess fuel [choke], decompression devices), general construction details of reciprocating IC engines (cylinder blocks and heads [use wet and dry liners], crankshafts and bearing arrangements, cam shafts and valve timing arrangements, piston assemblies [gudgeon pins and types of piston ring], bearing types and application, ball and roller solid bush, split bearings [white metalled and shell types], principles and construction of turbines (rotor and stator blade configurations, blade shapes-impulse and reaction types-multi staging, methods of attaching blades onto rotor discs, need to allow for expansion of gases and steamand gas), stages of a gas turbine engine and the associated components, compressor-blade materials, changes in air pressure and temperatures, compression chambers (materials, fuel injection and mixing arrangements [primary and secondary], internal and external combustion zones, blade materials, attachment methods [including shrouding], power take off arrangements (reduction gearing), control methods for safe and efficient running (acceleration control units, steady speed governors, overspeed and temperature trips, use of exhaust gases to preheat air inlet to combustion zones), dispersal methods for exhaust gases in accordance with current regulations and good practice, stages of steam turbines and the associated components, control nozzle arrangements), speed governing and overspeed trips, exhaust steam arrangements and condensers, materials used for different components and power units and the reasons for their selection, possible causes of corrosion in IC engines (cooling water, condensation, reactions with combustion products, requirements and checks needed for standard maintenance and installation routines associated with the components and systems listed, possible causes of commonly observed symptoms related to IC engines (smoke from exhaust, overheating, knocking or pinking, misfiring or loss of power, excessive consumption [of fuel or oil])

Learning outcome

The learner will:

2 Understand how to plan and prepare for the maintenance or installation operation

Assessment criteria

The learner can:

2.1 evaluate the type and **extent of work** to be carried out

2.2 describe how **current legislation** and codes of practice relate to the given tasks

2.3 list how to carry out a **risk assessment.**

Range

(AC2.1)
- **extent of work**: layout, function of components and operational features of the pneumatic system to be installed or maintained (special considerations as prescribed by the manufacturer, methods of lifting, supporting or otherwise making system components safe, work to be undertaken may interact with or affect other systems or production facilities).

(AC2.2)
- **current legislation**: specific implications of Statutory regulations, Codes of practice related to installing or maintaining steam generating systems, disposal of toxic waste and other substances as defined by COSHH and environmental protection acts, pressure systems and portable gas containers and working at heights and in confined areas legislation (PA)

(AC2.3)
- **risk assessment**: methods of isolating the equipment or system (isolating switches, removal of fuses, closing or locking off of valves, removal of valves and blanking of pipes, procedures for de-pressurising systems and testing them to be in a safe condition, procedures for draining oil and other substances and their safe and legitimate disposal, need for providing equipment to deal with spillage and contamination (including any special Personal Protective Equipment (PPE) such as breathing apparatus), fire and personal injury, emergency shut down and evacuation procedures for the work area.

Learning outcome

The learner will:

3 Know how to carry out inspections and general maintenance tasks

Assessment criteria

The learner can:

3.1 describe how to carry out an **inspection**

3.2 describe how to **diagnose system faults and rectify components**

3.3 describe how to **reassemble** system following repair.

Range

(AC3.1)
- **inspection**: on power generation equipment or system. Methods used to avoid distortion and damage to, or leakage from, pipework (disconnecting, aligning, connecting), precautions needed to safely and effectively dismantle components, make identification (witness)marks on components so they can be correctly re assembled or re-aligned, label and safely store parts that have been removed, precautions needed to avoid danger from, or damage to, components whilst installing, dismantling and assembling from misalignment, use or wrong tools or excessive force, uncontrolled release of springs and scoring of surfaces; protect dismantled components from contamination (blanking off open ports, use of correct cleaning agents and lint free cloths).

(AC3.2)
- **diagnose system faults and rectify components**: rectify by repair or replace, essential points to be checked when inspecting pneumatic components (bearing surfaces, erosion and pitting, split or worn seals, signs of overheating (colour changes), condition of filters for signs of metallic or other particles, indications of emulsions or oil deteriorationof continuity of the weld

(AC3.3)
- **re-assembly**: procedures for re-assembling components to avoid damage using the approved sequence for tightening bolts and applying specified torque and the application of lubrication to seals, need for correctly labelling re-built components for replacement in a system or returning to stores, checking oil for signs for oxidation and acidity, bench testing re-assembled components, pressure testing pipework and pressure vessels, precautions to be taken when refilling systems with hydraulic oil, methods of safely bleeding systems to eliminate air locks and avoid spillage, procedures for charging gas filled accumulators, present information that can be used to appraise the outcome of a maintenance or installation activity (e.g. destructive, non-destructive).

Learning outcome

The learner will:

4 Know how to commission or re-commission the system

Assessment criteria

The learner can:

4.1 describe how to bring the system **online and adjust** as required until the working parameters have been fully met

4.2 identify **hazardous substances** that may have been used or discovered during the work and give the approved method of disposal for each such substance

4.3 describe the reasons for **handing over** the system to the authorised persons

4.4. list reasons why it is important to complete a report on the action taken.

Range

(AC4.1)
- **online and adjust**: precautions to be taken when refilling or recharging the systems and opening up the system to the sources of pressure, methods of safely draining, bleeding and purging systems to avoid undue leakage or contamination, set up and test interlocks, sensors and limit switches, removal of protective covers and blanks, opening appropriate valves or switches, operating the system under gradually increasing pressure or loads.

(AC4.2)
- **hazardous substances**: materials used that are classified as hazardous and those that can be recycleand polymers

(AC4.3)
- **handing over:** necessity for, and methods of, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, need to let all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person, procedure for terminating any ‘permits to work’ that have been.

Unit 312 Generation distribution of electrical power systems

Unit level:	Level 3
GLH:	80
Unit aim:	This unit will enable the learner to understand the principles applied to the generation and distribution of electrical power systems. They will learn about power distribution, insulated and earthed neutral. They will also develop an understanding of shore supply connections.

Learning outcome

The learner will:

1 Understand power distribution systems

Assessment criteria

The learner can:

1.1 describe marine electrical **distribution systems**

1.2 describe the types of **services** supplied by distribution systems

1.3 explain the function of distribution switchgear

1.4 explain the applications of devices for distribution **system protection**

1.5 describe the use of **emergency supplies.**

Range

(AC1.1) • **distribution systems**: High Voltage (HV), Low Voltage (LV), AC systems, power sources, switchboards, distribution boards, generators.

(AC1.2) • **services**: essential, non-essential

(AC1.4) • **system protection**: fuse discrimination, relays, interlocks, local shedding, undervoltage protection v overvoltage protection.

(AC1.5) • **emergency supplies**: lighting, alarms, communication, watertight doors, power sources (generator, battery), testing.

Learning outcome

The learner will:

2 Understand insulated and earthed neutral systems

Assessment criteria

The learner can:

2.1 explain the operation of an insulated LV shipboard system

2.2 explain the operation of an earthed HV system

2.3 explain the effects of **faults** on **distribution systems**

2.4 describe the application of **components** used to monitor distribution systems.

Range

(AC2.3)
- **faults**: HV, LV, earth fault, short-circuit fault, open-circuit fault.
- **distribution systems**: insulated system, earthed system.

(AC2.4)
- **components**: current transformers, Earth fault relays, voltage transformers

Learning outcome

The learner will:

3 Understand shore supply connections

Assessment criteria

The learner can:

3.1 describe the purpose of shore supply connections

3.2 describe the type of **connection** used for shore power

3.3 explain how to address compatibility of **differences** between shore and ship supplies.

Range

(AC3.2)
- **connection**: connection box, location, earthing provision, data plate, phase-sequence indicator, supply protection interlocks

(AC3.3)
- **differences**: frequency, voltage. of continuity of the weld

Unit 313 Platework fabrication of materials

Unit level:	Level 3
GLH:	68
Unit aim:	This unit enables the leaner to develop an understanding of the underlying process technology required for the fabrication of platework, including bolted and welded fabrications, developed platework, tubular node connection, boxed girder construction and pressure vessels. It covers health and safety aspects of fabrication, necessary planning and template development lay outs, marking out, cutting and forming and joining for the production of platework fabrications.

Learning outcome

The learner will:

1 Understand how to apply safe working practices to platework fabrication

Assessment criteria

The learner can:

1.1 describe the health and safety **regulations** relevant to platework fabrication

1.2 identify **hazards and risks** associated with hot working

1.3 describe recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards

1.4 describe **safe working practices.**

Range

(AC1.1)
- **regulations:** Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels).

(AC1.2)
- **hazards and risks**: hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), arc radiation (visible light, infra-red, ultra-violet, effects, protection (Personal Protective Equipment (PPE),

screening, warnings [verbal, notices], hot metal/slag from (thermal cutting process, welding processes, grinding).

(AC1.4) • **safe working practices**: thermal cutting and welding: safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance.

Learning outcome

The learner will:

2 Know the terminology and symbols used within welding

Assessment criteria

The learner can:

2.1 describe the key principles of cutting and **cutting techniques**

2.2 describe the preparation and use of cutting equipment for a range of given applications

2.3 describe the preparation and use of **thermal cutting equipment** for a range of given applications

2.4 critically compare thermal and mechanical methods of cutting thick plate.

Range

(AC2.2) • **cutting equipment:** drills (twist drill nomenclature, drilling machines [pedestal, bench, radial arm, portable, hand, electric power, pneumatic]), tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, power punch (including CNC control), cold sawing (circular saws, band saws [vertical, horizontal], reciprocating, friction), portable angle grinders/sanders.

(AC2.3) • **thermal cutting equipment**: oxy-fuel gas cutting (principle, manual cutting of plate and sections, machine cutting of plate, reason for 'three-point' support of plate, control of distortion), electric arc process (plasma-arc, laser cutting).

(AC2.4) • to include cost of equipment, suitability, versatility, accuracy, quality of cut.

Learning outcome

The learner will:

3 Know how to prepare the equipment for platework forming

Assessment criteria

The learner can:

3.1 describe the key principles of forming and **forming techniques**

3.2 describe the preparation and use of **forming** equipment for a range of given applications

3.3 critically compare the mechanical **methods of forming** thick plate.

Range

(AC3.2)
- **forming equipment:** rolling machines (pyramid type, pinch type [three and four pinch], mechanical, angle-ring bending, section rolls), folding machines (horizontal, vertical, double arm folder) press brake (tooling [dies, forming tools], mechanical, electro-hydraulic, up-stroking, down-stroking, CNC control), fly press (tooling [dies, forming tools]); methods of spring-back control for bending and folding, tooling design for air bending techniques, specialised tooling for press brake, use of polyurethane block for use with double arm folder, methods of pre-setting plate edges for rolling.

(AC3.3)
- **methods of forming**: cylinders, methods of conical and helical rolling, methods of rolling sectional material, stops, guides fitted to aid production; guarding (interlocking devices, fail safe circuits, light guards, gates).

(AC3.3)
- to include cost of equipment, suitability, versatility, accuracy, quality of finish.

Learning outcome

The learner will:

4 Know how to produce fabrications using platework techniques

Assessment criteria

The learner can:

4.1 describe **fabrication assembly** methods to produce square, rectangular and circular forms from thick plate to ± 2.0 mm tolerance

4.2 describe **joining methods** to produce fabricated platework assemblies to ± 2.0 mm tolerance

4.3 describe the importance of **restoring work areas** to a clean and safe condition on completion of the operation.

Range

(AC4.1)
- **fabrication assembly:** transfer of patterns to metal, use of level surfaces for assembling, methods used for alignment (strong backs and wedges, draw cleats/lugs, draw bolts), methods of avoiding twist, methods of controlling distortion, use of stays to maintain shape, use of jigs and fixtures and clamping devices, use of tack bolts and tack welds, care and use of lifting tackle, importance of close contact surfaces, removal of all temporary tack weld and the reinstatement of a good surface.

(AC4.2)
- **joining methods**: Thermal joining techniques: manual metal arc welding, MIG welding, procedures, settings and consumables to produce sound and effective tacking, interpret weld symbols to BS EN 22553, range of joint configuration used in thick platework ('open' square corner joints, lap fillets, tee fillets, cruciform joints, single and double vee butts, welding techniques (single and multi-run, stringer beads and weaving), joint design and welding sequence (weld strength, distortion control, weld economics), jigs and fixtures to aid assembly; manipulators, positioners, rotators to facilitate welding and

control distortion/ maintain dimensional accuracy; **Mechanical methods of joining**: bolting (bolts: [black bolts, high strength friction grip bolts, close tolerance bolts, fitted bolts], bolting requirements [cleanliness of contact surfaces, correct tensioning, hole clearance, tolerances, alignment of holes]) **Dimensional accuracy**: function of a datum line or surface, measuring equipment to check dimensional accuracy, specific tolerances, methods of checking accuracy (dimensions, alignment, form, squareness, freedom from twist and distortion, surface condition).

(AC4.3)

- **restore work areas**: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work).

Unit 314 Sheet metal work fabrication of materials

Unit level:	Level 3
GLH:	45
Unit aim:	This unit enables the leaner to develop a thorough understanding of the underlying process technology required for the fabrication of thin plate, including developed thin plate components, ducting, double curvature work and light sheet metal fabrication. It covers the health and safety aspects of fabrication work, cutting and forming of sheet metal and the production of fabrications using sheet metalwork techniques, including joining by soldering (soft and hard) and resistance welding (spot, seam and projection).

Learning outcome

The learner will:

1 Understand safe working practices and regulations for sheet metalwork fabrication

Assessment criteria

The learner can:

1.1 describe the health and safety **regulations** relevant to sheet metalwork fabrication

1.2 identify **hazards and risks** associated with hot working

1.3 describe recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards

1.4 describe **safe working practices.**

Range

(AC1.1)
- **regulations:** Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels).

(AC1.2)
- **hazards and risks**: hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers).

(AC1.4) • **safe working practices**: safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance.

Learning outcome

The learner will:

2 Know how to prepare and use sheet metal cutting tools and equipment

Assessment criteria

The learner can:

2.1 describe the key principles of cutting sheet metalwork

2.2 describe preparation and use of **cutting equipment** for a range of given applications

2.3 describe preparation and use of **cutting tools** for a range of given applications.

Range

(AC2.2) • **cutting equipment**: drills (twist drill nomenclature, drilling machines [pedestal, bench, portable, hand, electric power, pneumatic]), trepanning, tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (treadle, mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, fly press, power punch (including CNC control), portable angle grinders/sanders.

(AC2.3) • **cutting tools**: hand shears (straight, left hand, right hand, universal), bench shears (hand-lever, throatless, corrugated), tinman's hand-level punch.

Learning outcome

The learner will:

3 Know how to prepare equipment and tools for sheet metal forming

Assessment criteria

The learner can:

3.1 describe the key principles of forming sheet metalwork

3.2 describe preparation methods for **forming equipment** for a range of given applications

3.3 describe preparation and use of **forming tools** for a range of given applications.

Range

(AC3.2) • **forming equipment**: jennys (tooling), rolling machines (pyramid type, pinch type, slip rolls, hand-operated, mechanical, cone rolls, angle-ring bending), folding machines (box and pan, universal swing-beam, angle bending, simple bench mounted bending), press brake (tooling [dies, forming tools], mechanical, electro-hydraulic, up-stroking, down-stroking, CNC control), fly press (tooling [dies, forming tools]), stretch forming/shrinking machines, vibratory forming machines.

(AC3.3) • **forming tools**: types and sizes of hammers, planishing hammers, stretching hammers, blocking hammers, hollowing hammers, mallets, wedge shaped mallets, wooden blocks, sand bags, range of bench stakes.

Learning outcome

The learner will:

4 Know how to produce fabrications using sheet metalwork techniques

Assessment criteria

The learner can:

4.1 describe **fabrication techniques** to produce square, rectangular, cylindrical, conical forms (including offsets) and transition pieces from sheet metal to ± 0.5 mm tolerance

4.2 describe **joining** operations to produce fabricated sheet metal assemblies to ± 0.5 mm tolerance

4.3 evaluate fabrications for dimensional accuracy and fitness for purpose

4.4 describe the importance of **restoring work areas** to a clean and safe condition on completion of the operation.

Range

(AC4.1) • **fabrication techniques**: transfer of patterns to metal/plastics, stiffening techniques (swaging, beading, wired edges [including false], folds, flanging), forms (square, rectangular, cylindrical, conical: offset: square, rectangular, cylindrical, conical; boxed, curved panels, double curvatures, segmental bends), techniques used to produce transition pieces (square to round, round to square, breeches), stretching and shrinking techniques (hand forming, machine forming), hand forming techniques (hollowing, raising, planishing, flanging, double curvature, 'split and weld' methods), wheeling techniques.

(AC4.2) • **joining**: methods of fabrication assembly (holding methods, clamping, distortion control methods), use of joints, including self-secured (lap, grooved seam, lock-formed, Pittsburgh lock, panned down, knocked-up, jointing allowances, junctions that require notched corners), soldering and hard solder (brazing) techniques (principles of soldering, benefits and limitations, joint design, preparing the joint, cleaning the joint, types of soft solder [melting points, applications], types of fluxes, heat sources [copper bit, flame, hot plate, furnace, induction, resistance, dip], cleaning the soldered joint), braze welding, resistance welding processes (spot, seam, projection, principles of resistance welding [power source, generation of heat, electrodes [sizes, types, functions, methods of cooling, electrode arms).

