

**City & Guilds Level 3 End-
point Assessment for
Engineering Maintenance
Technician (Single
Discipline) (9331-11)**

Standard: ST1426

EPA Plan: Version 1.0

QN: 610/6875/5

EPA Pack for Providers and Employers

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For external use

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1. Apprenticeships



This pack will help providers and employers prepare apprentices for the End-point Assessment (EPA) of their City & Guilds Level 3 End-point Assessment for Engineering Maintenance Technician (Single Discipline) (9331-11). It explains how apprentices will demonstrate the knowledge, skills and behaviours (KSBs) which they developed during their apprenticeship.

This pack is for apprentices who are enrolled on the Level 3 Engineering Maintenance Technician (Single Discipline) Standard (ST1426) V1.0 and undertaking one of the following options:

- electrical engineering maintenance technician
- control and instrumentation engineering maintenance technician
- mechanical engineering maintenance technician.

This pack must be used alongside the:

- 9331-11 Recording Forms for Providers and Employers (separate forms are provided for each option)
- [EPA Documents Library](#), which includes the Manual for the End-point Assessment Service, information about the EPA Service, policies about malpractice and appeals, FAQs, and a video about the EPA which can be shared with apprentices.

The City & Guilds Manual for the EPA Service includes information on:

- application, registration and booking
- assessment
- results and post results (including resits)
- fees
- quality assurance.

Full-time engineering maintenance technician (single discipline) apprentices will typically spend 42 months on-programme working towards meeting the Standard. The apprentice must spend at least 12 months on-programme and complete the required amount of off-the-job training in line with the apprenticeship funding rules. The employer should ensure that the apprentice has access to development opportunities to gain the KSBs, as outlined in the Standard, and must hold regular progress reviews with the provider and apprentice.

Once the apprentice has completed their training, they should be ready to go through Gateway to the EPA. See the '[Gateway](#)' and 'Assessment instructions' sections within this pack to understand what happens.

The EPA for this apprenticeship includes the following assessments which can be taken in any order, as requested by the apprentice:

Electrical engineering maintenance technician

- 300 Multiple-choice Test (facilitated online via e-volve online assessment platform)
- 700 Observation with Questions (facilitated by an IEPA)
- 710 Interview Underpinned by a Portfolio of Evidence (facilitated by an IEPA)

Mechanical engineering maintenance technician

- 301 Multiple-choice Test (facilitated online via e-volve online assessment platform)
- 701 Observation with Questions (facilitated by an IEPA)
- 711 Interview Underpinned by a Portfolio of Evidence (facilitated by an IEPA)

Control and instrumentation engineering maintenance technician

- 302 Multiple-choice Test (facilitated online via e-volve online assessment platform)
- 702 Observation with Questions (facilitated by an IEPA)
- 712 Interview Underpinned by a Portfolio of Evidence (facilitated by an IEPA)

Preparing for EPA

In preparation for EPA, providers and employers should:

- read the 'Assessment instructions' sections before reaching Gateway – the EPA Partnership Managers can help with any queries
- review which completed **recording forms and evidence** must be submitted, and when
- use the **recording forms** provided in the format laid out, unless indicated otherwise
- plan the venue and resources required for EPA – make sure the assessment environment is secure and comfortable, without interruptions
- use Proficient to help manage the apprentice's progress through EPA
- for on-site assessment, arrange for a designated contact to be available on the day to ensure the correct resources are available.

To help apprentices prepare for EPA, providers and employers should:

- explain the assessments and **recording forms** to the apprentice – refer to details in the 'Assessment instructions' sections of this pack
- agree a realistic timeframe for submission of evidence that meets the EPA deadlines – any delays in submission of evidence will delay the assessments
- make sure the apprentice has the resources and time to prepare for, and undertake, EPA

- take the apprentice through some mock assessments
- share the EPA Preparation Guide with the apprentice, which includes information about system requirements for virtual meetings
- let City & Guilds know if access arrangements are required to support an apprentice through EPA. Information about City & Guilds access arrangements, including reasonable adjustments is on the City & Guilds website, under [EPA Documents Library](#).

