SQA Advanced Unit specification

General information

Unit title: Fluid Mechanics: Theory and Laboratory Skills (SCQF level 7)

Unit code: HV0A 47

Superclass: RC

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to introduce learners to key aspects of fluid mechanics. Learners will also develop practical skills in techniques relevant to fluid mechanics. The Unit is suitable for learners studying at SQA Advanced Certificate level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of chemical engineering or to seek employment in chemicals processing or oil refining industries.

Outcomes

On successful completion of the Unit the learner will be able to:

- Apply the theory of fluid mechanics to the measurement of pressure and flow in fluids.
- Estimate energy requirements and specify equipment for fluid transfer operations.
- Perform practical experiments related to measuring flow and friction losses in fluids.

Credit points and level

1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners have prior knowledge of Physics and/or Mathematics at SCQF level 6 or equivalent.

Core Skills

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

Complete Core Skill	None
Core Skill component	Using Number at SCQF level 6

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

Context for delivery

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

Equality and inclusion

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

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

SQA Advanced Unit specification: Statement of Standards

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

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

Outcome 1

Apply the theory of fluid mechanics to the measurement of pressure and flow in fluids.

Knowledge and/or Skills

- Fluid statics theory
- Manometric methods
- The fluid energy equation
- Constriction flowmeters and the Pitot tube

Outcome 2

Estimate energy requirements and specify equipment for fluid transfer operations.

Knowledge and/or Skills

- Energy requirements for fluid transfer operations
- Frictional energy losses in pipelines and pipe fittings
- Velocity profiles in laminar and turbulent flow regimes
- Pump and compressor equipment for fluid transfer operations

Outcome 3

Perform practical experiments related to measuring flow and friction losses in fluids.

Knowledge and/or Skills

- Flow and friction losses in fluids experiments
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results

- Evaluation skills
- Result analysis and conclusions

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 2 could be assessed using a holistic closed-book assessment under supervised conditions. Outcomes may also be assessed individually. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment — whether holistically or individually — be completed within 90 minutes.

Written and/or oral recorded evidence for Outcome 3 should be assessed by production of a full laboratory report. An assessor's observation checklist could be used to record performance evidence of practical experiments.

Outcome 1

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- apply fluid statics theory to measure the pressure of liquids and gases by use of vertical and inclined tube manometers.
- estimate liquid level in process vessels by measurement of pressure and differential pressure.
- apply the fluid energy equation to the measurement of fluid flow and measure the flowrate of liquids and gases by use of the orifice-plate meter and the Venturi meter.
- estimate the velocity of liquids and gases by use of the Pitot tube.

Where calculations are performed, the learner must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked.

The answer should derive from the application of the formulae and correct application of the principles of the calculation.

Outcome 2

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- estimate the energy requirements for fluid transfer operations involving changes in fluid velocity, fluid elevation and fluid pressure.
- estimate frictional energy losses in pipelines and pipe fittings using empirical equations and friction charts.
- describe velocity profiles in laminar and turbulent flow regimes and predict flow regime in fluid transfer operations.
- identify pump and compressor equipment for fluid transfer operations.

Where calculations are performed, the learner must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked.

The answer should derive from the application of the formulae and correct application of the principles of the calculation.

Outcome 3

Learners will perform a minimum of one practical experiment, the content of which will be related to Outcomes 1–2. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- follow instructions to perform experiments related to flow and friction losses in fluids.
- work in a safe manner regarding current health and safety regulations.
- achieve consistent and accurate results.
- record experimental observations and results clearly and accurately.
- evaluate validity of results in terms of sources of and values of experimental errors.
- Analyse results correctly and state valid conclusions.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Learners must report results by production of a full laboratory report.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake different practical experiments of similar complexity. Where a laboratory report does not meet the required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

SQA Advanced Unit Support Notes

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Unit Support Notes are offered as guidance and are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit is may form part of a group award or be completed as a free-standing Unit. It is designed to introduce learners to key aspects of fluid mechanics.