(AC4.4) • **restore work areas**: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area,

work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work).

Unit 315 Fabrication and erection of structural steel

Unit level:	Level 3
GLH:	68
Unit aim:	This unit enables the leaner to develop the skills and the underlying process technology required for the fabrication and erection of structural steelwork. The unit is broadly divided into structural materials, fixtures and fastenings, structural fabrication, site work and safe working practices during fabrication and on site.

Learning outcome

The learner will:

1 Understand safe working practices and regulations for steelwork fabrication and erection

Assessment criteria

The learner can:

1.1 describe the health and safety **regulations** relevant to structural steelwork

1.2 identify **hazards and risks** associated with hot working

1.3 describe recommend safety precautions, procedures and Personal Protective Equipment (PPE) to overcome hazards

1.4 describe **safe working practices.**

Range

(AC1.1)
- **regulations:** Health and Safety at Work etc. Act, COSHH (risk assessment, consumable data sheets, training and awareness, safe working procedures, hierarchy of control), PUWER (scope within the welding environment), RIDDOR (application to fabrication process, major injuries, over three day injuries, diseases, dangerous occurrences) Management of Health and Safety at Work Regulations (risk assessment, control measures, training and awareness, safe working procedures), Personal Protective Equipment At Work Regulations (application to welding process, employers' duties, employees' duties, protection against hazards [fumes, airborne particles, arc radiation, hot metal, sparks, falling objects, factors render Personal Protective Equipment (PPE) provided as protection ineffective or unsafe]), Noise at Work Regulations (action levels).

(AC1.2)
- **hazards and risks**: hot working (sources of combustion, identification of hazards, methods of reducing risks, identification of extinguishers), arc radiation (visible light, infra-red, ultra-violet, effects, protection (PPE, screening, warnings [verbal, notices], hot metal/slag from (thermal cutting process, welding processes, grinding).

(AC1.4) • **safe working practices**: (thermal cutting and welding: safe start-up and shutdown procedures, safe use of equipment, equipment checks by operator, routine maintenance.

Learning outcome

The learner will:

2 Know how to prepare structural materials for steelwork fabrication

Assessment criteria

The learner can:

2.1 critically compare **structural steels** used in fabrication

2.2 compare the **forms of supply** of materials available

2.3 compare the forms of **pre-fabricated sections** and **fixtures** available.

Range

(AC2.1) • **structural steels:** low carbon steel, low alloy steels, high yield alloy steels, weather resistant steels (WR 55 grades); applications, limitations, load bearing capabilities, ease of fabrication (marking out, cutting, joining), density; application for: (access) platforms, decking and walkways, stairways and hooped ladders, hand railings; (support) saddles, brackets and cleats, frameworks, bracings and ties.

(AC2.2) • **forms of supply**: sections (rolled steel angle [RSA] {equal leg, unequal leg}, universal beam [UB], universal column [UC], rolled steel channel [RSC], rolled steel joist [RSJ], tee bar) hollow sections (circular hollow section [CHS], rectangular hollow section [RHS]) plates (plain, non-slip [durbar and chequer], expanded, pierced and punched), flat bars.

(AC2.3) • **pre-fabricated sections:** plate girders, box girders, lattice girders, castellated beams, cambered beams, laced stanchions, battened stanchions, portal frames.

(AC2.3) • **fixtures**: cleats (beam to beam connections, beam to column connections), columns (base plates, end plates, splice plates), gusset plates.

Learning outcome

The learner will:

3 Know how to perform marking out and cutting operations on structural materials

Assessment criteria

The learner can:

3.1 describe **marking out** operations on structural steelwork to meet specification

3.2 describe **cutting** operations on structural steelwork to meet specification

3.3 critically compare thermal and mechanical methods of cutting structural steelwork.

Range

(AC3.1)
- **marking out:** directly onto steelwork, using templates (types: plate, sections, cleats; application of templates: box, battened, part), datum, centre lines, set out points, avoidance of cumulative error in marking out by the avoidance of string dimensions, non-slip plate (chequer) avoiding 'wrong hand' or 'mirror image' errors, setting out a camber, derive the shapes of bolted gusset plates from standard hole pitch and edge distance.

(AC3.2, 3.3.)
- **cutting**: Mechanical: drills (twist drill nomenclature, drilling machines [pedestal, bench, radial arm, portable, hand, electric power, pneumatic]), tank cutters, hole saws, rotary shears (portable shears, nibblers [shear type, punch type, combination shears]), guillotines (mechanical, pneumatic, CNC control, back stops, front stops, guides), universal shearing machine, power punch (including CNC control), cold sawing (circular saws, band saws [vertical, horizontal], reciprocating, friction), portable angle grinders/sanders, reasons for reaming punched holes. Thermal: oxy-fuel gas cutting (principle, manual cutting of plate and sections, machine cutting of plate, reason for 'three-point' support of plate, control of distortion), electric arc process (plasma-arc, laser cutting)..

(AC3.3)
- to include cost of equipment, suitability, versatility, accuracy, quality of cut.

Learning outcome

The learner will:

4 Know how to produce fabricated steelwork structures

Assessment criteria

The learner can:

4.1 describe **fabrication assembly** operations to produce welded beam to beam connection from structural steelwork to ± 2.0 mm tolerance

4.2 explain the form and applications of **joining methods** used in structural steelwork

4.3 evaluate fabrications for **dimensional accuracy** and fitness for purpose

4.4 explain the importance of performing a trial **erection** of fabricated sections

4.5 describe how to tension bolts to the recommended torque

4.6 describe the importance of restoring **work areas** to a clean and safe condition on completion of the operation.

Range

(AC4.1)
- **fabrication assembly**: forming processes (plate rolls [pinch, pyramid], section rolls, beam bender), use of level surfaces for assembling, methods used for alignment (strong backs and wedges, draw cleats/lugs, draw bolts), methods of avoiding twist, methods of controlling distortion, use of stays to maintain shape, use of jigs and fixtures and clamping devices, use of tack bolts and tack welds, care and use of lifting tackle, importance of close contact surfaces, removal of all temporary tack weld and the

reinstatement of a good surface, reasons for part assemblies, trial erections and sub-assemblies.

(AC4.2) • **joining methods**: Thermal joining techniques: manual metal arc welding, MIG welding, procedures, settings and consumables to produce sound and effective tacking, interpret weld symbols to BS EN 22553, range of joint configuration used in thick steelwork ('open' square corner joints, lap fillets, tee fillets, cruciform joints, single and double vee butts, welding techniques (single and multi-run, stringer beads and weaving), joint design and welding sequence (weld strength, distortion control, weld economics), jigs and fixtures to aid assembly; manipulators, positioners, rotators to facilitate welding and control distortion/ maintain dimensional accuracy (restraint, welding sequence, pre-setting) methods of rectifying excessive distortion in welded structures (mechanical force, heat) Mechanical methods of joining: bolting – bolts (black, high tensile, high strength friction grip [HSFG], load indicating, close tolerance, torshear), washers (plain, hardened steel, load indicating, taper, tab, anti-vibration), shear connectors, factors that contribute to the quality of bolted connections (cleanliness of surfaces in contact, alignment of holes, correct tensioning [torque wrench, impact wrench]).

(AC4.3) • **dimensional accuracy**: function of a datum line or surface, measuring equipment to check dimensional accuracy, specific tolerances, methods of checking accuracy (dimensions, alignment, form, squareness, freedom from twist and distortion, surface condition).

(AC4.4) • **erection**: levelling steelwork and steelwork bases, plumbing vertical members, checking alignment, handle, move and lift structural sections safely, use of ancillary equipment used on site to lift, move or adjust the position of steelwork (pulleys, block and tackle, pull-lifts, hydraulic jacks, podger spanners, drifts, wedges, temporary props and bracings, falsework, modification techniques to steelwork on site (misaligned holes, incorrect sized members, maximum thickness of packings, fouling existing steelwork or services), consequences of cutting holes in beams to facilitate service piping or ducting.

(AC4.6) • **restore work areas**: leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work).

Unit 316 Pattern development for fabrication

Unit level:	Level 3
GLH:	100
Unit aim:	This unit enables the learner to develop the skills and the knowledge of the underlying process technology required for obtaining flat layouts of 3D forms that can be used for producing templates to mark out the material for fabrication to the required form.

Learning outcome

The learner will:

1 Be able to determine lines of intersection

Assessment criteria

The learner can:

1.1 determine lines of intersection using projection

1.2 determine lines of intersection using the principle of the **common central sphere**

1.3 determine lines of intersection using the method of cutting planes

1.4 determine **joint lines of ducts.**

Range

(AC1.2)
- **common central sphere**: right cylindrical branches onto transformer pieces, oblique cones to right cones, oblique cones to oblique cones, inclined right cylinder branches on right cones on and off centre, cylindrical and rectangular branch intersections onto rectangular hoppers, cylindrical and rectangular branches on spherical, doomed or dished ends.

(AC1.4)
- **joint lines of ducts**: where the centre lines lie on centre and in the same plane, a right angled tee piece of equal cross-section, a right angled tee piece of unequal cross-section, junctions of three cylinders.

Learning outcome

The learner will:

2 Be able to develop patterns using parallel line techniques

Assessment criteria

The learner can:

2.1 apply the **parallel line** method of pattern development

2.2 apply the parallel line method of pattern development to **complex forms.**

Range

(AC2.1)
- p**arallel line**: segmental bends (right cylindrical and oblique), square or rectangular ducts cut obliquely, right cylinders cut obliquely, oblique cylinders cut obliquely.

(AC2.2)
- **complex forms**: branch pipes on to boiler, shells, dished ends and domed ends, cylindrical branches onto right and cylindrical segmental bends to include interpenetration of the branch pipe, square and rectangle branches onto right and oblique cones, swan neck transition pieces, rectangle to rectangle in angular planes, transition pieces of apparently twisted sides with openings at right angles and different levels.

Learning outcome

The learner will:

3 Be able to develop patterns using radial line techniques

Assessment criteria

The learner can:

3.1 apply the **radial line** method of pattern development

3.2 apply the radial line method of pattern development to **complex forms.**

Range

(AC3.1)
- **radial line:** right cones and frusta, oblique cones and frusta, oblique cones cut by a flat surface, oblique cones cut by a curved surface, two way breeches piece made from right cones, two-way breeches piece made from oblique cones.

(AC3.2)
- **complex forms:** right cones in multiple connections of right cylinders and right cones, breeches pieces involving oblique cones, tapered segmental bends (‘lobster back bends’).

Learning outcome

The learner will:

4 Be able to develop patterns using triangulation.

Assessment criteria

The learner can:

4.1 apply the **triangulation** method of pattern development

4.2 apply the triangulation method of pattern development to **complex forms.**

Range

(AC3.1)
- **triangulation:** hoppers based on square or rectangular based pyramids, square or rectangle to round transformers, round to square or rectangle transformers, transformers and hoppers on and off centre, between parallel planes, transformers and hoppers between parallel and non-parallel planes, right cylinders, oblique cylinders, right cones, oblique cones.

(AC3.2)
- **complex forms:** rectangular to round off-set transformers, breeches pieces branching from cylindrical main to equal and unequal diameter ducts, rectangular kinked sided hoppers (kinked to produce maximum volume, kinked to produce minimum volume), spiral blade segments by triangulation.

Learning outcome

The learner will:

5 Know how to produce templates of developed patterns

Assessment criteria

The learner can:

5.1 describe pattern development techniques to prepare **templates** for the marking out of a fabrication

5.2 perform **calculations** to produce dimensions for checking templates

5.3 review and revise layouts to accommodate **material thickness**

5.4 describe the importance of **restoring work areas** to a clean and safe condition on completion of the operation.

Range

(AC5.1)
- **templates:** purpose, means of checking, types and applications, use of purpose (avoid repetitive measurements, avoid unnecessary material wastage, act as a guide to cutting process[es], means of checking [lengths, angles, shapes, forms], precise method of marking hole positions, reliable means of assuring repeatability), types and applications (pattern development, internal, external, roof truss, gusset, back-marks, hole, bushed,

box), use of CAD packages (standard CAD [eg AutoCAD], specialist packages [pattern development software]), template production techniques (template shop/loft, setting out floor), tools used (saws, planes, drills, marking gauge, steel rule, compasses, dividers, trammels, protractor, engineers square, flat (plate) square, straight edge, hammers, centre/dot/nipple punches, chalk line and soft chalk, french chalk, coloured and indelible pencils/crayons), materials (template paper, hardboard, timber, sheet metal, steel plate), information contained on templates (job/contract number, size/thickness of material, steel section and length, quantity required, bending/folding instructions, orientation [eg 'this side up', 'left side', 'right hand', etc], drilling requirements, cutting instructions, assembly reference mark, datum[s].

(AC5.2)
- **calculations:** length of cylinder (πd), angle at the apex of a developed right cone/frusta pattern/half pattern, use of triangles, use of trigonometry, application of the neutral line.

(AC5.3)
- **material thickness:** methods of marking out from templates, including: external forms, internal forms, holes, back marks, pitch, use of datums; determine modified set-outs to accommodate plate thickness (application of the neutral line), use of instructions added to templates and patterns produced by the triangulation method enabling them to be used effectively.

(AC5.4)
- **restoring work areas:** leave the work area free of unused consumables, cleaning the work area, putting tools and equipment into safe storage, identify any materials used that are classified as hazardous and those that can be recycled, reporting any damage caused by the maintenance or installation activity where additional restoration work may be needed, informing all interested parties know of any changes that may affect the operation of the system, or of any new conditions that could exist in the work area, work termination documents or reports that may be required are completed and passed on to an authorised person (eg terminating permits to work).

Unit 317 Further electrical and electronic principles

Unit level:	Level 3
GLH:	80
Unit aim:	The purpose of this unit is to enable learners to develop an understanding of complex electrical and electronic theorems, which will enable learners to be able to analyse specified networks and a range of circuits.

Learning outcome

The learner will:

1 Understand electrical theorems

Assessment criteria

The learner can:

1.1 explain methods of resolving network problems using electrical **theorems or laws**

1.2 use electrical theorems or laws to solve problems involving networks.

Range

(AC1.1, 1.2)

- **theorems and laws**: Ohm's law; Kirchhoff's current and voltage laws; Thévenin's theorem; Norton's theorem; Maximum power transfer theorem; Superposition, Theorem.)

Learning outcome

The learner will:

2 Understand complex notation theory

Assessment criteria

The learner can:

2.1 explain the **properties** of R, L and C circuits

2.2 explain the **representation** of series R, L and C circuits

2.3 evaluate complex variables in **operations**

2.4 convert electrical values between polar and rectangular form

2.5 calculate **power** using **relationships.**

Range

(AC2.1)
- **properties**: Voltage, Current, Phase Angle, Frequency, Resistance, Reactance and Impedance (R, XL, XC, Z).

(AC2.2)
- **representation**: By complex impedance and complex admittance.

(AC2.3)
- **operations**: Addition; subtraction; multiplication; division.

(AC2.5)
- **power:** Real; Reactive; Apparent; Power Factor.
- **relationships:** P=Re[VI*] and Q=Im[VI*].

Learning outcome

The learner will:

3 Understand how to analyse RLC circuits

Assessment criteria

The learner can:

3.1 represent differing **types** of R, L and C circuits using phasor diagrams

3.2 explain the conditions of resonance for **RLC circuits**

3.3 explain power factor **relationships** using diagrams

3.4 produce plots of the frequency responses of tuned RLC circuits

3.5 solve problems of **resonance** in RLC circuits

3.6 solve problems relating to power-factor improvement.

Range

(AC3.1)
- **types**: Series; parallel.

(AC3.2)
- **RLC circuits**: Series; parallel.

(AC3.3)
- **relationships**: Real power; Reactive power; Apparent power.

(AC3.5)
- **resonance**: Quality factor; bandwidth; impedance; reactance; capacitance.

Learning outcome

The learner will:

4 Understand how to analyse three-phase circuits

Assessment criteria

The learner can:

4.1 illustrate three-phase systems using phasor diagrams

4.2 solve **problems** in balanced three-phase loads

4.3 evaluate methods of three-phase power measurement for different **systems.**

Range

(AC4.2)
- **problems**: Involving line values (voltage and current); phase values (voltage and current); power and power-factor; Star connection and Delta connection.

(AC4.3)
- **systems**: Balanced; unbalanced; star (three-wire, four-wire); delta.

Learning outcome

The learner will:

5 Understand how to solve the transient response of first-order circuits

Assessment criteria

The learner can:

5.1 produce graphs of growth and decay of transient **components** in circuits

5.2 solve problems relating to **time** and steady state values of **circuits**

Range

(AC5.1)
- **components**: Voltages and currents.

(AC5.2)
- **circuits**: RL and RC.
- **time**: Time constant; rise-time and fall-time.

Unit 318 Maintenance of utility systems

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the learner to develop an understanding of three key utility systems: compressed air, steam and electricity. They will learn the principles of each of the systems and the function of components that exist within the systems. Learners will also develop an understanding of the principles of maintenance and how they can be applied to hydraulic systems.

Learning outcome

The learner will:

1 Understand the operation of compressed air systems

Assessment criteria

The learner can:

1.1 explain the relationships between force, pressure and area

1.2 explain the relationship between volume, temperature and pressure

1.3 explain the relationship between relative humidity, air pressure and temperature

1.4 explain the function of **components** in compressed air systems.