Authenticating the apprentice's work

The independent end-point assessor (IEPA) must ensure all decisions satisfy validity, authenticity, currency and sufficiency (VACS). For evidence produced outside controlled conditions, the apprentice will be required to:

- sign a declaration that the work is their own
- reference all sources.

The employer/provider should also aid authentication by:

- supplementary (oral) questioning to gauge familiarity with the topic
- looking out for any changes to the apprentice's usual writing style, unusual sources/examples or the use of US spellings or phrases that might indicate cutting and pasting from the internet
- requiring access to evidence of steps in the process, for example drafts, notes, planning etc.

City & Guilds have produced forms for use when reviewing evidence produced outside of controlled conditions. These forms include a Declaration of Authenticity form which must be completed when submitting evidence.

City & Guilds Position Statement on Artificial Intelligence

The following guidance on artificial intelligence is designed to help candidates, teachers and assessors to complete non-exam assessments (NEAs), coursework and other internal assessments successfully. Please ensure familiarity with it.

[Position Statement on AI | City & Guilds](#)

Health & Safety and Codes of Practice

The importance of safe working practices, the demands of the Health and Safety at Work Act and any Codes of Practice associated with the industry **must** always be adhered to.

Following safe working practices is an integral part of all City & Guilds assessments, and it is the responsibility of the provider and employer to ensure that all the health and safety requirements are in place when apprentices are working on any projects or before apprentices begin any EPA.

Should an apprentice fail to follow correct health and safety practices and procedures during an EPA, the IEPA may advise the apprentice to stop and explain why.

Results submission and feedback

The Multiple-choice Test component will be delivered using the e-volve on-screen test platform. Test results will be available on Walled Garden within 24 hours following the test.

The IEPA will not provide feedback to the apprentice during or immediately following the assessment process. The provider will be informed by the City & Guilds EPA Team of the assessment results.

The IEPA will communicate the grade allocated for each assessment to the Lead Independent End-point Assessor (LIEPA) for quality assurance and sampling. The LIEPA will submit the results to the City & Guilds EPA Team.

Summary feedback will be provided to all apprentices after any grade determination has been carried out. The feedback will cover the areas against which insufficient evidence has been provided, leading to a 'fail'. Our 'end-point assessment feedback' will also cover the areas against which the apprentice's evidence has resulted in the award of a pass, merit or distinction.

If the apprentice has passed EPA, the City & Guilds EPA Team will issue the EPA Statement of Achievement to the provider confirming the grade achieved and will notify Skills England who will issue the apprenticeship certificate.

Professional recognition

This apprenticeship aligns with the Institution of Mechanical Engineers (IMechE) and the Institution of Engineering and Technology (IET) for Engineering Technician (EngTech).

Statement of Achievement

A printed EPA Statement of Achievement will be issued to each successful apprentice.

Providers and employers with access can view and download PDF copies of the Statement 24 hours after the results are published. A PDF supports more efficient processing of funding claims by providing evidence of apprentice certification before the apprentice's paper certificate arrives.

The overall apprenticeship certificate will be issued by Skills England.

Digital credentials

A digital credential is a verified, visual representation of knowledge and skills earned in various learning environments. Please see an example below:



Digital credentials are issued and verified online, making it easy for individuals to demonstrate their competencies to employers, clients and peers online. Each digital credential has a unique URL that can be shared electronically via social media, in an email signature and on a CV. This is a complimentary service in addition to the paper certificate.

For further information, please visit the City & Guilds EPA Digital Credentials webpage and the general terms in respect of our privacy policy or contact digitalsupport@cityandguilds.com.

2. The apprenticeship Standard

Occupation summary

Engineering maintenance technicians work in a range of industries that use plant, equipment and systems. This includes energy, leisure, entertainment, manufacturing, processing and utilities companies. The working environments vary across the industries.