Outcome 1 — Apply the theory of fluid mechanics to the measurement of pressure and flow in fluids

The fluid static pressure equation and its application to the measurement of pressure in fluids by manometric methods:

- The Torricelli vacuum
- Static pressure in liquid columns
- The U-tube, the inclined tube and the single-tube manometer
- Manometry using immiscible liquids

Other common methods of pressure measurement and the use of pressure to determine liquid levels in process vessels:

- The Bourdon-tube pressure gauge
- The electronic strain gauge and the differential pressure cell
- Pressure gauges as level indicators
- Errors from atmospheric pressure variations
- Differential pressure cells as level indicators

The fluid energy equation and its application to the measurement of fluid flow:

- The fluid energy (Bernoulli) equation
- Solutions of the fluid energy equation for the constriction flow meter and the Pitot tube
- The orifice-plate meter and the Venturi meter
- Calibration of constriction flow meters
- The variable-area flow meter
- Applications of the Pitot tube

Outcome 2 — Estimate energy requirements and specify equipment for fluid transfer operations

The use of the fluid energy equation to determine energy requirements for fluid transfer operations involving changes in the height, pressure and velocity of the transferred fluid:

- Calculation of potential, kinetic and pressure energy changes
- Relative contributions of potential, kinetic and pressure energy changes

The description of laminar, transitional and turbulent flow regimes and the use of the Reynolds number for the prediction of flow regimes:

- Friction in fluids and fluid viscosity
- Velocity profiles in laminar flow regimes
- Turbulent and transitional flow regimes
- Dimensionless numbers and the Reynolds number
- Prediction of flow regimes using the Reynolds number
- The implications of flow regime for fluid transfer operations

Empirical methods for the estimation of frictional energy losses in pipelines and pipe fittings:

- The force balance in a flowing fluid
- Frictional energy losses as pressure losses
- The dimensionless friction factor and its relation to the Reynolds number
- Empirical methods for determination of the friction factor
- Friction charts
- Frictional energy losses in laminar, turbulent and transitional flow
- The effect of surface roughness

The types of pump and compressor equipment in use for fluid transfer operations in the oil refining and chemicals industries and their principal operating characteristics:

- Centrifugal pumps and compressors and their operating characteristics
- Positive displacement pumps and compressors and their operating characteristics
- Reciprocating pumps and compressors
- The Monod pump, the peristaltic pump and other specialised designs

Outcome 3 — Perform practical experiments related to measuring flow and friction losses in fluids

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1 and 2.

In carrying out such activities, learners should follow good laboratory practice and carry out or be familiar with the risk and COSHH assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

If this Unit is delivered as part of a Group Award designed to provide learners with technical knowledge and skills for employment in the oil refining and chemicals manufacturing industries, it is recommended that the Unit is delivered early in the Group Award. Since the Unit is introductory, it should be assumed that learners have no previous knowledge of fluid mechanics.

It is envisaged that Outcome 1 is delivered prior to Outcome 2. Outcome 1 could commence with the application of fluid statics theory in measuring the pressure of liquids and gases by use of vertical and inclined tube manometers, followed by the estimation of liquid level in process vessels by measurement of pressure and differential pressure. Following this, delivery could focus on applying the fluid energy equation to the measurement of fluid flow by use of the orifice-plate meter and the Venturi meter and to estimate the velocity of liquids and gases by use of the Pitot tube.

Outcome 2 will introduce the use of the fluid energy equation to determine energy requirements for fluid transfer operations involving changes in the height, pressure and velocity of the transferred fluid, changes of potential, kinetic and pressure energy. As well as relative contributions of potential, kinetic and pressure energy changes, the description of laminar, transitional and turbulent flow regimes and the use of the Reynolds number for the prediction of flow regimes should be introduced. This will also include: velocity profiles in laminar turbulent and transitional flow regimes, dimensionless numbers and the Reynolds number, prediction of flow regimes using the Reynolds number, and the implications of flow regime for fluid transfer operations.

Delivery could then focus on empirical methods for the estimation of frictional energy losses in pipelines and pipe fittings, which should include: the force balance in a flowing fluid, frictional energy losses as pressure losses, the dimensionless friction factor and its relation to the Reynolds number, empirical methods for determination of the friction factor, friction charts, frictional energy losses in laminar, turbulent and transitional flow, and the effect of surface roughness. Energy requirements for fluid transfer, the types of pump and compressor equipment in use for fluid transfer operations in the oil refining and chemicals industries and their principal operating characteristics could then be covered. This will include: centrifugal pumps and compressors and their operating characteristics, positive displacement pumps and compressors and their operating characteristics, reciprocating pumps and compressors, and the Monod pump, the peristaltic pump and other specialised designs.