Range

(AC1.4)
- **components**: Compressors, actuators, valves, motor, pipework, fittings, filter, receiver, dryers, gauges.

Learning outcome

The learner will:

2 Understand the operation of steam systems

Assessment criteria

The learner can:

2.1 explain the **modes of heat transfer**

2.2 explain the relationship between pressure, **energy** and temperature

2.3 describe the operating principles of heat exchangers

2.4 explain **factors** that affect the efficient operation of heat exchangers

2.5 interpret steam tables

2.6 explain the function of **components** in steam systems.

Range

(AC2.1) • **modes of heat transfer**: Conduction, convection, radiation.

(AC2.2) • **energy**: Latent heat energy, sensible heat energy.

(AC2.4) • **factors**: Scaling, fouling, corrosion, heat coefficient.

(AC2.6) • **components:** Burner, boiler, valves, pipework, heat exchangers, steam trap, condensate, feedwater, strainer, gauges**.**

Learning outcome

The learner will:

3 Understand the operation of electrical systems

Assessment criteria

The learner can:

3.1 explain the common **units** used in electrical systems

3.2 explain the **relationship** between voltage, current and resistance

3.3 explain the types of electrical **supplies** used in electrical systems

3.4 explain **components** used in electrical systems.

Range

(AC3.1) • **units**: Voltage, current, resistance.

(AC3.2) • **relationships**: Ohms law, power’

(AC3.3) • **supplies**: d.c., a.c. (single-phase, three-phase).

(AC3.4) • **components**: Generators, transformers, protective devices, cabling, motors, switches, contactors, relays, containment systems.

Learning outcome

The learner will:

4 Understand how to maintain utility systems

Assessment criteria

The learner can:

4.1 describe **resources** required for maintenance activities

4.2 explain **control measures** required to minimise health and safety risks

4.3 describe how to dismantle **utility systems** for maintenance activities

4.4 describe how to complete utility system **maintenance activities**

4.5 describe how to assemble utility systems following **maintenance activities**

4.6 describe **re-commissioning** operations to bring utility systems on-line.

Range

(AC4.1)
- **resources**: Tools, materials, equipment, information, documentation.

(AC4.2)
- **control measures**: Risk assessment, Method statements, PPE, Permit to work.

(AC4.3, 4.5)
- **utility systems**: Compressed air, steam, electricity.

(AC4.4)
- **maintenance**: Compressed air, steam, electricity.
- **activities**: Inspection, tolerance/performance checks, corrosion checks, mechanical damage repair, termination/fastener security (torque setting), lubrication, cleaning, component replacement, base overhaul.

(AC4.6)
- **re-commissioning**: Electrical tests, Mechanical tests, fluid tests, safety and protective device settings, performance tests, recharging systems.

Unit 319 Maintenance of electrical equipment and systems

Unit level:	Level 3
GLH:	80
Unit aim:	The unit enables learners to develop an understanding of how electrical systems operate with an emphasis on the role of motors within a system. They will develop an understanding of how systems function and how to interpret different types of drawings that represent the systems. Learners will develop an understanding of the principles of maintenance and how they apply to electrical systems.

Learning outcome

The learner will:

1 Understand how electrical systems function

Assessment criteria

The learner can:

1.1 explain the function of electrical system **components**

1.2 explain how components work together in an **electrical system**

1.3 explain **methods** used to protect electrical systems

1.4 explain how electrical system power requirements determine **supplies.**

Range

(AC1.1)
- **components**: a.c. motors (induction and synchronous), motor construction (cylindrical and salient pole), single-phase motors; d.c. motors (series, shunt and compound); power factor correction equipment, circuit protection devices, isolators, switches, switchgear.

(AC1.2)
- **electrical system**: Power and control systems, starting methods (direct online, star delta, capacitor start, invertor drive phase induction start, capacitor start, capacitor start and run, motor starters).

(AC1.3)
- **methods**: Fuses, circuit breakers, isolators, overloads, undervoltage, earthing, residual current devices, no volt releases, insulation, enclosures, containment systems.

(AC1.4)
- **supplies**: Cable types (steel wire armoured (SWA) and Mineral Insulated Copper cable (MICC)), cable size, containment systems, (Busbar systems, underfloor ducting, rising mains).

Learning outcome

The learner will:

2 Understand electrical system information

Assessment criteria

The learner can:

2.1 identify standard symbols of **electrical system** drawings

2.2 interpret **electrical system** drawings

2.3 analyse electrical system **data**.

Range

(AC2.1, 2.2)
- **electrical system** drawings: Circuit, wiring, layout

(AC2.3)
- **data**: Manufacturers data, catalogues, Internet, component data sheets (PA)

Learning outcome

The learner will:

3 Understand how to maintain electrical systems

Assessment criteria

The learner can:

3.1 describe **legislation** relating to electrical equipment and systems

3.2 describe **resources** required for maintenance activities

3.3 explain **control measures** required to minimise health and safety risks

3.4 describe how to **dismantle** electrical systems for maintenance activities

3.5 describe signs of electrical component **non-compliance**

3.6 describe how to complete electrical system maintenance activities

3.7 describe how to **assemble** electrical systems following maintenance activities

3.8 describe **re-commissioning** operations to bring system on-line.

Range

(AC3.1)
- **legislation**: Electricity at Work Regulations, IEE Wiring Regulations.

(AC3.2)
- **resources**: tools, equipment, materials, information, documentation.

(AC3.3) • **control measures**: Risk assessment, Method statements, PPE, Permit to work.

(AC3.4) • **dismantle**: Safe isolation, releasing stored energy, supporting components, removing components, laying out components, proof marking removed components.

(AC3.5) • **non-compliance**: Erosion, wear, corrosion, discolouration, damage (mechanical/heat), contamination, failure.

(AC3.6) • **maintenance**: Inspection, tolerance/performance checks, corrosion checks, mechanical damage repair, termination/fastener security (torque setting), lubrication, cleaning, component replacement, base overhaul.

(AC3.7) • **assemble**: Sequence of assembly, positioning components, setting, aligning and adjusting components, securing components.

(AC3.8) • **re-commissioning**: Visual inspection, electrical testing, re-energising procedures (sequencing), functional tests.

Unit 320 Electrical maintenance on ships

Unit level:	Level 3
GLH:	80
Unit aim:	This unit will enable the learner to acquire essential knowledge and understanding of safe electrical maintenance of ship systems. They will develop an understanding of power distribution systems as well as low voltage, high voltage and lighting systems. Learners will gain an understanding of the principles of maintenance, with an emphasis on safety, and how they are applied when carrying out electrical maintenance activities on ships.

Learning outcome

The learner will:

1 Understand power distribution systems

Assessment criteria

The learner can:

1.1 describe marine electrical **distribution systems**

1.2 describe the types of **services** supplied by distribution systems

1.3 explain the function of distribution switchgear

1.4 explain the applications of devices for distribution **system protection**

1.5 describe the use of **emergency supplies.**

Range

(AC1.1) • **distribution systems**: High Voltage (HV), Low Voltage (LV), AC systems, power sources, switchboards, distribution boards, generators.

(AC1.2) • **services**: Essential, non-essential.

(AC1.4) • **system protection**: Fuse discrimination, relays, interlocks, local shedding, undervoltage protection v overvoltage protection

(AC1.5) • **emergency supplies**: Lighting, alarms, communication, watertight doors, power sources (generator, battery), testing.

Learning outcome

The learner will:

2 Understand ship electrical systems

Assessment criteria

The learner can:

2.1 explain the **application** of **luminaires** in electrical systems

2.2 explain the **application** of **electrical machines** in electrical systems

2.3 explain the use of **electrical components** in electrical systems

2.4 explain the function and operation of electrical drives and **control.**

Range

(AC2.1)
- **application**: Use, limitations, benefits.
- **luminaires**: GLS lamps, mercury vapour lighting, sodium vapour lighting, energy saving lamps, LED lighting tungsten, fluorescent.

(AC2.2)
- **application**: Use, limitations, benefits.
- **electrical machines**: Motors (a.c./d.c.) single-phase, three-phase, generators.

(AC2.3)
- **electrical components**: Power factor correction equipment, circuit protection devices, isolators, switches, switchgear, cabling, containment systems.

(AC2.4)
- **control**: Direct on line starting, reduced voltage starting, variable speed control, variable frequency control.

Learning outcome

The learner will:

3 Understand safety requirements of electrical maintenance on ships

Assessment criteria

The learner can:

3.1 describe **safe systems of work** for electrical maintenance on ships

3.2 explain safety **considerations** for the maintenance of electrical systems

3.3 explain **safety precautions** required for inspecting and testing electrical equipment.

Range

(AC3.1) • **safe systems of work**: Programme of work by authorised person, switching schedule, permit to work, means of isolation (from mains, local), system earthing, use of earth bonding leads.

(AC3.2) • **considerations**: Access, safe working area, handling of components, IP rating of equipment, ventilation, waste disposal.

(AC3.3) • **safety precautions**: Safe isolation, lock-off tag-out, CAT rated test equipment, PPE.

Learning outcome

The learner will:

4 Understand how to maintain electrical systems

Assessment criteria

The learner can:

4.1 describe **legislation** relating to electrical equipment and systems

4.2 describe **resources** required for maintenance activities

4.3 explain **control measures** required to minimise health and safety risks

4.4 describe how to **dismantle** electrical systems for maintenance activities

4.5 describe signs of electrical component **non-compliance**

4.6 describe how to complete electrical system **maintenance** activities

4.7 describe how to **assemble** electrical systems following maintenance activities

4.8 describe **re-commissioning** operations to bring system on-line.

Range

(AC4.1) • **legislation**: Electricity at Work Regulations, IEE Wiring Regulations.

(AC4.2) • **resources**: Tools, equipment, materials, information, documentation.

(AC4.3) • **control measures**: Risk assessment, Method statements, PPE, Permit to work.

(AC4.4) • **dismantle**: Safe isolation, releasing stored energy, supporting components, removing components, laying out components, proof marking removed components.

(AC4.5) • **non-compliance**: Erosion, wear, corrosion, discolouration, damage (mechanical/heat), contamination, failure.

(AC4.6) • **maintenance**: Inspection, tolerance/performance checks, corrosion checks, mechanical damage repair, ermination/fastener security (torque setting), lubrication, cleaning, component replacement, base overhaul.

(AC4.7) • **assemble**: Sequence of assembly, positioning components, setting, aligning and adjusting components, securing components.

(AC4.8) • **re-commissioning**: Visual inspection, electrical testing, re-energising procedures (sequencing), functional tests.

Unit 321 Maintenance of fluid power systems

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the learner to develop an understanding of the components of fluid power systems and how they contribute to their operation. They will develop an understanding of the principles of hydraulic and pneumatic systems and how the systems are presented in engineering schematics. Learners will also develop an understanding of the principles of maintenance that can be applied to fluid power systems.

Learning outcome

The learner will:

1 Understand the principles of fluid power systems

Assessment criteria

The learner can:

1.1 explain the relationships between force, pressure and area

1.2 explain the relationship between volume, temperature and pressure

1.3 explain the relationship between relative humidity, air pressure and temperature

1.4 explain the relationship between flow, velocity and area

1.5 describe the **properties** of **hydraulic fluids.**

Range

(AC1.5)

- **properties:** viscosity, density, lubricity , flash point, fire resistance
- **hydraulic fluids:** water, oil

Learning outcome

The learner will:

2 Understand the operation of fluid power systems

Assessment criteria

The learner can:

2.1 explain the function of **components** in fluid power systems

2.2 describe **methods** of fluid power system control

2.3 explain the operation of a fluid power system cycle.

Range

(AC2.1) • **components:** compressors, pumps, actuators, valves, motor, pipework, fittings, accumulators, receivers, dryers, filter, reservoir, gauges

(AC2.2) • **methods**: mechanical, electrical, electronic

Learning outcome

The learner will:

3 Understand fluid power system engineering schematics

Assessment criteria

The learner can:

3.1 identify standard symbols of **components** in fluid power systems

3.2 describe the relative positions of components in a fluid power schematic.

Range

(AC3.1) • **components:** compressors, pumps, actuators, valves, motor, pipework, fittings, accumulators, receivers, dryers, filter, reservoir, gauges

---

Learning outcome

The learner will:

4 Understand principles of fluid power systems maintenance

Assessment criteria

The learner can:

4.1 explain control measures required to minimise health and safety risks

4.2 describe signs of component non-compliance

4.3 describe causes of deterioration of hydraulic power fluids

4.4 describe re-commissioning operations to bring system on-line

4.5 explain the possible causes of common faults.

Range

(AC4.1) • **signs:** erosion, wear, corrosion, discolouration, damage, contamination, failure

Unit 322 Maintenance of hydraulic systems

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the learner to develop an understanding of the components of hydraulic systems and how they contribute to their operation. They will develop an understanding of the principles of hydraulic systems and how the systems are presented in engineering schematics. Learners will also develop an understanding of the principles of maintenance and how they can be applied to hydraulic systems.

Learning outcome

The learner will:

1 Understand the principles of hydraulic systems

Assessment criteria

The learner can:

1.1 explain the relationships between force, pressure and area

1.2 explain the relationship between flow, velocity and area

1.3 describe the **properties** of **hydraulic fluids.**

Range

(AC1.3)

- **properties:** viscosity, density, lubricity, flash point, fire resistance
- **hydraulic fluids:** water, oil

Learning outcome

The learner will:

2 Understand the operation of hydraulic systems

Assessment criteria

The learner can:

2.1 describe the **purpose** of fluids in hydraulic systems

2.2 describe the purpose of additives in hydraulic fluids

2.3 explain the function of **components** in hydraulic systems

2.4 describe **methods** of hydraulic system control

2.5 explain the relationship between components and fluid flow rate in hydraulic systems

2.6 explain the operation of a hydraulic system cycle.

Range

(AC2.1)
- **purpose:** energy transfer, lubrication, cleaning, dispersal

(AC2.3)
- **components:** pumps, actuators, valves, motor, pipework, fittings, accumulators, filter, reservoir, gauges

(AC2.4)
- **methods:** mechanical, electrical, electronic

Learning outcome

The learner will:

3 Understand hydraulic system engineering schematics

Assessment criteria

The learner can:

3.1 identify standard symbols of **components** in hydraulic systems

3.2 describe the relative positions of components in a hydraulic schematic.

Range

(AC3.1)
- **components:** pumps, actuators, valves, motor, pipework, accumulators, filter, reservoir, gauges

---

Learning outcome

The learner will:

4 Understand the principles of hydraulic systems maintenance

Assessment criteria

The learner can:

4.1 describe **resources** required for maintenance activities

4.2 explain control measures required to minimise health and safety risks

4.3 describe how to **dismantle** hydraulic systems for maintenance activities

4.4 describe **signs** of component non-compliance

4.5 describe causes of deterioration of hydraulic fluids

4.6 describe how to **assemble** hydraulic systems following maintenance activities

4.7 describe **re-commissioning** operations to bring system on-line

4.8 explain the possible causes of common faults.

Range

(AC4.1)
- **resources:** tools, equipment, materials, information, documentation

(AC4.3)
- **dismantle:** releasing stored energy, supporting components, draining and removing fluids, disconnecting pipework, removing components, laying out components, proof marking removed components

(AC4.4)
- **signs:** erosion, wear, corrosion, discolouration, damage, contamination, failure

(AC4.6)
- **assemble:** checking components for serviceability, positioning equipment, aligning pipework, dressing and securing pipework, setting, aligning and adjusting components, securing components, filling system, priming, cleaning

(AC4.7)
- **re-commissioning:** recharging systems, pressurising system, bleeding and purging systems, setting up and testing safety devices, bringing systems back to the specified working conditions

Unit 323 Maintenance of pneumatic systems

Unit level:	Level 3
GLH:	80
Unit aim:	This unit enables the learner to develop an understanding of the components of pneumatic systems and how they contribute to their operation. They will develop an understanding of the principles of pneumatic systems and how the systems are presented in engineering schematics. Learners will also develop an understanding of the principles of maintenance and how they can be applied to pneumatic systems.

Learning outcome

The learner will:

1 Understand the principles of pneumatic systems

Assessment criteria

The learner can:

1.1 explain the relationships between force, pressure and area

1.2 explain the relationship between flow, velocity and area

1.3 explain the relationship between volume, temperature and pressure

1.4 explain the relationship between relative humidity, air pressure and temperature.

Learning outcome

The learner will:

2 Understand the operation of pneumatic systems

Assessment criteria

The learner can:

2.1 explain the function of **components** in pneumatic systems

2.2 describe **methods** of pneumatic system control

2.3 explain the operation of a pneumatic system cycle.

Range

(AC2.1) • **components:** compressors, actuators, valves, motor, pipework, fittings, filter, receiver, dryers, gauges

(AC2.2) • **methods**: mechanical, electrical, electronic

Learning outcome

The learner will:

3 Understand pneumatic system engineering schematics

Assessment criteria

The learner can:

3.1 identify standard symbols of **components** in pneumatic systems

3.2 describe the relative positions of components in a pneumatic schematic.