This is a core and options apprenticeship. An apprentice must be trained and assessed against the core and **one** option. The options are:

- 300/700/710 Electrical engineering maintenance technician
- 301/701/711 Mechanical engineering maintenance technician
- 302/702/712 Control and instrumentation engineering maintenance technician.

Occupational duties

This apprenticeship Standard has a number of duties which someone working in the role would typically be able to undertake. These duties are underpinned by a range of KSBs which a successful apprentice will be able to demonstrate:

Core duties (applicable to all options)	KSBs
Duty 1 Maintain and promote work site health, safety and environmental compliance. For example, conduct risk assessments and follow emergency procedures.	K3 K8 K10 K11 K12 K13 K14 K15 K16 K24 K29 K30 K31 S6 S7 S8 S9 S11 S12 S16 S17 S18 S19 S24 B1 B2
Duty 2 Liaise with stakeholders on maintenance work. For example, pre-job briefings, to plan work, to co-ordinate work with other maintenance disciplines, and to provide technical and regulatory advice.	K2 K3 K4 K27 K28 K29 K30 K31 S2 S4 S18 S19 S20 S24 B3 B4
Duty 3 Prepare for engineering maintenance work. For example, organise resources, obtain supplies of consumables and order parts.	K1 K3 K4 K5 K7 K17 K18 K29 K30 K31 S1 S2 S3 S4 S5 S13 S16 S18 S19 S24 B3
Duty 4 Review and accept job requirements. For example, accept safe system of work or permit to work.	K3 K29 K30 K31 S18 S19 S24



Core duties (applicable to all options)	KSBs
Duty 5 Ensure work meets regulatory, industry and company quality standards.	K3 K6 K9 K19 K20 K21 K22 K23 K29 K30 K31 S1 S10 S14 S15 S16 S18 S19 S20 S24
Duty 6 Conduct post-job close out. For example, sign-off job, handover engineering plant and equipment.	K3 K29 K30 K31 S18 S19 S24
Duty 7 Complete engineering maintenance records to company requirements. For example, job reports, stock control records and fault-finding reports.	K3 K12 K17 K25 K29 K30 K31 S13 S18 S19 S21 S22 S23 S24
Duty 8 Contribute to improvement activities. For example, support alternative ways of working to improve safety, reliability, sustainability, reduce cost or drive efficiency. Complete continued professional development.	K3 K17 K26 K27 K29 K30 K31 K32 S18 S19 S24 S25 S26 B5

Electrical engineering maintenance technician duties	KSBs
Duty 9 Conduct planned, preventative, and reactive maintenance on electrical aspects of plant, equipment, and systems.	K33, K34, K35, K36, K37, K38, K39, K40, K41, K42, K43, K44, K45 S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37
Duty 10 Conduct fault diagnosis and problem solving on electrical plant, equipment, and systems.	K33, K34, K35, K36, K37, K38, K39, K40, K41, K42, K43, K44, K45 S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37
Duty 11 Remove and replace electrical plant, equipment, and systems.	K33, K34, K35, K36, K37, K38, K39, K40, K41, K42, K43, K44, K45 S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37
Duty 12 Conduct inspection, examination, and testing of electrical plant, equipment, and systems.	K33, K34, K35, K36, K37, K38, K39, K40, K41, K42, K43, K44, K45 S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37

Electrical engineering maintenance technician duties	KSBs
<p>Duty 13 Ensure availability and performance of electrical maintenance tools and equipment.</p>	<p>K33, K34, K35, K36, K37, K38, K39, K40, K41, K42, K43, K44, K45</p> <p>S27, S28, S29, S30, S31, S32, S35, S36, S37</p>