It is recommended that the understanding of principles rather than memorisation of complex formulae is emphasised in the delivery of Outcomes 1 and 2.

It is envisaged that Outcome 3 is carried out after Outcome 1 is completed and during the delivery of Outcome 2. Practical work could include the use of plant or laboratory fluid transfer equipment to demonstrate the principles of constriction flow measurement and the estimation of frictional energy losses in pipes and fittings. The learner could apply

much of the theory learned in the previous Outcomes to practical situations, such as investigating flow measurements by constriction or frictional losses due to bends, pipe fittings and valves.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1 and 2 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Outcomes may also be assessed individually. Assessment should be carried out in supervised conditions. It is recommended that the assessment be completed within 90 minutes when both Outcomes are assessed together, or 45 minutes when assessed separately. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Where evidence of Outcome 1 and Outcome 2 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment must be included in the alternative (re-sit) assessment.

As the understanding of principles rather than memorisation of complex formulae is emphasised in the delivery of Outcomes 1 and 2, it may be appropriate for learners to have access to their own course materials during the assessment, provided that the problems set do not appear explicitly in the course materials.

For Outcomes 1 and 2, the Evidence Requirements state that learners 'must provide a satisfactory response' which includes reasonable answers derived 'from the application of the formula and correct application of the principles of the calculation'. This allows for acknowledgement of the correct working and application of formulae, even where learners'
final answer may be inaccurate. The statement allows for the eventuality where a single error at one stage in an extended calculation sequence has a cumulative effect on the final answer, even though working/formulae are otherwise correctly applied. Acknowledgement of the correct working should be given in such cases.

In Outcome 3 learners are required to undertake one assessed practical experiment, the content of which will be related to Outcomes 1–2. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments related to Outcome 1 and Outcome 2 are:

- investigating flow measurements by constriction.
- investigating frictional losses due to bends, pipe fittings and valves.

Assessed practical experiments will usually be performed individually. However, there may be some experiments that are suitable to be undertaken in pairs or small groups, if this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Opportunities for e-assessment

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

Opportunities for developing Core and other essential skills

This Unit has the *Using Number* component of *Numeracy* embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved *Using Number* at SCQF level 6.

The delivery and assessment of this Unit will also provide learners with the opportunity to develop the Core Skills of *Problem Solving* and *Working with Others* at SCQF level 6.

***Problem Solving* — Critical Thinking at SCQF level 6**

Learners will be required to interpret and work through problems in assessments and during the laboratory aspect of Outcome 2.

***Working with Others* — Working Co-operatively with Others at SCQF level 6**

Learners will negotiate laboratory space, shared facilities and could also work as part of a team.

History of changes to Unit

Version	Description of change	Date

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

General information for learners

Unit title: Fluid Mechanics: Theory and Laboratory Skills (SCQF level 7)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of an SQA Advanced Diploma engineering programme. The Unit introduces the theory of fluid mechanics and its practical applications. Before progressing to this Unit it would be beneficial to have prior knowledge of Physics and/or Mathematics at SCQF level 6 or equivalent.

On completion of the Unit, you should be able to:

- Apply the theory of fluid mechanics to the measurement of pressure and flow in fluids.
- Estimate energy requirements and specify equipment for fluid transfer operations.
- Perform practical experiments related to measuring flow and friction losses in fluids.

Assessment

For Outcomes 1 to 2, depending on which centre you attend, assessment may be conducted on an Outcome by Outcome basis or by one single assessment. Assessment will be conducted under closed-book, supervised conditions.

Outcome 3 will be assessed after you have learned the necessary practical skills, and will take the form of a practical experiment. You will report the results from the practical experiment in a full laboratory report.

Core Skills

This Unit has the *Using Number* component of *Numeracy* at SCQF level 6 embedded in it. You will also have opportunities to develop the Core Skills of *Problem Solving* and *Working with Others* at SCQF level 6.