Range

(AC3.1, 3.2) • **components**: compressors, actuators, valves, motor, pipework, fittings, filter, receiver, dryers, gauges

Learning outcome

The learner will:

4 Understand the principles of pneumatic systems maintenance

Assessment criteria

The learner can:

4.1 describe **resources** required for maintenance activities

4.2 explain control measures required to minimise health and safety risks

4.3 describe how to **dismantle** pneumatic systems for maintenance activities

4.4 describe **signs** of component non-compliance

4.5 describe how to **assemble** pneumatic systems following maintenance activities

4.6 describe **re-commissioning** operations to bring system on-line

4.7 explain the possible causes of common faults.

Range

(AC4.1) • **resources:** tools, equipment, materials, information, documentation

(AC4.3) • **dismantle:** releasing stored energy, supporting components, disconnecting pipework, removing components, laying out components, proof marking removed components

(AC4.4) • **signs:** erosion, wear, corrosion, discolouration, damage, contamination, failure

(AC4.5) • **assemble:** checking components for serviceability, positioning equipment, aligning pipework, dressing and securing pipework, setting, aligning and adjusting components, securing components, cleaning

(AC4.6) • **re-commissioning:** pressurising system, setting up and testing safety devices, bringing systems back to the specified working conditions

Unit 324 Principles of welding

GLH:	80
Unit aim:	This unit enables the leaner to understand the underlying principles that enable effective welding to take place, without focusing on specific welding processes. Welding metallurgy, the physical science of welding, weld symbols, joint design, distortion, defects and testing: non-destructive (NDT) and destructive (mechanical) are included.

Learning outcome

The learner will:

1 Understand the fundamentals of welding

Assessment criteria

The learner can:

1.1 explain the characteristics of an **electric arc** used for welding purposes

1.2 explain the purpose of **electrode coverings** used for welding purposes

1.3 explain the **effects** of fluxes and electrode coverings/cores upon welding processes

1.4 explain the purpose of **shielding gases** used for welding purposes.

Range

(AC1.1)
- **Electric arc**: voltage distribution across the arc, heat generation at the cathode and anode, arc characteristics (alternating current [a.c.], direct current [d.c.]), effects and influence of magnetic fields, factors that influence metal transfer (surface tension, gravity, electromagnet [Lorentz] force, hydrodynamic forces due to gas flow pinch effect

(AC1.2
- **Electrode coverings**: rutile, basic, cellulosic, iron powder

Additional guidance:
- processes manual metal arc (MMA) welding, types of covering (rutile, basic, cellulosic, iron powder)

(AC1.3
- **Effects**: facilitates arc striking, stabilises and directs the arc, assists control of the size and frequency of filler metal globules/droplets, protects filler metal from atmospheric contamination during transfer, protects deposited metal from contamination, provides appropriate weld contour, prevents rapid cooling of weld metal (thermal blanket effect), provides a flux for the molten pool to remove oxides and impurities, supplies additional metal to weld pool

(AC1.4 • **Shielding gases**: tungsten inert gas (TIG) welding, metal active gas (MAG), metal inert gas (MIG) welding, inert gases (argon, helium), inert gas mixtures (CO_2, Ar/CO_2, Ar/O_2/CO_2, Ar/He/O_2/CO_2, Ar/O_2, Ar/H_2, N_2, Ar/N_2) [where: Ar = argon, He = helium, O_2 = oxygen, H_2 = hydrogen, N_2 = nitrogen, CO_2 = carbon dioxide]; influence of shielding gases (protection from gases in the atmosphere, composition of atmosphere, arc characteristics, mode of metal transfer, penetration, weld bead profile, speed of welding, wetting/undercutting tendency, cleaning action, weld metal mechanical properties.

Learning outcome

The learner will:

2 Know how to apply welding symbols to joint preparations

Assessment criteria

The learner can:

2.1 describe the difference between the **features** of welded joints

2.2 describe how to apply BS EN 22553 to **types of joints**

2.3 describe how to apply **weld dimensions** to weld symbols.

Range

(AC2.1) • **Features:** face, toes, root, HAZ (heat affected zone), convex fillet profile, concave fillet profile, mitred fillet profile, root face, root gap, root radius (‘U’ butt profile), land (‘U’ butt profile), bevel angle, included angle, weld width, throat thickness, leg length(s), fusion zone (depth of fusion), excess weld metal, penetration, fusion line (boundary

(AC2.2) • **Types of joints:** Welded, brazed and soldered joints — symbolic representation on drawings, symbols for the communication of the designation of welded joints; types of joint (butt, tee, lap, corner); types of weld preparation (square butt [open], square butt [closed], flanged butt, single-vee butt, double-vee butt, single ‘U’ butt, double ‘U’ butt, fillet, single-bevel butt, double-bevel butt, single ‘J’ butt, double ‘J’ butt, spot, seam, projection, surfacing, plug, edge, surface, inclined, fold); application of types of weld preparation (arrow line, reference line, identification line, symbol, non-symmetrical welds, symmetrical welds); supplementary and complimentary symbols (finished flush by grinding, finished flush by machining, convex, concave, backing [sealing] run, permanent backing strip, removable backing strip, toes blended smoothly, peripheral welds, field or site welds, numerical indication of welding process [EN 24063 — Welding, brazing, soldering and braze welding of metals — nomenclature of processes and reference numbers for symbolic representation on drawings]

(AC2.3) • **Weld dimensions:** leg length, throat thickness, fillet welds, square butt welds, root gaps, intermittent fillet welds, staggered intermittent fillet welds.

Learning outcome

The learner will:

3 Understand the effects of distortion and residual stresses due to welding

Assessment criteria

The learner can:

3.1 explain the **reasons for distortion** due to welding

3.2 classify **types of distortion**

3.3 explain the methods of **distortion control**

3.4 explain the methods of **distortion rectification**

3.5 explain the **residual stress** effects of welding.

Range

(AC3.1) • **Reasons for distortion**: uneven expansion and contraction, degree of restraint.

(AC3.2) • **Types of distortion:** longitudinal, transverse, angular, buckling, bowing, dishing, twisting.

(AC3.3) • **Distortion control:** pre-setting, pre-bending, weld sequencing, skip welding, back-stepping, balanced welding, intermittent welding, tack welding, pre and post weld heat treatment, joint design, chills, restraint (clamping, jigs, back-to-back assembly)

(AC3.4) • **Distortion rectification**: mechanical methods (peening, jacking, pressing, bending, rolling, hammering, planishing); thermal methods (use of heat strips, use of heat triangles); combination of mechanical and thermal methods (hot working).

(AC3.5) • **Residual stress:** (Definition: stresses locked in after the original cause of stress has been removed: causes (restraint due to uneven expansion and contraction [natural], restraint due to distortion control methods [clamping, jigs, back-to-back assembly, balanced welding]), effects (pattern across joint cross-section [areas of tension, areas of compression], influence upon mechanical properties in service), stress relieving methods (normalising, thermal stress relief).

Learning outcome

The learner will:

4 Understand the metallurgical effects of welding

Assessment criteria

The learner can:

4.1 explain the **heat distribution** during welding

4.2 explain the **effects of heat** due to welding

4.3 explain the relationship between the iron-carbon (Fe-C) **thermal equilibrium diagram** for plain carbon steels and welded joints

4.4 explain the reasons for **cracking** due to welding

4.5 explain the effects of **dilution** on fully fused joints in dissimilar metals.

Range

(AC4.1)
- **Heat distribution:** thermal gradients, heat flow, weld thermal cycle, effects upon the structure of the weld metal, effects upon the structure of the parent metal (heat-affected zone [HAZ], HAZ sub-zones [overheated, refining, transition]

(AC4.2)
- **Effects of heat:** temperature, methods of heat production (electric arc, electrical resistance, combustion), determination of heat input during arc welding (J/s, [k]J/mm), pre and post weld heat treatment, stress relief, methods of temperature measurement (pyrometer, temperature indicating crayons), means of heat transfer/loss (conduction, convection, radiation**)**

(AC4.3)
- **Thermal equilibrium diagram**: influence of percentage carbon content in iron, influence of temperature, upper critical point, lower critical point, eutectoid, relationship to heat treatment processes, relationship to weld and HAZ

(AC4.4)
- **Cracking:** cold-cracking due to hydrogen in steels, definition, conditions necessary for cold cracking, influence of hydrogen, influence of stresses, influence of susceptible microstructure, methods of avoiding, reheat cracking, definition, types of steels sensitive to reheat cracking, reheat cracking due to heat treatment, reheat cracking due to multi-pass welding

Additional Guidance

- cold-cracking due to hydrogen in steels, definition, conditions necessary for cold cracking, influence of hydrogen (sources of hydrogen, control of hydrogen in the deposited weld metal) influence of stresses (nature of stresses, methods of avoiding) influence of susceptible microstructure (nature, methods of avoiding), cracking mechanism in the weld metal and the HAZ, effect of preheating, use of stainless steel weld metal; lamellar tearing, definition, causes (through thickness properties, inclusions) methods of avoiding (influence of joint design, bead sequence, influencing factors [manganese/sulphur ratio, copper content, oxygen content, depth to width ratio of the weld, crack susceptibility); reheat cracking, definition, types of steels sensitive to reheat cracking, reheat cracking due to heat treatment, reheat cracking due to multi-pass welding

(AC4.5)
- **Dilution**: determine the amount of dilution in a weld deposit, factors affecting dilution, welding procedure, methods of reducing dilution, use of solid phase welding processes

Additional Guidance

- determine the amount of dilution in a weld deposit, factors affecting dilution, welding procedure (welding process, welding technique), methods of reducing dilution (buttering, control of heat input [including welding current {use of small electrodes at low current, allowing the work to cool between runs/layers, fast travel speed, avoiding the use of pre-heat (not always possible), careful selection of welding process}], use of solid phase welding processes

Learning outcome

The learner will:

5 Know how to determine the integrity of welded joints

Assessment criteria

The learner can:

5.1 classify the types of **weld defects** (EN 26520)

5.2 explain the application of **visual examination** methods to welded joints

5.3 explain the application of **penetrant testing** methods to welded joints

5.4 explain the application of **magnetic particle testing** methods to welded joints

5.5 explain the application of **radiography** methods to welded joints

5.6 explain the application of **ultrasonic testing** methods to welded joints

5.7 explain the application of **mechanical testing** methods to welded joints

5.8 explain the methods of **container testing.**

Range

(AC5.1)
- **Weld defects:** cracks (longitudinal, transverse, edge, HAZ, crater, centreline, fusion zone, underbead), lack of fusion (root, side wall, inter-run), porosity (scattered, cluster, isolated pore, root, blow holes, worm holes), piping (craters), solid inclusions (slag, copper, tungsten, oxide), lack of penetration, undercut, oxidation, excessive weld metal (including penetration), under fill, concavity, overlap, burn-through, possible causes, remedial action.

(AC5.2)
- **Visual examination:** applications, requirements (equipment, personnel) benefits, limitations.

(AC5.3)
- **Penetrant testing: dye,** fluorescent, test procedure, applications, equipment requirements, limitations.

(AC5.4)
- **Magnetic particle testing**: magnetic flow (types of magnet [horseshoe, yoke]), current flow (a.c. [skin effect], d.c., types of magnetisation [prods, bar, coil, tubular, kettle element]), test procedure, applications, equipment requirements, benefits, limitations.

(AC5.5)
- **Radiography:** sources of radiation (x-ray, gamma ray), principle, applications, equipment requirements, benefits, limitations, radiation hazards (effects of radiation on the human body, radiation monitoring, personal monitoring, radiation enclosures, precautions for site radiography), radiographic techniques (plate, pipe [single wall – single image {including panoramic}, double wall – single image, double wall – double image [ellipse, superimposed]).

(AC5.6)
- **Ultrasonic testing:** applications, procedure, applications, equipment requirements (ultrasonic testing set [cathode ray tube {oscilloscope}, controls, calibration], probes [normal, angle, probe index, selection criteria, beam spread, far zone, near zone, dead zone], leads, calibration blocks, couplant), benefits, limitations, techniques (thickness

testing, lamination testing, transmission method, reflection method), determination of geometry (beam angle, skip distance), procedures for reporting and recording flaws in welded components.

(AC5.7) • **Mechanical testing:** impact tests (izod, charpy), bend tests (root, face, side), tensile (determination of tensile strength, determination of yield stress, determination of percentage elongation, transverse, all weld metal, tensile/shear [application to lap joints, application to double lap joints]), fracture (nick break), macro examination (specimen preparation, magnification), micro examination (specimen preparation, magnification), hardness surveys (weld zone, HAZ, parent metal, location of indents, testing methods (Vickers, Brinell, Rockwell), testing of spot welded joints (peel test, tensile/shear, cross tensile, 'U' tensile, twist or torsion.

(AC5.8) • **Container testing:** hydraulic pressure, pneumatic pressure, by filling, by immersion, health and safety considerations.

Unit 325 Principles of fabrication

GLH:	80
Unit aim:	This unit enables the leaner to understand the underlying principles that apply to the selection of materials and mechanical joining processes used in fabrication, without focusing on specific fabrication disciplines. Included is fabrication materials, allowances for bending and rolling, the principles of shearing, joining using non-thermal methods and finishing

Learning outcome

The learner will:

1 Know how classify common materials used in fabrication engineering

Assessment criteria

The learner can:

1.1 critically compare **materials** from a range found in fabrication engineering

1.2 explain the commercial **forms of supply** of materials available

1.3 state the criteria used for the **selection** of materials for a given application

1.4 explain the different material **structures**

1.5 explain the variation in properties that result from different types of **metallic structures**

1.6 explain the requirements for the **heat treatment** of metals.

Range

(AC1.1)
- **Materials: -** metallic (low-carbon steel, low alloy steels, high yield steels, austenitic stainless steels, clad and coated materials [galvanised steel, tin plated steel, plastic coated steel, clad steels, anodised aluminium], aluminium/aluminium alloys, copper/copper alloys, titanium/ titanium alloys), polymers (thermoplastics, thermosetting), composites (glass fibre, carbon fibre, aramid fibre)

(AC1.2)
- **Forms of supply**: sheet, plate, section (RSJ, channel, column, beam, tee, angle (equal leg, unequal leg), hollow section (square, rectangular, round [tubular]), pipe, fibre reinforcing materials (FRP)

(AC1.3)
- **Selection** strength/weight ratio, resistant properties (heat, corrosion, wear), cost, weldability, formability, machinability, appearance, availability.

(AC1.4)
- **Structures: crystalline,** chain molecules, amorphous

(AC1.5) • **Metallic structures:** fine grained structure, coarse grained structure, effect of grain size upon working properties

(AC1.6) • **Heat treatment:** annealing (steels, stainless steels, non-ferrous metals), normalising of steels, hardening of steels, tempering of steels, precipitation hardening of aluminium alloys

---

Learning outcome

The learner will:

2 Know how to determine the bending and rolling allowances for fabricated forms and the principles of shearing

Assessment criteria

The learner can:

2.1 explain the **mechanics of bending**

2.2 define the term **neutral line**

2.3 explain the purpose of **bending allowances** and apply bending allowance formulas

2.4 explain the purpose of **rolling allowances** and apply rolling allowance formulas

2.5 calculate the included angle of patterns of right cones using formula

2.6 explain the **principles of shearing.**

Range

(AC2.1) • **Mechanics of bending**: tensile stresses, compressive stresses, neutral plane, spring back, compensation for spring back

(AC2.2) • **Neutral line:** principle, application to bending and rolling

(AC2.3) • **Bending allowances:** definition, radius of bend, application (thin sheet materials, thick plate materials, pipe, circular forms, 'U' bends, right-angle bends, non-right-angle bends, compound forms)

(AC2.4) • **Rolling allowances:** definitions (diameter of cylinder, length/height of cylinder, circumference of cylinder), application (circular cylinders, elliptical cylinders, taking into account material thickness, determination of the length of pre-setting required to avoid 'flats' when rolling

(AC2.6) • **Principles of shearing:** shear angle, rake angle, clearance, shearing action (area under shear, shear force required), mechanical advantage of lever system for hand-operated shears (bench, hand), principle of moments for lever system for hand-operated shears (bench, hand), piercing and blanking (area under shear, shear force required)

Learning outcome

The learner will:

3 Understand the difference between different non-thermal joining methods

Assessment criteria

The learner can:

3.1 classify **bolting** methods from a range found in fabrication engineering

3.2 classify **mechanical fastenings** applied to thin plate fabrication engineering

3.3 explain the reasons for and the methods available to protect metal surfaces prior to and after assembly

3.4 classify **joint configurations** from a range found in fabrication engineering

3.5 explain the **benefits of using jigs** and **fixtures**

3.6 explain the use of **adhesive bonding** in the joining of fabricated assemblies

3.7 calculate **joining allowances.**

Range

(AC3.1)
- **Bolting:** black bolts, high strength friction grip (HSFG), close tolerance bolts, fitted bolts, load indicating bolts, torshear, importance of cleanliness of contact surfaces, correct tensioning, hole diameters, tolerances and alignment of holes to produce satisfactory bolted connections

(AC3.2)
- **Mechanical fastenings:** bolts, captive nuts, studs, self-tapping screws, special thin plate fastenings, solid and tubular rivets, blind rivets (pop rivets)

(AC3.3)
- **Protect metals:** materials supplied with protective layers, preventing damage during fabrication and transportation. Protection against contamination, surface damage, corrosion and arcing during welding.