Control and instrumentation engineering maintenance technician duties	KSBs
<p>Duty 14 Conduct planned, preventative, and reactive maintenance on control and instrumentation aspects of plant, control and instrumentation equipment, and control systems including calibration.</p>	<p>K46, K47, K48, K49, K50, K51, K52, K53, K54, K55, K56, K57, K58, K59, K60</p> <p>S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51</p>
<p>Duty 15 Conduct fault diagnosis and problem solving on control and instrumentation equipment and control systems.</p>	<p>K46, K47, K48, K49, K50, K51, K52, K53, K54, K55, K56, K57, K58, K59, K60</p> <p>S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51</p>
<p>Duty 16 Remove and replace control and instrumentation equipment and control systems.</p>	<p>K46, K47, K48, K49, K50, K51, K52, K53, K54, K55, K56, K57, K58, K59, K60</p> <p>S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51</p>
<p>Duty 17 Conduct inspection, examination, and testing of control and instrumentation equipment and control systems.</p>	<p>K46, K47, K48, K49, K50, K51, K52, K53, K54, K55, K56, K57, K58, K59, K60</p> <p>S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51</p>
<p>Duty 18 Control and instrumentation. Ensure availability and performance of control and instrumentation maintenance tools and equipment.</p>	<p>K46, K47, K48, K49, K50, K51, K52, K53, K54, K55, K56, K57, K58, K59, K60</p> <p>S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51</p>

Mechanical engineering maintenance technician duties	KSBs
<p>Duty 19 Conduct planned, preventative and reactive maintenance on mechanical aspects of plant, equipment and systems.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64</p>
<p>Duty 20 Conduct fault diagnosis and problem solving on mechanical aspects of plant, equipment and systems.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64</p>
<p>Duty 21 Remove and replace mechanical plant, equipment and systems.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64</p>
<p>Duty 22 Conduct inspection, examination and testing of mechanical aspects of plant.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64</p>
<p>Duty 23 Manufacture or assemble components for example, bespoke gaskets.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64</p>
<p>Duty 24 Ensure availability and performance of mechanical maintenance tools and equipment.</p>	<p>K61, K62, K63, K64, K65, K66, K67, K68, K69, K70, K71, K72, K73</p> <p>S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S63, S64</p>

Knowledge, skills and behaviours (KSBs)

Apprentices must demonstrate all of the core KSBs as well as the KSBs that are applicable to the selected option.

Ref.	Core knowledge, skills and behaviours	Assessment method
K1	Sectors in which engineering maintenance takes place. Impact of sector on maintenance activities.	Interview Underpinned by a Portfolio of Evidence
K2	Maintenance disciplines and functional areas and how they work together.	Interview Underpinned by a Portfolio of Evidence
K3	Individual maintenance technician's roles and responsibilities. Escalation procedures.	Interview Underpinned by a Portfolio of Evidence
K4	Business operation considerations: quality, cost, delivery, and ethical practices.	Observation with Questions
K5	Planning, prioritisation, organisation, and time management techniques.	Observation with Questions
K6	Equipment life cycle considerations.	Multiple-choice Test
K7	Maintenance strategies: planned preventative maintenance (PPM), condition-based maintenance (CBM), scheduled maintenance, total productive maintenance (TPM), breakdown and run to failure maintenance.	Multiple-choice Test
K8	Health and safety regulations – key features and impact on role: ATEX - safety requirements for workplaces and equipment used in explosive atmospheres, Control of Asbestos Regulations, Control of Major Accident Hazards (COMAH) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Display Screen Equipment Regulations (DSE), Health and Safety at Work Act (HASAWA), Lifting Operations and Lifting Equipment	Multiple-choice Test

