SQA Advanced Unit Specification

General information for centres

Unit title: Meter Systems in Measurement and Control Engineering

Unit code: HV68 47

Unit purpose: This Unit is designed to enable candidates to gain knowledge and understanding and apply meter proving in industrial Measurement and Control Engineering systems. On completion of the Unit candidates should be able to:

1 Explain physical properties of hydrocarbons and measurement terms.
2 Apply gas metering systems.
3 Apply liquid metering systems.

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

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

Recommended prior knowledge and skills: Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a basic knowledge of industrial measurement and control engineering. This may be evidenced by the possession of NC Measurement and Control or NC Multidisciplinary Engineering or Higher Process Measurement or Higher Process Control or NQ Units in Measurement and Control. There could also be an advantage in possessing or working towards the SQA Advanced Units HV67 47 Measurement Systems 1, HV63 47 Distributed Control Systems and HV69 47 Process Analysers: On Line.

Core Skills: There are opportunities to develop the Core Skills of Written Communication (Writing) and Written Communication (Reading) at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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

Assessment: The assessment for Outcomes 1, 2 and 3 can be assessed separately with each assessment lasting one hour OR alternatively integrated into an end of Unit assessment. The integrated paper should be taken by candidates at one single assessment event and should last approximately three hours. The integrated assessment paper should be composed of a balance of short answer, restricted response and structured questions. The assessment singly or integrated should be conducted under controlled supervised conditions. The integrated assessment should be carried out towards the end of the Unit delivery. Candidates must achieve all minimum evidence specification for each Outcome in order to pass the Unit.

Unit specification: statement of standards

Unit title: Meter Systems in Measurement and Control Engineering

Unit code: HV68 47

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

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

Outcome 1

Explain physical properties of hydrocarbons and measurement terms

Knowledge and/or skills

- Units of measurement
- Standard reporting conditions
- Physical properties of hydrocarbons
- Accuracy repeatability, bias/error and uncertainty

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence maybe provided in response to specific questions.

Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above.

In any assessment of this Outcome three out of four knowledge and/or skills should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of four knowledge and/or skills items is required each time the Outcome is assessed.

Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- explain the fundamental and derived Units used in meter proving
- explain the standard reporting conditions for gas and liquid meter proving
- explain the physical properties of gas and liquid hydrocarbons
- explain the measurement terms relevant to meter proving and its certification

Evidence should be generated through assessment undertaken in controlled supervised conditions.

Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed any textbooks, handouts or notes in the assessment.

Questions used to elicit candidate evidence may take the form of short answer restricted response or structured questions. This evidence can be assessed separately lasting one hour or integrated with Outcomes 2 and 3 and should last approximately three hours.

Outcome 2

Apply gas metering systems

Knowledge and/or skills

- Principle of operation of primary gas metering systems
- Standard volume and energy flow equations
- Secondary gas metering systems
- Flow computing in gas flow metering
- Quality methods in gas metering
- Examples of gas sample and metering systems

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions.

Each candidate will need to demonstrate that they can answer questions based on a sample of the knowledge and/or skills above. In any assessment of this Outcome five out of six knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on a different sample of five out of six knowledge and/or skills items as required each time the Outcome is assessed.

Candidates must provide a satisfactory response to all items where sampling takes place a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- explain the principle of operation of primary gas metering systems
- apply standard volume and energy flow equations
- explain the principle of operation of secondary gas metering systems
- apply flow computing to gas flow metering
- apply quality methods to gas metering
- explain methods of gas sample and metering systems

Evidence should be generated through assessment undertaken under controlled supervised conditions.

Assessments should be conducted under closed book conditions and as such candidates must not be allowed to bring textbooks, handouts or notes to the assessment.

Questions used to elicit candidate evidence may take the form of short answer questions, restricted response and structured questions. This evidence can be assessed separately lasting one hour or integrated with Outcomes 1 and 3 and should last approximately three hours.

Outcome 3

Apply gas metering systems

Knowledge and/or skills

- Principle of operation of primary liquid metering system
- Types of meter provers
- Meter K-factor
- Flow computer calculations and functions
- Quality methods used in liquid metering
- Examples of liquid sample and metering systems

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis.

The evidence maybe provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items above. In any assessment of this Outcome five out of six knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different five out of six knowledge and/or skills items is required each time the Outcome is assessed.