(AC3.4)
- **Joint configurations**: self secured, lap joints, flanged joints, thermal/mechanical bonded, grooved seams, double grooved seams, knocked up, panned down, slip joints, flexible joints, threaded joints

Addition Guidance
- Flexible joints: hinges, rubber, interface, universal joints, expansion joints, expansion Hoops

(AC3.5)
- **Benefits of using jigs and fixtures:** position of component(s), joint alignment, mass production/repetitive work, distortion control/dimensional accuracy, economy of operation

(AC3.6)
- **Adhesive bonding:** methods available (heat activated, solvent activated, impact activated), preparation of surfaces, applications, health and safety considerations

(AC3.7) • **Joining allowances:** self secured joints, joints joined by: riveting, bolting, adhesive bonding

---

Learning outcome

The learner will:

4 Understand different methods used for finishing fabricated components

Assessment criteria

The learner can:

4.1 explain the methods of removal of **surface contaminants** prior to finishing

4.2 explain the common **causes of corrosion** and degradation of common engineering materials

4.3 classify the methods of **corrosion prevention** or retardation commonly found in fabrication engineering

4.4 classify the **methods of application** for common surface coatings

4.5 evaluate the **merits and suitability** of purpose of the various surface preparations and protections.

Range

(AC4.1) • **Surface contaminants:** for: scale, oxide, slag, excessive build up and weld metal penetration, spatter

(AC4.2) • **Causes of corrosion:** oxidation of ferrous materials, direct chemical attack on metals, electrolytic corrosion, conditions and regions that can be conducive to corrosive activity (bi-metallic joints, immersed in aqueous solutions, adjacent to changes in grain structure [heavily worked material-stress corrosion], surface flaws, increased temperature

(AC4.3) • **Corrosion prevention:** painting, cladding with corrosion and/or heat resistant materials, cladding with plastics, metallic coatings, cathodic protection, anodic protection, fouling and anti-fouling coatings, corrosion inhibitors

(AC4.4) • **Methods of application:** painting (brush, dip, spray), metallic coatings (metal spraying, hot dip galvanising, electroplating)

(AC4.5) • **Merits and suitability**: cost, portability, functional effectiveness (influence upon: environmental performance, application of surface coatings, aesthetic appeal, material selection)

Unit 326 Advanced mathematics and science

GLH:	80
Unit aim:	This unit enables the leaner to develop the skills in and understanding of mathematics and science to facilitate progression onto awards that require a Level 3 mathematics and science component. It is primarily aimed at those leaners who wish to progress to higher education and has been applied to practical engineering principles of mathematics topics.

Learning outcome

The learner will:

1 Be able to perform calculation involving indices, logarithms and algebra

Assessment criteria

The learner can:

1.1 use **powers and roots** to solve problems

1.2 use **logarithms** to solve problems

1.3 use **number bases** to solve problems

1.4 use **algebra** to solve problems.

Range

(AC1.1)
- **Powers and roots:** meanings of the terms: base, index, power, root and reciproca a^0=1, a^(-n)=1/a n, a_n^1 =n√a, evaluate: a^m a^n,a^((n+m)),a^m/a^n,a^(m-n), (am)n,amn,am express decimal fractions in standard form, solve algebraic problems involving transposition of terms with indices

(AC1.2)
- **Logarithms:** define a logarithm as a power applied to a base number, logarithms to the base 10, logarithms to the base 'e' stating its application, logarithms to simplify calculations

(AC1.3)
- **Number bases:** application of binary and hexadecimal numbering systems in data transmission, storage and programming, calculations using binary and hexadecimal numbers, conversions of numbers between denary, binary and hexadecimal bases

(AC1.4)
- **Algebra:** algebraic and graphical methods to solve simultaneous and quadratic

equations, define the roots of an equation, simple arithmetic and geometric series, factorial notation for combinations and permutations

---

Learning outcome

The learner will:

2 Be able to perform calculations using trigonometry

Assessment criteria

The learner can:

2.1 perform calculations involving trigonometric ratios for the four quadrants

apply the Sine Rule (A/sina + B/sinb + C/sinc) to practical problems

2.3 apply the Cosine Rule (a2 = b2 + c2 – 2.b.ccosa) to practical problems

2.4 plot graphs of the functions $y = Rsin(t + \theta) and\ y = Rcos\ (t + \theta)$

2.5 perform calculations to solve problems involving **areas**

2.6 differentiate between different **trigonometric identities**

2.7 explain that a complex number is a combination of 'j' notation and a rational number

2.8 explain the graphical represent **vector quantities** and **polar quantities.**

Range

(AC2.5) • **Areas:** non right-angled triangles, angles between lines, true length of lines, true angle between planes

(AC2.6) • **Trigonometric identities:** Tan = Sin/Cos, Cot = 1/Tan, Sec= 1/Cos Cosec =1/Sin

(AC2.8) • **Vector quantities**: complex numbers, modulus, argument

(AC2.8) • **Polar quantities**: complex numbers, argand diagrams, rotating vector, polar to Cartesian form and vice-versa

---

Learning outcome

The learner will:

3 Be able to perform calculations using calculus

Assessment criteria

The learner can:

3.1 apply the rules of **differentiation**

3.2 apply Simpson's Rule to the calculation of areas of irregular sections

3.3 apply the rules of **integration**

3.4 perform calculations that apply differentiation to problems such as velocity and acceleration

3.5 perform calculations involving maxima and minima to determine the minimum material required to produce a regular-shaped square or circular container of maximum volume

3.6 perform calculations that apply integration to problems such as summation of irregular areas, volumes of revolution, centroid of area and second moment of area.

Range

(AC3.1)
- **Differentiation: products,** quotients, function of a function and algebraic expressions (polynomial expressions, exponential expressions, simple trigonometrical functions (Sin, Cos and Tan only)), calculations involving a second derivative

(AC3.3)
- **Integration:** polynomial expressions, exponential expressions, simple Trigonometric functions, integration by substitution, integration by parts

---

Learning outcome

The learner will:

4 Be able to perform calculations involving statistics

Assessment criteria

The learner can:

4.1 calculate the **mean and standard deviation** for a sample of engineering components

4.2 perform estimates of failure rates of engineering artefacts or systems

4.3 define probability

4.4 define dependent and independent events, addition and multiplication laws of probability, permutations and combinations applied to probability, normal probability distribution, confidence limits and statistical testing.

Range

(AC4.1)
- **Mean and standard deviation:** gather and collate data from various sources and solve problems involving: frequency distributions (mean, median, mode, standard deviation), extrapolated data, interpolated data, use a calculator to perform statistical calculations

Learning outcome

The learner will:

5 Be able to perform tests to determine stress, strain and elasticity of materials

Assessment criteria

The learner can:

5.1 perform **tensile tests** on a range of materials and determine Young's Modulus for each material

5.2 perform **shearing tests** and determine the modulus of rigidity of materials.

Range

(AC5.1)
- **Tensile tests:** direct stress, direct strain, elastic limit, yield stress, tensile strength breaking point, Modulus of Elasticity, factor of safety, calculations comparing the properties of different materials

(AC5.2)
- **Shearing tests**: shear stress, shear strain, Modulus of Rigidity, Poisson's ratio, calculations comparing the properties of different materials

Learning outcome

The learner will:

6 Be able to solve problems involving kinematics

Assessment criteria

The learner can:

6.1 define **velocity and acceleration**

6.2 solve practical problems involving bodies in **linear motion** and trajectories

6.3 use **vector diagrams** to determine achieved tracks and relative velocities.

Range

(AC6.1)
- **Velocity and acceleration:** velocity as a vector quantity that is the rate of change of distance with respect to time, area under a velocity/time curve represents the distance travelled, acceleration is the rate of change of velocity with time, area under and acceleration/time curve represents velocity

(AC6.2)
- **Linear motion**: solve problems for linear and rotary motion both graphically and using the formulae

(AC6.3)
- **Vector diagrams**: velocities of bodies subjected to linear motion (ships in tides, aircraft in winds)

Learning outcome

The learner will:

7 Be able to solve problems involving dynamics

Assessment criteria

The learner can:

7.1 explain Newton's Laws of Motion

7.2 define the acceleration due to gravity as 9.81 ms-2

7.3 define that 1 newton is the force required to accelerate a mass of 1 kg at the rate of 1 ms-2

7.4 solve practical problems involving accelerating/decelerating masses both graphically and using the formulae f = ma

7.5 define momentum as the product of mass and velocity

7.6 solve practical problems involving colliding bodies by calculation

7.7 use calculations to find the moment of inertia of disks and rimmed flywheels

7.8 define radius of gyration

7.9 define potential energy and solve practical problems involving P.E = mgh

7.10 explain the relationship between work done in raising a body to potential energy

7.11 define linear and angular kinetic energy in terms of (mv2)/2 and (m2w2)/2

7.12 solve energy conversion problems both graphically and using formulae

7.13 solve problems associated with stored energy both graphically and using the formula SE = 1/2fx.

Learning outcome

The learner will:

8 Be able to solve problems involving bending beams

Assessment criteria

The learner can:

8.1 construct shear force and bending moment diagrams for simply supported beams and cantilevers

8.2 perform calculations to determine **maximum bending moments**

8.3 define units of second moment of area as m4

8.4 solve problems associated with the stresses produced in bending beams

8.5 compare the resistance in bending of tee, 'I' and channel beam cross-sections.

Range

(AC8.2) • **Maximum bending moments**: point loads, uniformly distributed loads, combinations of point and uniformly distributed loads, identify points of contra flexure, assumptions made in calculating stress due to bending

Learning outcome

The learner will:

9 Be able to solve problems involving fluids

Assessment criteria

The learner can:

9.1 define **Boyle's law**

9.2 define **Charles' law**

9.3 define the combined gas laws

9.4 solve practical **gas law problems** by calculation

9.5 solve practical **fluid flow rate** problems by calculation.

Range

(AC9.1) • **Boyle's law:** at constant temperature, the volume of a given mass of gas is inversely proportional to its pressure

(AC9.2) • **Charles' law:** at constant pressure, the volume of the gas is directly proportional to absolute temperature.

(AC9.4) • **Gas law problems**: Boyle's law, Charles' law, combined gas laws

(AC9.5) • **Fluid flow problems**: velocity of flow, volume flow rate, mass flow rate, continuity equation for an incompressible liquid

Learning outcome

The learner will:

10 Be able to demonstrate the effects of electromagnetism and alternating current

Assessment criteria

The learner can:

10.1 demonstrate the effect of a magnetic field on a current carrying conductor

10.2 demonstrate the effect of a magnetic field on a moving conductor

10.3 apply Fleming's Left-hand Rule to establish the direction of the force on a current flowing at right angles to the direction of a magnetic field

10.4 perform calculations to determine the magnitude of the force on a current flowing at right angles to a magnetic field using the formula F = B.I./

10.5 explain the practical applications of **force exerted on a current in a magnetic field**

10.6 define **Faraday's law** of electromagnetic induction

10.7 explain the practical applications of **electromagnetic induction.**

Range

(AC10.5) • **Force exerted on a current in a magnetic field:** electric motor, moving coil loudspeaker

(AC10.6) • **Faraday's law:** effect of moving a conductor across a magnetic field, calculating the value of an induced E.M.F.

(AC10.7) • **Electromagnetic induction**: electric generator, eddy-current brake, method of generating an alternating electro-motive force (emf), sketch the graph of instantaneous conductor emf against angular position of coil, define the period and frequency of an alternating current.

Unit 327 Marine internal combustion engines theory and maintenance

GLH:	145
Unit aim:	This unit is concerned with identifying the principles of Submarine Diesel Internal Combustion engines. It will necessitate identifying and understanding the function, construction and operation of engine and system components. It will cover the procedures and techniques involved with safely isolating systems, removing and replacing components, restoring a system back to a full working condition and the selection of appropriate tools and equipment for carrying out the required maintenance. The unit will also include identification of engine problems with suggested remedial actions.

Learning outcome

The learner will:

1 Know the components and features of submarine internal combustion engines and associated systems

Assessment criteria

The learner can:

1.1 describe the **hazards and safety precautions** associated with the operations and maintenance of a diesel engine.

1.2 explain the **principles of operation** of internal combustion engines

1.3 describe the **construction and function** of submarine diesel engines

1.4 describe the construction and function of **associated auxiliary systems** with submarine diesel engines.

1.5 explain the requirements for **shock and vibration mountings** fitted

1.6 explain the construction and operation of **diesel engine governing arrangements.**

1.7 describe the operation and construction of submarine diesel engine **mechanical over speed trips and mechanical supercharger** and air induction system.

Range

(AC1.1)
- **Hazards and safety precautions:** fire, mechanical, electrical, fluid, gas, noise, tag out system and ventilation.

(AC1.2)
- **Principles of operation**: combustion requirements/process, engine terminology, compression ratio formula, types of submarine diesel engine in use

(AC1.3) • **Construction and function**: crankcase and crankshafts, cylinder liners, pistons, rings and connecting rods, cylinder heads,

(AC1.4) • **Associated auxiliary systems**: lubricating oil systems, fresh and salt water systems, air start system, fuel system

(AC1.5) • **Shock and vibration mountings**: types, function, classification, purpose of vibration/shock mounts, deterioration, protection and failures, routine for mount change, fitting and inspection of resilient mounts, flexible pipes and bellow

(AC1.6) • **Diesel engine governing arrangements:** function and types of governors, generator requirements/principles, construction and function of major components

(AC1.7) • **Mechanical over speed trips and mechanical supercharger**: methods of control function of major components associated with over speed trips and superchargers

---

Learning outcome

The learner will:

2 Understand the remedial actions for selected diesel engine problems

Assessment criteria

The learner can:

2.1 identify the causes of **common observed symptoms** related to diesel engines

2.2 explain possible **engine deterioration or defects** from variations in the recorded readings

2.3 describe different types of fault diagnosis on diesel engines.

Range

(AC2.1) • **Common observed symptoms:** engine start problems/slow cranking speed, engine turns but does not fire, engine oil pressure problems, engine oil, coolant and exhaust temperature problems, engine speed problems

(AC2.2) • **Engine deterioration or defects:** fuel consumption problems; exhaust/lubricating oil temperature variations, coolant/oil level variations

Learning outcome

The learner will:

3 Understand types of maintenance carried out on internal combustion engines and associated systems

Assessment criteria

The learner can:

3.1 describe the removal and replacement of submarine **diesel cylinder heads**

3.2 describe the liner wear and the **procedure for measuring wear**, identifying any special tools used.

3.3 describe the methods and equipment available for taking and recording a **set of crankshaft deflections.**

3.4 describe **removal of air start motor**

3.5 describe **oil and coolant testing**

3.6 describe inspection of a submarine **mechanical supercharger and diesel engine governor**

3.7 describe **basic timing and the use of the dummy injector**

3.8 explain **tests on an engine fuel injector**

3.9 describe the **removal and replacement of pistons, rings and connecting rods and bearings**

3.10 describe maintenance requirements of **Diesel Generator (DG) exhaust system and valves**

3.11 explain operations and adjustments of the **Teddington series watch keeping panel**

3.12 explain the principles and limitations of conducting a **diesel engine performance trial**

3.13 explain the effects and hazards of running **diesel engines under various load and ambient conditions.**

3.14 describe basic engine **documentation for record and reference.**

Range

(AC3.1) • **Diesel cylinder heads:** special tools, bumping clearance, setting tappets, removal pre-requisites, lifting devices/storage, procedure removal/replacement and inspections.

(AC3.2) • **Procedure for measuring wear**: sources of wear – internal/external, methods of reducing wear measurement/special tools

(AC3.3) • **Recording a set of crankshaft deflections**: causes of excessive deflections, pre-requisites/procedure and limits.

(AC3.4) • **Removal of air start motor**: precautions when removing and all HP air hazards associated with removal of components.

(AC3.5) • **Oil and coolant testing:** reasons for testing, procedures, limits, how to record readings

(AC3.6) • **Mechanical supercharger and diesel engine governor:** oil levels/filters, system venting, data recorded, function, design, types, construction

(AC3.7) • **Basic timing and the use of the dummy injector**: camshaft purpose, material and construction, definitions and terminology, timing diagrams, Identify/positioning of timing or datum cylinder, procedures.

(AC3.8) • **Tests on an engine fuel injector:** purpose, precautions/warnings, spill timing, linkages, Valenta fuel pump timing, injector tests, and Quality Assurance procedures

(AC3.9) • **Removal and replacement of pistons, rings and connecting rods and bearings:** Precautions, special tools required, procedures for removal and replacement

(AC3.10) • **Diesel Generator (DG) exhaust system:** precautions exhaust manifold and fittings and valve grinding

(AC3.11) • **Teddington series watch keeping panel:** Channel select/accept and reset/displays, simulator test, numeric display, system status, Keyboard/normal/update key, use of function codes, changing set points

(AC3.12) • **Diesel engine performance trial:** Maintenance effecting performance, calculations of power output, reasons for/and periodicity of performance trials, pre-requisites and procedures, recording limits and parameters.

(AC3.13) • **Diesel engines under various load and ambient conditions:** warnings, definitions and conditions, defects and data recorded.

(AC3.14) • **Documentation for record and reference:** diesel engine logbook, related documentation. Identify diesel authorities and service providers, procedures for carrying out maintenance and repair, diesel operation, test and trials, Health &Safety.

Unit 328 Marine Mechanical System and Equipment Maintenance

GLH:	52
Unit aim:	To highlight and explain the principles of maintenance of associated marine system equipment to enable engineering activities to be carried out prior to, during and after the operation of these systems. It will necessitate an understanding of the precautions, procedures and principles to be considered whilst carry out practical maintenance tasks. It will consider planning maintenance tasks, safety precautions, use of specialist tools, procedures and techniques involved with specific equipment maintenance, testing and fault diagnosis.

Learning outcome

The learner will:

1 Understand safety matters, precautions, procedures and principles to be considered whilst carrying out specified practical maintenance tasks.

Assessment criteria

The learner can:

1.1 explain the **principles** to be considered when planning a maintenance task.

1.2 explain the **safety precautions** to be followed when using a range of hazardous materials.

1.3 explain the use of a range of **specialised tools**

1.4 describe the procedure for taking **wear down readings** and changing of a journal bearing.

1.5 explain the **methods of aligning** of flanges/ pipe-work - order of tightening

1.6 explain making and use of joints

1.7 describe visual **Non Destructive Examination** (NDE)/Non Destructive Testing (NDT) techniques.

1.8 describe **major maintenance** items carried out whilst docked down.

Range

(AC1.1)

- **Principles**: equipment availability, permission, spares/tools required, Tag out system, opening/refitting/closing procedure, removal routes, personnel required, specialist skill, knowledge, reference books/manuals, estimate time for maintenance task.

(AC1.2) • **Safety precautions:** Health and Safety at Work, Control of Substances Hazardous to Health (COSHH), Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).

(AC1.3) • **Specialised tools:** torque wrenches, valve seat cutting gear, helicoil set, extractors, GO/NOGO gauges, stretch gauges.

(AC1.4) • **Wear down readings:** poker gauge, wear down micrometers, Bridge gauges, micrometers, plastiguage results hygiene

(AC1.5) • **Methods of aligning:** reasons for use, making joints, order of tightening, types of joints.

(AC1.7) • **Non Destructive Examination:** the requirement and application of NDE/NDT, the visual equipment used in the performance of maintenance, the procedures for crack detection (dye penetrant, handling ardrox, magnetic particle, eddy current), the methods of ultrasonic leak and flaw detection

(AC1.8) • **Major maintenance:** Out to in testing (reasons for test, test requirements, Depth Dependent System Test Pressure (DDSTP)), PMS surveys carried out whilst docked down (surveys required iaw PMS, pressure hull penetrations), purpose, methods & acceptance standards for hydrostatic pressure testing (purpose testing, method of testing, acceptance of standards).

Learning outcome

The learner will:

2 Understand planned and corrective maintenance procedures on a selection of mechanical marine system equipment.

Assessment criteria

The learner can:

2.1 describe the **terminology associated** with pumps and the factors affecting the selection of a pump

2.2 describe the types of **dynamic and positive** displacement pumps used and their **construction/operation**

2.3 describe the function, requirements and fitting of a **rotary pump seal**

2.4 describe the balance arrangements and the **typical maintenance** for in service pumps

2.5 describe the different types of resilient mounts

2.6 describe **inspections and maintenance** procedures.

2.7 describe the **construction and operation** of the major components of a **High Pressure Air Compressor (HPAC)**

2.8 describe **the hazards and safety procedures** to be observed when carrying out maintenance routines

2.9 describe the routine for **removal, inspection,** refitting/replacement of major Component and re-commissioning/setting to **work of High Pressure Air Compressor (HPAC**)

2.10 **describe heat exchanger design** considerations and the job of detecting and repairing leaks, including the safety precautions, maintenance procedures and how to **set to work** with functionally test.

Range

(AC2.1) • **Factors**: discharge/suction conditions, control, size, weight, fluid to be pumped, prime

(AC2.1) • **Mover Terminology associated:** suction lift/delivery/friction/static/velocity/total head suction lift Learning outcome

(AC2.2) • **Dynamic & positive:** reciprocating, rotary

(AC2.2) • **Construction/operation:** gearwheel, screw, mono, lobe, vane, screw, imo pump, radial/axial piston, types of dynamic displacement pump (centrifugal volute casing, diffuser ring, axial flow).

(AC2.3) • **Rotary pump seal:** requirement/fitting, list the various types of seals used, construction, materials, operation and applications of common seals used.

(AC2.4) • **Typical maintenance:** approach for maintaining displacement pumps, safety precautions and procedures, use of specialist tools, removal and refitting of bearing, removal/refit of rotating element seals, removal/refit pump sealing rings, dimensional checks using di charts, joint making process, maintaining pump mountings, alignment (between driving and driven units) process, the calibration of instrumentation, test and set to work procedure, Balance arrangements: Thrust, motion, counteracting, preventing (eye to eye/back to back, weight balance, area reduction, balance piston) resilient mounts: J mounts, L mounts, M mounts, X mounts, P&D mounts

(AC2.6) • **Inspections & maintenance:** conditions, contamination, movement, specialist paint, Heat and oil shields, tag-out, jack up, change restrictions, retighten, settling time, check alignment, decelerators, check clearances, correct securing arrangements, deflection checks

(AC2.7) • .**(HPAC):** High Pressure Air Compressor (HPAC)

(AC2.7) • **Construction and operation:** Operation, control and monitoring, construction of major components

(AC2.8) • **Hazards and safety procedures:** working with HP air- precautions, HP air isolations, compressor safety.

(AC2.9) • **Removal, inspection:** stage valve assemblies, back pressure maintaining valve, drive systems, mechanical lubrication systems, AC oil pump, relief valves.

(AC2.9) • **Work of HPAC:** safety, pre-requisites, commissioning.

(AC2.10) • **Heat exchanger design :** tube materials, design considerations, advantages of Titanium

(AC2.10) • **Maintenance procedures:** cleaning/ blowing heat exchangers (equipment, cleaning techniques, mechanical/chemical cleaning), leak detection process (fluorescein dye, pressure testing, leak detection, ultra-sonic), repair procedures (plugging, 10% rule, replacement), replace/remake joints for flanged surfaces.

(AC2.10) • **Set to work:** checks, functional/final checks.

Learning outcome

The learner will:

3 Understand vibration analysis on running machinery.

Assessment criteria

The learner can:

3.1 explain the reasons for **Condition Monitoring** (CM) and Condition Based Maintenance (CBM)

3.2 explain where **vibration limits** are found

3.3 **define vibration** and their units.

3.4 explain how **monitoring positions** are identified

3.5 explain how to **configure** condition monitoring test equipment

3.6 use **configure** condition monitoring test equipment

3.7 define the form used to record a fault or defect.

Range

(AC3.1) • **Condition monitoring**: To monitor a machines condition, to anticipate machinery failure, to assess and control the amount of noise and vibration passed to the ship's hull, as a quality control function, to detect and identify faults in a machine.

(AC3.2) • **Vibration limits:** Machinery BR (Book of reference), Manufacturers Handbook, Vibration severity charts, Baseline or Base level readings.

(AC3.3) • **Definitions of vibration**: Displacement (Microns), Peak velocity (mm/sec), Peak acceleration (G (Gravity)), Frequency (CPM (Cycles per minute)), Amplitude (None (It is just a number)), Spike energy (GSE).

(AC3.4) • **Monitoring positions**: Markings (salmon pink triangle), direction of positions marked.

(AC3.5) • **Configure** connecting, selecting, downloading, reconnecting, uploading, and reviewing**.**

Unit 329 Fitting and machining

GLH:	300
Unit aim:	This unit is concerned with the knowledge that sits behind the use of hand, bench, portable tools and machining by turning and milling to manufacture components made to drawings and from a variety of materials. The unit includes uses and limitations of fitting/machining processes, marking out techniques, measuring to a predetermined accuracy and hand thread production. It also covers the processes required and safe working practices to complete the machining operations.

Learning outcome

The learner will:

1 Understand the use of hand, bench and portable tools applicable to the fitting trade.

Assessment criteria

The learner can:

1.1 identify the **hazards and precautions** present in the fitting and machine workshop environment

1.2 explain how to overcome hazards present in the fitting and machine workshop environment

1.3 identify the **tools, materials and techniques** used to mark out components/materials in the machine or fitting shop

1.4 describe the uses, maintenance and limitations of a specified **range of hand tools**

1.5 describe principles of measurement

1.6 use a range of **measuring instruments** to a pre-determined accurac

1.7 explain the **purpose of cutting compounds** used in hand and machine processes

1.8 explain the construction, maintenance, uses and limitation of a specified range of **hand thread production/repai**r equipment and techniques

1.9 mark out materials to be used in manufacture of required items to the required specifications.

Range

(AC1.1)
- **Hazards and precautions:** centre lathes, grinders and hand tools. Overcome by following personal safety, machine safety, COSHH

(AC1.3)
- **Tools, materials and techniques:** marking off table or suitable sized surface plate, rule stand, scriber, engineers try square, scribing block/surface gauge, angle plates, parallel

strips, dividers, trammels, odd leg or hermaphrodite callipers, combination set v blocks, marking out, material preparation, datum points, measuring equipment

(AC1.4) • **Range of hand tools:** maintenance and limitations (chisels, files, hammers, scrapers, hacksaws).

(AC1.6) • **Measuring instruments:** micrometers, Vernier scales, dials test indicators, accuracy, Tolerances

(AC1.7) • **Purpose of cutting compounds:** specific hazards and precautions, heat dissipation, lubrication, other compounds, main functions

(AC1.8) • **Hand thread production/repair:** specific hazards and precautions, die nuts, stocks and dies, taps and wrenches, thread inserts, thread files, limitations of hand produced/repaired threads.

Learning outcome

The learner will:

2 Understand how to manufacture components using machining processes.

Assessment criteria

The learner can:

2.1 explain the principles of cutting metal with **single point hand and machine tools**

2.2 explain the use and limitations of **power drilling machines and drill bits**

2.3 explain the uses and limitations of the **standard centre lathe**

2.4 describe the production of **screw threads** on a centre lathe

2.5 explain the processes **for carrying out practical tasks.**

Range

(AC2.1) • **Single point hand and machine tools:** cutting actions, tool angles, cutting forces, state when chip breakers will be used, tool profiles and applications, speeds and feeds, tipped tools

(AC2.2) • **Power drilling machines and drill bits:** safety, work/tool bit security, drill bits and uses, limitations of bench drills, capacity of radial arm drill, speed and feed calculations, accuracy of hole size/position, reamers and reaming.

(AC2.3) • **Standard centre lathe:** hazards and safety, types of cutting tool, uses and limitations of between centres work holding, chucks, plate, taper turning methods, machine calculations, off-set turning

(AC2.4) • **Screw threads:** direct approach, angular approach, single/multi start, right or left hand, thread indicator dial, imperia//metric thread, procedure, calculations

(AC2.5)

- **Carry out practical tasks:** safety, selection of tools, marking out processes, tolerances, procedures/sequences, fitting, drilling, centre lathe processes, shafts/taper shafts, knurling, spindles, flanged nuts, collets, flanged drilling, sleeve/pulley, milling process, setups, and sequence of operations.

Unit 330 Welding and pipe work processes

GLH:	303
Unit aim:	This unit is concerned with the technology and practices involved in the application of welding and pipe work processes. The unit is broadly divided into manufacture and repair of pipe work/flanges, welding and burning processes, which involve safety aspects, preparation of equipment, welding processes, which include, gas, manual metal arc, metal inert gas and tungsten inert gas techniques and finally post hot work testing.

Learning outcome

The learner will:

1 Understand how to manufacture and repair pipe work, flanges and plate in support of defect rectification or damage.

Assessment criteria

The learner can:

1.1 describe the **hazards associated with gas heating** equipment and the precautions taken to overcome them

1.2 explain the uses, preparations and limitations of **oxy-acetylene equipment** for gas heating

1.3 explain the uses, preparations and limitations of **sievert propane equipment** for heating

1.4 explain the **metal joining process** of using an alloy of lower melting point than the parent metal

1.5 describe the methods used when taking **a template wire**, its representation and limitations.

1.6 produce a full scale drawing to aid the manufacture of wire template.

1.7 manufacture template wires

1.8 identify pipe flanges and fittings

1.9 describe the need for **heat treatment** and the temperatures required

1.10 describe the **requirements for a filler media** when bending pipes and the different fillers used and their limitations

1.11 describe **pipe bending methods** and their tolerances, features of pipe flanges and pipe work fittings

1.12 describe **silver solder techniques**

1.13 explain the **pressure testing process.**

Range

(AC1.1) • **Hazards associated with gas heating:** Fire, gasses, light emission, fumes, enclosed vessel/systems, protective equipment

(AC1.2) • **Oxy-acetylene equipment:** regulations, cylinders, regulators, hoses, flashback, arrestors, blowpipe, nozzles, flame/flame defects

(AC1.3) • **Sievert propane equipment:** feature, propane torch, regulator

(AC1.4) • **Metal joining process:** requirements, bonding process, filler requirements, excess heat, fluxes, capillary/non capillary joints, soft soldering, low temperature brazing

(AC1.5) • **A template wire:** template wires, methods, template wire and pipe bend names

(AC1.9) • **Heat treatment:** annealing and stress relieving, temperatures

(AC1.10) • **Requirements for a filler media:** requirements and filler material

(AC1.11) • **Pipe bending methods:** types of bend, compression, press, draw, hand bending tolerances, local correction of bends, distinguishing features of pipe flanges and pipe work fittings, single/double bore flanges, pipe fittings, bosses, union connectors, pipe bending processes, compression, draw, press.

(AC1.11) • **Pipework:** Compression, draw and press, bending machines, annealing process, stress relieving treatment, braze welding, patch repair to pipe work.

(AC1.12) • **Silver solder techniques:** solder/flux used, heat application, ventilation, cleanliness

(AC1.13) • **Pressure testing process:** blanks, fill/vent pipe, connect pump, pressurise, check for leaks.

Learning outcome

The learner will:

2 Understand how to produce welded joints using a variety of welding processes.

Assessment criteria

The learner can:

2.1 identify the **hazards and precautions** associated with welding processes

2.2 describe the uses, techniques and limitations of **the welding process**

2.3 explain **welding preparation, process and techniques**

2.4 describe the **manual metal arc (MMA) welding process**

2.5 prepare equipment for welding processes

2.6 describe the **cutting and flame gouging process** for mild steel plate up to 15mm in thickness.

Range

(AC2.1)
- **Hazards and precautions:** Fires, gases, light emission, fumes, enclosed vessels/systems prevention of fire, protective equipment.

(AC2.2)
- **The welding process**: Heat source, flame types and uses, filler rods and fluxes, joint , design and preparation, regulations, cylinders, hoses, flashback arrestor, nozzles, the flame, welding terminology, flame defects, welding faults, stresses and distortion in welding.

(AC2.3)
- **Welding preparation, process and techniques:** specific safety precautions, protective clothing, assemble/prepare equipment, welding flame, stress distortion, welding parameters, techniques, leftward, rightward, welding practice requirements, weld types – butt, fillet, lap, open corner, welding positions – downward, horizontal vertical, vertical, overhead.

(AC2.4)
- **Manual metal arc (MMA) welding process:** specific safety precautions, weldability, electric arc process, types of welding supply and set up, electrodes, welding positions, joints, welding terminology, welding faults, welding , symbols, equipment set up, transformer, leads – supply, return, earth, electrode holder and lead, work piece preparation, parameters, effect of incorrect preps.

(AC2.6)
- **Cutting and flame gouging process:** principles of gas cutting, fuel gasses for cutting, cutting blowpipe, effects of incorrect parameters, machine cutting, flame gouging, equipment assembly, pug cutter assembly and techniques.

Learning outcome

The learner will:

3 Understand how to carry out post hot work procedures.

Assessment criteria

The learner can:

3.1 describe the **equipment set up, process principles** for dye penetrant testing

3.2 explain how to complete the **Welding Inspection Report**

3.3 describe procedure **for cleaning and securing.**

Range

(AC3.1)
- **Equipment set up, process principles:** dedicated area – ventilated booth, protective clothing, dye penetrant materials, COSHH regulations. Pre clean test piece, application/removal of penetrant, application of developer, inspection/post

(AC3.2)
- **Welding Inspection Report:** types of process, material, joint, weld procedure, welders identification (name), inspection procedure, defects found/acceptance or rejection (standard)/corrective actions

(AC3.3)
- **Cleaning and securing testing area:** secure equipment, cleaner, dye penetrant, developer, secure storage locker, COSHH regulations, Secure area, cleaning area , disposal of cleaning material and consumables, designated receptacles, isolation of power supply for ventilation

Unit 331 Electrical and electronic cable maintenance and repair

GLH:	138
Unit aim:	This unit involves the knowledge that sits behind the manufacture/repair of electrical components to assist in defect rectification and battle damage repair. It will necessitate an understanding of soldering techniques, cable jointing /termination processes, maintenance and testing of a range of electrical and electronic devices. It will also necessitate an understanding of the precautions, procedures and principles to be considered whilst carrying out practical maintenance tasks.

Learning outcome

The learner will:

1 Know how to produce a wire loom to a given specification using approved techniques and cable banding.

Assessment criteria

The learner can:

1.1 describe the **operational requirements** and special precautions applicable to cables

1.2 describe **cable crimping** and user control tests

1.3 identify **types of taper pins and blocks**, insertion, testing and extraction methods.

1.4 explain **heat shrinking processes**

1.5 identify the procedures involved in **production of a wire loom**, incorporating crimped terminations and heat shrink processes

1.6 carry out **cable banding process** describing associated safety precautions

1.7 manufacture a wire loom incorporating crimp terminations and heat shrinking processes.