Candidates must provide a satisfactory response to all five items. When sampling takes place a candidate's response can be judged satisfactory where evidence provided is sufficient to meet the requirement for each item by showing that the candidate is able to:

- explain the principle of operation of primary liquid metering systems
- apply types of meter provers
- evaluate meter K-factor from known data
- apply flow computing to liquid flow metering
- apply quality methods used in liquid metering
- explain examples of liquid sample and metering systems.

Evidence should be generated through assessment undertaken under controlled supervised conditions.

Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed to bring textbooks, handouts or notes to the assessment.

Questions used to elicit candidate evidence may take the form of short answer questioning restricted response and structured questions. This evidence can be assessed separately lasting one hour or integrated with Outcomes 1 and 2 and should last approximately three hours.

Administrative information

Unit code: HV68 47

Unit title: Meter Systems in Measurement and Control Engineering

Superclass category: WD

Original date of publication: November 2017

Version: 01

History of Changes:

Version	Description of change	Date

Source: SQA

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

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

Unit specification: support notes

Unit title: Meter Systems in Measurement and Control Engineering

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

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

Guidance on the content and context for this Unit

The Unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas.

1 The physical properties of hydrocarbons and the associated measurement terms.
2 The application of gas metering systems.
3 The application of liquid metering systems.

The Unit is at SCQF level 7 has been developed as part of the SQA Advanced Certificate/Diploma in Measurement and Control Engineering Awards. However, this does not preclude the use of this Unit in other awards where award designers feel it is appropriate.

In designing this Unit, the writer has identified the range of topics that they would expect to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This is done to assist lecturers to decide what depth of treatment should be given to the topics attached to each Outcome.

A list of topics for each Outcome is given below.

Outcome 1

Explain physical properties of hydrocarbons and measurement terms (10 hours)

- Referring to standards – ISO 5167, ISO 6976 (energy), AGA7 (turbine), AGA8 (gas), 3 AGA3 (orifice) and API – Petroleum Measurement Manual, chapter
- (1-13)
- Units of Measurement – Pressure (bara), temperature (deg C), density (kg/m^3), length (m), volume (m^3/barrel), mass (tonne) and energy (mega joules)
- Standard reporting conditions (metric) – Pressure (1.01325 bara), temperature (15 deg C)
- Properties of Hydrocarbon – density, relative density, viscosity and calorific value. Hydrocarbon content; assay of gases C1 to C4, C5 + condensate, boiling point fractions C5 to 550 +, allocation of gas/oil from different sources
- Natural gas; mixture of hydrocarbons and non hydrocarbons (e.g. nitrogen, carbon dioxide/water)
- Measurement terms
  Accuracy: closeness of measured value to the true value.
  Repeatability: closeness of the measured value to the true value for repeated measurements of the same measured value
  Bias/error: difference between the measured value and the true value.
  Uncertainty: the range within which the true value is likely to lie at a stated value of probability
- Fiscal metering — meaning of the term and its application to metering.

Outcome 2

Apply gas metering systems (15 hours)

- Primary meter types — principle of operation of orifice plate, Venturi, gas turbine meter, ultrasonic (transient time) meter, V-core and Vortex meter. Mass flow equations from ISO 5167.

  Qm = 3.6CE $E\zeta\pi \frac{d^2}{4}\sqrt{2dp.\rho}$

  Where

  Qm is the mass flow rate, tonnes per hour
  C is the discharge coefficient for the orifice
  E is the velocity of approach factor for the orifice
  ζ is the expansibility factor for the orifice
  d is the orifice diameter, mm
  dp is the differential pressure, mbar
  ρ is the density, kg/cubic metre

  Standard volume equations $q_v = q_m$/standard density
  $q_e = qv$ x CV (MJ/m^3)
  $q_e = q_m$ x CV (MJ/kg)

- Secondary equipment — input/output relationship of ΔP transmitter, pressure transmitters (including absolute), temperature (R/T) transmitters, gas density transmitters (frequency relationship to density), flow computers and gas analysers. Calibration certificate, traceability and mass uncertainty.
- Gas quality —principle of operation of density and relative density transmitters, calorimeter (calorific value-CV), gas chromatography (GC for density or CV), water dewpoint transmitters and hydrogen sulphide analysis. Gas metering streams, installations systems.
- Flow computers — man-machine interface for system, measures field equipment signals and scale to engineering Units, accepts manual input data, used to calculate and totalise the flow and communicate with other systems eg DCS. Flow computer functions.