Range

(AC1.1)
- **Operational requirements:** consider environmental considerations; identify materials conductors and insulators, special precautions, construction of cables, current carrying capacity.

(AC1.2)
- **Cable crimping:** cable sizing/penetration, development of terminations, selection of terminations/crimp tools, cable doubling.

(AC1.2) • **User**: post crimp checks, crimping go/no go gauges

(AC1.3) • **Types of taper pins and blocks**: 4 types of pins, 2 types of blocks, specialist insertion/extraction tool and testing tool.

(AC1.4) • **Heat shrinking processes:** applications for process, materials, thermo guns.

(AC1.5) • **Production of a wire loom:** work quality, procedures, selection of cable size, heat shrink sleeving, terminations to be used.

(AC1.6) • **Cable banding process:** face and hand protection, banding seal seating, protection of cable insulation, correct use of machine.

Learning outcome

The learner will:

2 Know how to carry out cable jointing and cable termination using approved methods.

Assessment criteria

The learner can:

2.1 describe the **types of electro-magnetic** interference
2.2 explain methods of electro-magnetic **interference suppression**
2.3 explain cable jointing using the **emergency cable repair kit**
2.4 explain the **operation and application** of a polyweld kit
2.5 describe the various parts and **types of connectors**
2.6 Describe the **construction** of high density connectors
2.7 describe **methods of contact retention**
2.8 describe **methods of polarisation**
2.9 describe the **range of cables used** with 608 type connectors
2.10 explain the **method of terminating screens** and the requirements for over sleeving
2.11 describe the **tests carried out on 608 type** connectors
2.12 explain the **cable termination process.**

Range

(AC2.1) • **Types of electro-magnetic:** direct/conducted, natural/man made, sources of interference

(AC2.2) • **Interference suppression:** cable separation, filtering, screening

(AC2.3) • **Emergency cable repair kit:** cable orientation, preparation of cable end.

(AC2.4) • **Operation and application**: tools, process

(AC2.5) • **Types of connectors:** shape, method of attachment /retention.

(AC2.6) • **Construction:** contact housing, front outlet, accessory kit, rear outlet.

(AC2.7) • **Methods of contact retention**: springs in rubber insert, tool kits.

(AC2.8) • **Methods of polarisation:** master keyway, insert orientation/polarisation.

(AC2.9) • **Range of cables used:** preferred cable list.

(AC2.10) • **Method of terminating screens:** collectively/individually screened, oversleeving

(AC2.11) • **Tests carried out on 608 type:** Test Set 531-9694

(AC2.12) • **Cable termination:** cable identification, cable preparation.

Learning outcome

The learner will:

3 Understand soldering techniques in use in a variety of practical applications.

Assessment criteria

The learner can:

3.1 explain the **procedure and precautions** to be observed when using pace sensa-temp soldering irons, Printed Circuit Boards (PCB), heat shunt and de-soldering

3.2 describe the precautions to be observed when using **veroboard and semi-conductor** devices

3.3 identify the **operation of a latching** touch switch

3.4 describe the correct method for **assembling components** on a Printed Circuit Board (PCB)

3.5 Explain the **problems associated with heat** dissipation through copper strip with respect to PCBs

3.6 describe advantages and disadvantages of PCBs

3.7 describe **methods of assembling and testing** an electronic device.

Range

(AC3.1) • **Procedure and precautions:** correct soldering techniques, smooth bright surface, solder feathered out, no pits and spikes, correct tools, forming wire and components, use of soldering iron, de-solder tool/braid, solder, flux.

(AC3.2) • **Veroboard and semi-conductor:** handling, component and wire mounting, cleaning, heat hunts/sufficient heat.

(AC3.3) • **Operation of a latching**: orientation of components, bi-stable operation, resistor colour code, safety precautions.

(AC3.4)

- **Assembling components:** component mounting, advantages/disadvantages of PCBs

(AC3.5)
- **Problems associated with heat:** common Electro Static Sensitive Devices (ESSDs), handling of ESSDs, advantages/disadvantage

(AC3.7)
- **Methods of assembling and testing:** safety precautions see 4a, 5a, b, integrated circuit testing, use of test equipment, fault diagnosis.

Learning outcome

The learner will:

4 Understand stripping, maintenance, assembly and testing on a range of electrical and electronic devices and assemblies.

Assessment criteria

The learner can:

4.1 describe the function of the **electro-magnetic release** over current device

4.2 describe methods of **dismantling an electro-magnetic** device

4.3 explain the **functional tests** and Electro-Magnetic Release (EMR) test rig operation

4.4 explain electro-magnetic release **maintenance processes**

4.5 identify types of **electro-static sensitive devices** (ESSDs) in use and the procedures and precautions to be taken when handling them

4.6 explain the **assembly and test procedure** of an electronic device.

Range

(AC4.1)
- **Electro-magnetic release: requirements, discrimination**

(AC4.2)
- **Dismantling an electro-magnetic:** precautions produce drawings during dismantling, layout of components, labelling, checks, use of tools.

(AC4.3)
- **Functional tests**: EMR test rig, mechanical/electrical checks.

(AC4.4)
- **Maintenance processes:** strip, inspect clean (functional tests, procedure), re-assemble process (reference to dismantle notes, sequence of assembly, functional checks), adjust and functionally test (safety precautions)

(AC4.5)
- **Electro-static sensitive devices:** definition**.**

(AC4.6)
- **Assembly and test procedure:** safety precautions, soldering techniques, component mounting, handling ESSDs, work quality, test equipment/circuit testing, fault diagnosis.

Unit 332 Electrical submarine systems equipment maintenance

GLH:	134
Unit aim:	This unit is concerned with the maintenance, testing and fault diagnosis of electrical marine systems equipment. It will necessitate an understanding of the electrical machine principles, a study of the functions, construction and operations of the equipment. It will cover the safety precautions, procedures and techniques involved with equipment maintenance, testing and fault diagnosis.

Learning outcome

The learner will:

1 Understand maintenance and fault diagnosis on hull and ship system equipment

Assessment criteria

The learner can:

1.1 explain the **safety procedures and hazards** associated with the maintenance of electrical machines.

1.2 describe the **tests and precautions** necessary when servicing private and portable electrical equipment including fixed installation testing tests

1.3 explain the operation of various equipment using the appropriate **circuit diagrams**

1.4 describe the **Electricity at Work Regulations**.

Range

(AC1.1)
- **Safety procedures and hazards:** electric shock/danger to life, prevention/treatment of shock, earthing of equipment, tag out system, precautions when working on live equipment.

(AC1.2)
- **Tests and precautions:** types of test, equipment log, insulation/continuity checks – values, typical defects, organisation required for testing, periodic inspections.

(AC1.3)
- **Circuit diagrams:** fire detection systems, construction and operation of Cathodic protection system, construction and operation of galley and laundry equipment.

(AC1.4)
- **Electricity at Work Regulations:** the requirement for teaching the regulations, which regulations are applicable and how compliance is achieved.

Learning outcome

The learner will:

2 Understand maintenance and fault diagnosis on Alternating Current (a.c) machines, motors and starters.

Assessment criteria

The learner can:

2.1 describe the construction and **main components** of an Alternating Current (a.c) motor

2.2 explain the **operation of a 3-phase a.c motor**

2.3 explain the use of **test equipment** to carry out maintenance routines.

2.4 explain the **process of fuse selection** and the effects of single phasing on an a.c motor

2.5 describe the **procedures and routines** required when overhauling a typical a.c motor

2.6 describe the **routine followed to clean and refurbish** a water or oil contaminated motor.

2.7 describe the **cleaning techniques** used on electrical machines

2.8 describe the construction and **circuit operation** of an ac starter

2.9 describe the circuit operation, **Motor Thermal Protection** Unit (MTPU) and Motor Auxiliary control Unit (MACU) requirements of the standard starter type 2 size 60

2.10 describe the **setting up procedure** when replacing contacts on a contactor within a typical ac starter

2.11 explain **fault diagnostics** and repair processes on machine starters

2.12 describe the construction, **operation and maintenance** of A.C generators

2.13 dismantle, re-assemble and test an ac motor.

Range

(AC2.1)
- **Main components:** stator construction, rotor construction, fan/end covers.

(AC2.2)
- **Operation of a 3 phase:** operation (rotating magnetic field, emf induced in conductors, interaction with stator field), speed control of a typical ac 3 phase motor speed formula, pole switching).

(AC2.3)
- **Test equipment:** safety, selection of test equipment, accuracy of readings, explain procedures to (balance the field windings, conduct insulation resistance test).

(AC2.4)
- **Process of fuse selection**: why motor fuse require high rating, define single phasing (on a running motor, on a stopped motor).

(AC2.5)
- **Procedures and routines:** types of service motor, fault diagnosis/correction of faults, safety precautions, procedures (stripping, removal, refitting), test carried out on completion, documentation required tools and equipment, noise and earth bonding.

(AC2.6) • **Routine followed to clean and refurbish**: tag out routine, washout, and dismantle, refurbishment, rebuild, functional checks.

(AC2.7) • **Cleaning techniques**: general, vacuum, air hoses, chemical cleaning – toxicity guide.

(AC2.8) • **Circuit operation:** requirements of starter, overload devices, function and types of contactors, direct on line starters – circuit diagrams, major components

(AC2.9) • **Motor Thermal Protection:** MTPU principles, over temperature protection, power supplies, circuit descriptions (Schmitt trigger, trip relay stage, stop/start and delay circuit, thermistors trip, under voltage trip)

(AC2.10) • **Setting up procedure:** tag out, BRs (Books of Reference), selection of contacts, replacement procedure, earth bonding arrangements.

(AC2.11) • **Fault diagnostics:** select test equipment, precautions when using test equipment, safety/hazards associated with starter maintenance, insulation checks.

(AC2.12) • **Operation and maintenance:** design requirements (voltage steady state/transient condition, frequency steady state/transient conditions, power factor, overloads limitations, watertight integrity, generator output frequency, governor control), construction and operation (generator principles, voltage control, frequency control, brushless generator, rectifier assembly, diode failure unit/rectifier/failure device, open/short circuit diode, over voltage protection unit (ovpu) operation), daily maintenance procedures/checks (bearings, air temperatures, noise and vibration, cooler, watertight integrity and vent, heaters, diode failure unit, PMG belt tension and conditions), monthly maintenance procedures/checks (vibration analysis readings, monitor all bearings, water in generator, clean vent frills and emergency cooling flaps, generator cooling checks), describe the serviceability checks for diode assemblies on brushless generators. (procedure, test diode before fitting, fitting/removal procedure).

Learning outcome

The learner will:

3 Understand maintenance and fault diagnosis on Direct Current (d.c) machines, motors and starters.

Assessment criteria

The learner can:

3.1 describe the construction and **main components** of d.c motors

3.2 explain the **operation of Direct Current (dc) motors**

3.3 explain **speed control** of d.c motors

3.4 describe **d.c motor maintenance** routines

3.5 describe **common maintenance practices** carried out on electrical machines

3.6 describe **defects associated** with electrical machines

3.7 describe the **construction and circuit operation** of d.c starters

3.8 describe fault finding and **diagnostic on d.c starters.**

Range

(AC3.1) • **Main components:** mainframe, pole pieces, field windings, interpoles, armature/commutator, brush gear and brushes.

(AC3.2) • **Operation of dc motors**: Flemings rule, Maxwell's rule, back emf, torque, field strength and armature current, classification of motors (series, shunt, series motors, compound motors), armature reactions.

(AC3.3) • **Speed control**: formula, flux control, armature resistance control, voltage control.

(AC3.4) • **DC motor maintenance**: commutator and slip ring maintenance (commutator conditions, routine maintenance, commutator/slip ring damage, concentricity, restoration of a damage commutator/slip rings - grinding/skimming, undercutting/armature tests, commutator skin – initial running), brush gear maintenance (aims of maintenance, brush position, brush arm clearance, brush box stagger, brush spring pressure, types of brushes), motor field winding maintenance (balancing, removal replacement, polarity checks), armature drop test (procedure, diagnosis of readings), adjustment of magnetic neutral axis (reasons, procedures, effects of interpoles – series and shunt motors).

(AC3.5) • **Common maintenance practices:** earth bonding, resistance and insulation resistance checks, tests, trends, removal of corrosion, maintenance general (electrical technical Equipment, field windings, pole pieces, internal wirings, internal varnish conditions), 300kw machine maintenance (drive belt adjustment, bearings – vibration readings, Lubrication, identify maintenance schedule items/routines.

(AC3.6) • **Defects associated** low insulation resistance (causes, TG/MG recovery of low insulation), brush gear problems (high brush wear, causes of sparking), winding defects, bearing failures, vibration problems (causes, 300kw problems and remedial actions).

(AC3.7) • **Construction and circuit operation:** types (drum, face plate, knife type), general description (requirements, main components), time delay mechanism (clockwork, oil dashpot, eddy current brake), contactors, overload device, eddy current brake.

(AC3.8) • **Diagnostic on dc starters:** test gear, circuit operation of a typical dc starter.

Unit 333 Marine electrical circuit breakers and static frequency changers

GLH:	91
Unit aim:	This unit is concerned with the knowledge that underpins maintenance, testing and fault diagnosis of submarine electrical circuit breakers and static frequency changers. It will necessitate an understanding of the electrical and electronic principles, a study of the functions, construction and operations of the equipment. It will cover the safety precautions, procedures and techniques involved with equipment maintenance, testing and fault diagnosis.

Learning outcome

The learner will:

1 Know how to carry out operations, maintenance, set to work and fault diagnosis on AC and Direct Current (d.c) Air Circuit Breakers (ACB).

Assessment criteria

The learner can:

1.1 explain the **safety precautions** and procedures to be applied when working on an air circuit breaker.

1.2 explain the operation of the submarine **air circuit breaker**.

1.3 describe the layout and component **operation** of each component of the air circuit breaker.

1.4 describe the function and operation of the **Static Protection Unit**.

1.5 Explain the function and operating procedure of the **breaker test unit**. explain the differences between d.c and a.c breakers.

1.6 describe maintenance routines and **setting up procedures**.

Range

(AC1.1)
- **Safety precautions:** describe the Turbulent incident, 2 man rule, rip out control.

(AC1.2)
- **Air circuit breaker:** types of ACB, construction, operation (remote, manual, emergency), Indications, electrical supplies.

(AC1.3)
- **Layout and component operation**: major components, function and operation, the function and operation of static protection unit.

(AC1.4) • **Static Protection Unit:** unit function, mechanical and electrical description, low voltage and trip time circuit, overcurrent detection, test points, modes of breaker tripping/opening.

(AC1.5) • **Breaker test unit:** function, procedures, test leads, indication, setting up and functional checks

(AC1.6) • **Setting up procedures:** maintenance iaw Planned Maintenance Schedule (PMS), setting up procedures iaw BR/OI5060

Learning outcome

The learner will:

2 Understand selected planned maintenance, set to work and fault diagnosis procedures for the MK15 and 17 Static Frequency Changers (SFCs).

Assessment criteria

The learner can:

2.1 describe the performance **parameters of the SFC's**

2.2 describe the function of **major components** in power supplies circuits.

2.3 describe the operation of **safety devices** associated with SFCs.

2.4 explain use of test equipment, **maintenance routines**, set to work, test and tune.

Range

(AC2.1) • **Parameters of the SFC's**: input/output voltage, frequency and loading, voltage regulating/current limiting facilities (Mk15), two supply units (Mk17), protection devices (AC2.2)

(AC2.2) • **Major components:** Mk15 (major components, internal power supplies, 400Hz controlling waveform, power amplifier and output transformer stage, output regulation), Mk17 (major components, internal power supplies, control waveforms, inverter circuits, output voltage regulation).

(AC2.3) • **Safety devices:** Mk15 (alarms and trips, o/v trip/latching circuit, transient suppression, thermal cut out), Mk17 (monitored conditions, alarm protection circuits).

(AC2.4) • **Maintenance routines**: safety precautions, common faults and defects associated with SFCs, test equipment/maintenance iaw PSN No 343, Set to work test and tune iaw handbook, analyse readings

Unit 334 Marine systems electrical maintenance

GLH:	114
Unit aim:	This unit is concerned with the knowledge to undertake electrical maintenance of marine systems & equipment to enable engineering activities to be carried out prior to, during and after the operation of these systems. It will necessitate an understanding of the precautions, procedures and principles to be considered whilst carrying out practical maintenance tasks. It will consider planning maintenance tasks, safety precautions, use of specialist tools, procedures and techniques involved with specific equipment maintenance, testing and fault diagnosis.

Learning outcome

The learner will:

1 Understand cable jointing, termination and wire loom production.

Assessment criteria

The learner can:

1.1 describe the operational requirements and special precautions applicable to **cables**

1.2 describe the development of the need and procedures for **crimped terminations**

1.3 carry out various heat shrink processes

1.4 explain the types of **taper pins and blocks**, insertion, testing and extraction methods

1.5 describe the tools and **techniques employed in soldering** and properties of a good soldered connection.

1.6 carry out techniques for soldering terminations and PCB soldering

1.7 describe precautions taken when handling **Printed Circuit Boards (PCBs) and Veroboard**

1.8 describe the precautions to be observed when using semi-conductor devices.

Range

(AC1.1)
- **Cables:** Environmental considerations, materials, special precautions – Polytetrafluoroethylene (PTFE), construction, current carrying capacity, limited fire hazard cables.

(AC1.2)
- **Crimped terminations:** History of crimping, cable sizing, cable preparation, selection of termination, selection of crimp tools, cable doubling, insulation build up for thin wall insulation, range of crimping tools and methods of testing crimped joints, advantages of crimped joints

(AC1.4) • **Types of taper pins and blocks:** 4 types of pins, 2 types of blocks, specialist insertion/extraction tool and testing tool.

(AC1.5) • **Techniques employed in soldering**: tweezers (watchmakers, reversed, pointed), soldering iron (selection of tips), heat shunt, solder flux and cleaning solvent, forming wire and component leads. (Use Watchmakers tweezers, 1 – 2 diameters gap between the insulation and soldered joint with 1 – 2 diameter protrusion of wire, Bends for Stress Relief to be approx. 10mm plus 5mm of tinned conductor. Components to be mounted centrally where possible, Use Ribbon Cable / strippers / 'D' Pin connector soldering technique, Tag board strip soldering, Soldering iron (Clean tip only with a damp sponge, correct use, remove components/wires, use Heat Shunts as required. Good soldered connection (smooth bright surface, solder feathered out, no pits and spikes, outline of wire clearly visible).

(AC1.7) • **Printed Circuit Boards (PCB) & Veroboard**: Electro static discharge and precautions, use of special tools, storage of Electro-static Sensitive Devices (ESSDs), handling and cleaning, component and wire mounting.

Learning outcome

The learner will:

2 Understand maintenance and fault diagnosis on A.C motors and starters.

Assessment criteria

The learner can:

2.1 describe the construction and **operation of a 3 phase a.c induction** motor.

2.2 explain why motor **fuses** require high ratings

2.3 explain the problem with using high rating fuses and safety devices to overcome this

2.4 explain the **advantages and disadvantages** of induction motors

2.5 describe **speed control of a 3-phase** a.c induction motor

2.6 describe **typical defects and maintenance routines** on general motors (ac/dc)

2.7 describe the operation of a **typical Direct on line (D.O.L.) starter** and standard starter's requirements

2.8 describe the hazards associated with starter maintenance, components - standard starter's type 1

2.9 describe over temperature protection, components operation - standard starters type 2

2.10 describe the procedure for dismantling, re-assembling and testing a.c motor /starter for a bearing replacement.

Range

(AC2.1) • **Operation of a 3 phase ac induction:** Stator construction revision, rotor construction revision, operation revision.

(AC2.2) • **Fuses**: Reason for high current compared to normal current, protection devices fitted when running on normal current and the protection offered/designed for.

(AC2.4) • **Advantages and disadvantages**: Simple construction, Easy to maintain, No electrical connection between stator/rotor. High Starting Current, Higher fuse rating, Speed control.

(AC2.5) • **Speed control of a 3 phase ac induction motor:** Speed formula, star (low speed) 4 pole field, double star (high speed) 2 pole field, function.

(AC2.6) • **Typical defects and maintenance routines:** single phasing, single phasing on a running and stopped motor, salt water/oil contaminated motors, insulation break down.

(AC2.7) • **Operation of a typical D.O.L. starter:** overload protection device, function and types of contactor, standard starter circuit diagram.

Unit 335 Marine mechanical equipment and system maintenance

GLH:	133
Unit aim:	To highlight and explain the principles of marine system equipment used in maintenance to enable engineering activities to be carried out prior to, during and after the operation of these systems. It will necessitate an understanding of the precautions, procedures and principles to be considered whilst carry out practical maintenance tasks. It will consider planning maintenance tasks, safety precautions, use of specialist tools, procedures and techniques involved with specific equipment maintenance, testing and fault diagnosis.

Learning outcome

The learner will:

1 Understand precautions, procedures and principles to be considered whilst carrying out maintenance tasks.

Assessment criteria

The learner can:

1.1 explain the **principles** to be considered when planning a maintenance task

1.2 explain the **safety precautions** to be followed when using a range of hazardous materials.

1.3 explain the use of a range of **specialised tools**

1.4 describe the procedure for taking **wear down readings** and changing of a journal bearing

1.5 explain the **methods of aligning** of flanges/ pipe-work - making and use of joints and order of tightening

1.6 describe the **uses of flexible hoses**

1.7 explain the **categories** for inspection and life of flexible hoses.

Range

(AC1.1)
- **Principles:** equipment availability, permission, spares/tools required, tag out system, opening/refitting/closing procedure, removal routes, personnel required, specialist skill, knowledge.

(AC1.2)
- **Safety precautions:** Health and Safety at Work, COSHH.

(AC1.3) • **Specialised tools:** torque wrenches, valve seat cutting gear, helicoil set, extractors, GO/NO GO gauges, stretch gauges.

(AC1.4) • **Wear down readings:** poker gauge, wear down micrometers, bridge gauges, micrometers, plastiguage, results hygiene.

(AC1.5) • **Methods of aligning:** reasons for use, making joints, order of tightening, types of joints

(AC1.6) • **Uses of flexible hoses:** To permit relative movement of equipment, ensure correct function of shock vibration mounts, provide a noise isolating link, allow for temporary access (for flushing, etc.), allow easier equipment inter changeability.

(AC1.7) • **Categories: A** (High risk hoses), **B** (Medium risk hoses), **C** (Low risk hoses), **D** (Negligible risk hoses).

Learning outcome

The learner will:

2 Understand selected practical maintenance on pumps.

Assessment criteria

The learner can:

2.1 describe the **terminology** associated with pumps and the **factors** affecting the selection of a pump

2.2 describe the construction and operation of the **pumps**

2.3 describe the **sealing arrangements** and **balance arrangements** for in service pumps

2.4 describe the function of a **rotary pump seal.**

Range

(AC2.1) • **Terminology:** Suction lift and head, delivery head, friction, static & velocity head, total head, maximum suction lift

(AC2.1) • **Factors**: Discharge pressure, suction conditions, range of control, size and weight, fluid to be pumped, prime mover, mass flow or volume to be pumped.

(AC2.2) • **Pumps**: positive displacement, dynamic displacement, rotary displacement, centrifugal pumps and axial flow.

(AC2.3) • **Sealing arrangements**: device to inhibit the passage of fluid, correct fitting, cleanliness and alignment.

(AC2.3) • **Balance arrangements:** Thrust, motion, counteracting preventing (eye to eye/back to back, weight balance, area reduction, balance piston)

(AC2.4) • **Rotary pump seal:** eliminate leakage, absorb no power, no maintenance.

Learning outcome

The learner will:

3 Understand practical maintenance procedures on selected system

Assessment criteria

The learner can:

3.1 describe the **principles of compressed** High Pressure (HP) and Low Pressure (LP) Air Systems

3.2 describe the **construction & operation** of an **HP Air Compressor** and **LP Air Compressor**

3.3 describe the **Ships Staff Maintenance** procedures for Air compressors and systems

3.4 describe the **HP and LP air system defects** and associated cause

3.5 describe the types of resilient mounts used on ships

3.6 describe **inspections** and maintenance procedures and include removal/replace routines

3.7 describe the **safety precautions** and the **maintenance/repair procedures** for a leak on a **heat exchanger**, including how to **set to work** carry out a functionally test.

Range

(AC3.1)
- **Principles of Compressed Air:** Fact, flexible hoses, tag -out, pressurised air systems (dangers and precautions),principles of operation, types of compressors, uses of high pressure air (Hp air) systems, uses of low pressure air (LP air) systems.

(AC3.2)
- **Construction & Operation**: Compressed air systems, storage bottles, reducers, relief valves, isolating valves, OMS supply, pipework, charging panels, HP-LP cross connection, pressure gauges.

(AC3.2)
- **HP Air Compressor**: HP air compressor construction, Hamworthy Hp air compressor, air path through the Hamworthy, lubrication, cooling system, safety devices, fault finding LP Air System: LP air systems, filters, dryers.
- **LP Air Compressor**: Hydro vane compressor, construction of components, operation, oil system, oil removal, oil cooler, unloading, safety devices, fault finding.

(AC3.3)
- **Ships Staff Maintenance**: Hamworthy dolphin 100w 70n Hpac - removal of automatic cylinder valves, removal of cylinders, cleaning and inspecting automatic cylinder valves, assembling automatic cylinder valves, cleaning and inspecting cylinder and liner, renewing cylinder liners, assembling a cylinder, re-fitting cylinders to compressor, Crankcase components - removal of pistons, dismantling yoke assembly and connecting rods, assembling yoke, assembly and connecting rod, assembly of pistons.

(AC3.4)
- **HP and LP Air System Defects:** Current fault report forms Hamworthy 4th 100w 70n hpac normal readings, 4th stage relief valve blowing, 1st, 2nd, 3rd stage relief valve blowing, compressor will not operate at full pressure or at full capacity, valves require cleaning too often.

- **Shock and Vibration:** control, flexibility, support, types (J mounts, L mounts, M mounts, X mounts, P&D mounts).

(AC3.6)
- **Inspections**: conditions, contamination, movement, specialist paint, Heat and oil shields, tag-out, jack up, change restrictions, retighten, settling time, check alignment, decelerators, check clearances, correct securing arrangements, deflection checks.

(AC3.7)
- **Safety precautions**: tagged-out (isolated) correct tools/equipment for task, drain, correct PPE for task, personnel briefed.

(AC3.7)
- **Maintenance/repair procedures**: cleaning/ blowing heat exchangers (cleaning techniques, mechanical/chemical cleaning), leak detection process (fluorescein dye, pressure testing, leak detection, ultra-sonic), repair procedures (plugging, 10% rule, replacement), replace/remake joints for flanged surfaces.

(AC3.7)
- **Set to work**: Tag-in, leak test, measure temperatures (inlet and outlet), clean up area.

Maintenance on Pumps: Correct references, spares, tools, isolations, time to repair, H&S, dismantle, inspect, replace/repair, re-assemble, realign, final inspection via readings, record data, final check.

Learning outcome

The learner will:

4 Understand vibration analysis on running machinery.

Assessment criteria

The learner can:

4.1 explain the reasons for **Condition Monitoring** (CM) and Condition Based Maintenance (CBM)

4.2 explain where **vibration limits** can be found

4.3 explain the **definitions of vibration** and their units

4.4 explain how the **monitoring positions** are identified

4.5 explain how to **configure** condition monitoring test equipment and use for testing

4.6 carry out vibration analysis on a variety of machines

4.7 define the form used to record a fault or defect.

Range

(AC4.1)
- **Condition monitoring:** To monitor a machines condition, to anticipate machinery failure, assess and control the amount of noise and vibration passed to the ship's hull, as a quality control function, detect and identify faults in a machine.

(AC4.2)
- **Vibration limits:** Machinery BR, Manufacturers Handbook, Vibration severity charts, Baseline or Base level readings,

(AC4.3)
- **Definitions of vibration**: Displacement (Microns), Peak velocity (mm/sec), Peak acceleration (G (Gravity)), frequency (CPM (Cycles per minute)), Amplitude (None (It is just a number)), Spike energy (GSE).

(AC4.4) • **Monitoring positions:** Markings (salmon pink triangle), direction of positions marked.

(AC4.5) • **Configure:** connecting, selecting downloading, reconnecting, uploading, reviewing**.**

Unit 336 Marine controls systems and diagnostics

GLH:	81
Unit aim:	This unit is concerned with the principles of maintenance of marine control systems equipment to enable engineering activities to be carried out prior to, during and after the operation of these systems It will necessitate an understanding of the precautions, procedures and principles to be considered whilst carrying out practical maintenance tasks. It will consider planning maintenance tasks, safety precautions, use of specialist tools, procedures and techniques involved with specific equipment maintenance, testing and fault diagnosis

Learning outcome

The learner will:

1 Understand the components and principles of process and positional control systems.

Assessment criteria

The learner can:

1.1 define **types of control** and explain **application and the choices** of control medium

1.2 explain how to **modify open loop** system

1.3 explain **operator with automatic control** and how this could be done

1.4 explain control system **positive and negative feedback**

1.5 describe **open loop gain**

1.6 explain the type of system tests which are applied to **test "inputs"**

1.7 define **system behaviour** in relation to test inputs.

Range

(AC1.1) • **Types of control:** manual, remote/manual, servo/manual, automatic.

(AC1.1) • **Application and the choices:** regulatory, programmable, mechanical, electrical, pneumatic and hydraulic.

(AC1.2) • **Modify open loop:** adding an operator, we form a basic closed loop system using his eyesight and brain as an EMD and FEEDBACK PATH.

(AC1.3) • **Operator with automatic control:** This makes the system more practical and reduces manpower. A mechanical method of producing this is the centrifugal governor.

(AC1.4) • **Positive and negative feedback:** When feedback is in phase with the input. It has a regenerative and destabilising effect used in oscillators, Out of phase with the input, this type of feedback is most commonly used in Control Systems and is non regenerative. One of the more common ways to achieve Negative feedback is by subtracting Feedback from Input at the Error Measuring Device (EMD).

(AC1.5) • **Open loop gain:** System gain = output/input = θo / θI But θo = Gθe therefore θo / θi =Gθe / θI And θe = θi - HGθe therefore θi = θe + HGθe and θi = θe(1 + HG) Therefore Gθe / θe(1+HG) Overall System Gain = G / 1+GH

(AC1.6) • **Test inputs:** step, ramp, pulse, impulse and sine wave.

(AC1.7) • **System behaviour:** How system behaves whilst enforced change of output is taking place and how long it will take.

Learning outcome

The learner will:

1 Understand the operation of Positional Control systems.

Assessment criteria

The learner can:

2.1. describe the **principles and construction of synchros**

2.2. describe the **expansion of the basic synchro** unit into specific types

2.3. describe the **designation code and synchro conventions and wiring**

2.4. describe the operation of a **torque synchro chain** and disadvantages

2.5. define the term **servo mechanism**

2.6. analyse the modifications made to the **basic system to improve stability**

2.7. describe **stepper motors types,** construction and operation**.**

Range

(AC2.1) • **Principles and construction of synchros:** transformer action, secondary and primary voltage relationship, dot notation, windings, voltages.

(AC2.2) • **Expansion of the basic synchro:** torque TX and TR, TRX, receiver indicator, control transmitter, control differential transmitter, control transformer

(AC2.3) • **Designation code and synchro conventions and wiring:** voltage, frame size, function frequency and modification. Datum position, direction of rotation, reference supply, output waveforms.

(AC2.4) • **Torque synchro chain:** mechanical input is applied to the rotor shaft of the transmitter and the final output is the rotation of the receiver rotor

(AC2.5)

- **Servo mechanism:** Closed loop, continuous, control system in which the plant output is mechanical in nature, backlash.

(AC2.6)
- **Basic system to improve stability:** friction, velocity feedback, transient velocity feedback, phase advance.

(AC2.7)
- **Stepper motors:** Types (Variable reluctance, Permanent magnet, Hybrid), spaced windings, rotor, stator coils, pulsed outputs, stator windings, step angle, distance travelled, basic drive circuit, Torque/stepping rate.

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the Centres and Training Providers homepage on www.cityandguilds.com.

Centre Manual - Supporting Customer Excellence contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification, as well as updates and good practice exemplars for City & Guilds assessment and policy issues.

Specifically, the document includes sections on:

- The centre and qualification approval process
- Assessment, internal quality assurance and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Management systems
- Maintaining records
- Assessment
- Internal quality assurance
- External quality assurance.

Our Quality Assurance Requirements encompasses all of the relevant requirements of key regulatory documents such as:

- SQA Awarding Body Criteria (2007)
- NVQ Code of Practice (2006)

and sets out the criteria that centres should adhere to pre and post centre and qualification approval.

Access to Assessment & Qualifications provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **centre homepage** section of the City & Guilds website also contains useful information on such things as:

- **Walled Garden**: how to register and certificate candidates on line
- **Events:** dates and information on the latest Centre events
- **Online assessment**: how to register for e-assessments.

Centre Guide – Delivering International Qualifications contains detailed information about the processes, which must be followed, and requirements, which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification.

Specifically, the document includes sections on:

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre

- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Appendix 2 Useful contacts

UK learners General qualification information	**E: learnersupport@cityandguilds.com**
International learners General qualification information	**E: intcg@cityandguilds.com**
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	**E: centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	**E: singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	**E: intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems	**E: walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	**E: business@cityandguilds.com**
Publications Logbooks, Centre documents, Forms, Free literature	

If you have a complaint, or any suggestions for improvement about any of the services that we provide, email: feedbackandcomplaints@cityandguilds.com

About City & Guilds

As the UK's leading vocational education organisation, City & Guilds is leading the talent revolution by inspiring people to unlock their potential and develop their skills. We offer over 500 qualifications across 28 industries through 8500 centres worldwide and award around two million certificates every year. City & Guilds is recognised and respected by employers across the world as a sign of quality and exceptional training.

City & Guilds Group

The City & Guilds Group is a leader in global skills development. Our purpose is to help people and organisations to develop their skills for personal and economic growth. Made up of City & Guilds, City & Guilds Kineo, The Oxford Group and ILM, we work with education providers, businesses and governments in over 100 countries.

Copyright

Published by City & Guilds, a registered charity established to promote education and training

City & Guilds

1 Giltspur Street

London EC1A 9DD

www.cityandguilds.com