Outcome 3

Apply Liquid Metering Systems (15 hours)

- Primary meter device — principle of operation of oil turbine meter, flow meter pulse, security and fidelity. Turbine meter control charts.
- Measurement of liquid density (vibrating tube) method and frequency relationship to density. Use with flow computer.
- Meter prover — device to discharge a known quantity of liquid to the meter under test. Principle of operation of: uni-directional prover, bi-directural prover, compact prover, master meter prover and on line meter provers.
- Evaluation of Meter K- factor = $\frac{n}{v_p C_{ts} C_{ps}} x \frac{C_{tlm}}{C_{tlp}} x \frac{C_{plm}}{C_{plp}}$

Where

K is the meter K-factor, pulses/cubic metre
n is the number of pulses from the turbine meter during the proving run
ν_ρ is the volume of the prover during the proving run, in cubic metres, calculated from $\nu_\rho = \nu_c.C_{ts}.C_{ps}$

Where

ν_c is the prover volume as given in the current calibration certificate
C_{ts} is the correction for the effect of temperature on the prover steel
C_{ps} is the correction for the effect of pressure on the prover steel
C_{tlm} and C_{tlp} are corrections for the effect of temperature on the liquid, at the meter and prover conditions respectively.
C_{plm} and C_{plp} are corrections for the effect of pressure on the liquid, at meter and prover conditions respectively.
The corrections for the effect of temperature and pressure on the prover steel are calculated from:

$C_{ts} = 1 + e\,(T-T_c)$
$C_{ps} = 1 + (PD)/(E_t)$

Where

e is the cubical thermal expansion coefficient of the steel
T is the operating temperature of the prover, deg C
T_c is the temperature at which the prover volume was calibrated, deg C.
P is the operating pressure of the prover, bar
D is the certified diameter of the prover, mm
E is the modulus of elasticity of the steel
t is the certified thickness of the prover, mm

Minimum number of runs and frequency of proving.
Process of proving a meter.

- Flow computer calculations $Q_v = \frac{n}{k}$ $Q_m = Q_v$. Density
- Effects of liquid compressibility — Downer Equation
- Associated measurement devices and their principle of operation — Coreolis mass flow meter, liquid chromatography analysers
- Calibration certificate, traceability and mass uncertainty.
- Examples of typical liquid metering systems and liquid sample streams.

Unit Assessment

Written paper (integrated) —3 hours

Guidance on the delivery and assessment of this Unit

It is intended that this Unit is presented in the context of applying meter proving in industrial measurement and control engineering and is designed to provide candidates with technical knowledge and skills for the occupational area in which they are involved.

Outcomes can be assessed individually OR by one end assessment where the end assessment integrates the assessments for each Outcome. Assessment should be held in controlled conditions and candidates may not bring textbooks, handouts or any material prepared by themselves to the end assessment.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Written Communication (Writing) and Written Communication (Reading) at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

The Unit could be delivered by distance learning. However it would require planning by the centre to ensure the sufficiency and authenticity of candidate evidence. Agreement would have to be made to ensure that a single assessment for the end test is delivered in a supervised environment under controlled conditions.

To keep the administrative burden to a minimum, it is recommended that a single end test is used for distance learning candidates.

For information on open learning, please refer to SQA guide *Assessment and Quality Assurance of Open and Distance Learning (A1030, Feb. 2001).*

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.

General information for candidates

Unit title: Meter Systems in Measurement and Control Engineering

This Unit has been designed to provide you with knowledge, understanding and skills that will enable you to understand the basis of meter proving and its application in Measurement and Control Engineering.

The early part of the unit deals with the physical properties of hydrocarbons, measurement terms, relevant standards and Fiscal metering.

The middle part of the unit deals with gas metering systems- primary meter types, secondary equipment, gas quality and flow computers.

The final part of the unit deals with liquid metering systems- primary meter types, meter provers, evaluation of meter K-factor and flow computers.

The assessments will take place under controlled supervised conditions and you will not be allowed to take notes, handouts or textbooks to the assessment. The assessment can be carried out in an Outcome by Outcome basis or alternatively the Outcomes can be integrated into a single assessment carried out at the end of the Unit.