Ref.	Core knowledge, skills and behaviours	Assessment method
	Regulations (LOLER), Management of Health and Safety at Work, Manual Handling Operations Regulations, Personal Protective Equipment (PPE) at Work Regulations, Provision and Use of Work Equipment Regulations (PUWER), The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Working at Height Regulations, Working in Confined Spaces Regulations, Workplace (health, safety, and welfare) Regulations.	
K9	Work environment hazards and risks. Risk assessments.	Observation with Questions
K10	Safe systems of work.	Observation with Questions
K11	Personal protective equipment (PPE): selection, use, and care.	Observation with Questions
K12	Asset security requirements.	Observation with Questions
K13	Environmental regulations and standards – impact on role: Environmental Management Systems standard, Environmental Protection Act, and Hazardous Waste Regulations.	Multiple-choice Test
K14	The UK's net zero commitment. Principles of sustainability.	Interview Underpinned by a Portfolio of Evidence
K15	Recycling and waste management requirements.	Observation with Questions
K16	Emergency incident and response procedures.	Interview Underpinned by a Portfolio of Evidence
K17	Algebraic methods. Trigonometric methods and standard formulae to determine areas and volumes. Statistical methods to display data (mean, mode, median). Elementary calculus techniques: coefficient, gradient of a curve, rate of change.	Multiple-choice Test

Ref.	Core knowledge, skills and behaviours	Assessment method
K18	Properties of engineering materials and impact on use.	Multiple-choice Test
K19	Sources of engineering information.	Observation with Questions
K20	Engineering standards - British (BSI) and International (ISO).	Observation with Questions
K21	Engineering representations, sketches, drawings, and graphical information conventions.	Multiple-choice Test
K22	Quality management systems.	Observation with Questions
K23	Standard operating procedures (SOPs): what they are and why they are important.	Observation with Questions
K24	Foreign material exclusion requirements.	Observation with Questions
K25	Documentation requirements: documentation control, auditable records.	Observation with Questions
K26	Continuous improvement (CI) systems and techniques.	Interview Underpinned by a Portfolio of Evidence
K27	Team working principles.	Interview Underpinned by a Portfolio of Evidence
K28	Principles of equity, diversity, and inclusion in the workplace.	Interview Underpinned by a Portfolio of Evidence

Ref.	Core knowledge, skills and behaviours	Assessment method
K29	Verbal communication methods and techniques. Engineering maintenance terminology.	Observation with Questions
K30	Written communication techniques.	Interview Underpinned by a Portfolio of Evidence
K31	Digital and information technology to support engineering maintenance. General data protection regulation (GDPR). Cyber security.	Interview Underpinned by a Portfolio of Evidence
K32	Industry 4.0 - the integration of physical systems with internet connectivity and cloud computing: technologies, systems, and benefits.	Multiple-choice Test
S1	Review and use information. For example, work instructions, drawings, design specifications, and plant configurations.	Observation with Questions
S2	Use planning, prioritising, organising, and time management techniques to plan tasks.	Observation with Questions
S3	Identify and organise resources to complete tasks. For example, consumables.	Observation with Questions
S4	Respond and adapt to work demands. For example, adapt working methods to reflect changes in working environment, re-prioritise workloads to react to breakdowns and fault scenarios.	Interview Underpinned by a Portfolio of Evidence
S5	Identify equipment to work on. Check plant configuration is as defined.	Observation with Questions
S6	Prepare the work area for maintenance tasks.	Observation with Questions
S7	Identify environmental and health and safety hazards and risks and apply control measures.	Observation with Questions

Ref.	Core knowledge, skills and behaviours	Assessment method
S8	Apply health, safety, and environmental procedures in compliance with regulations, standards, and guidance. For example, signage and barriers, working at height, confined spaces, and COSHH.	Observation with Questions
S9	Follow security procedures. For example, site access, document classification, and securing assets.	Observation with Questions
S10	Follow emergency incident and response procedures.	Interview Underpinned by a Portfolio of Evidence
S11	Apply sustainability principles. For example, minimising waste.	Interview Underpinned by a Portfolio of Evidence
S12	Segregate items for reuse, recycling, and waste.	Observation with Questions
S13	Use mathematical principles and formulae to support engineering maintenance.	Multiple-choice Test
S14	Apply engineering maintenance standards and procedures.	Observation with Questions
S15	Apply foreign material exclusion procedures.	Observation with Questions
S16	Follow maintenance tools and equipment control procedures. For example, handling and storage.	Observation with Questions
S17	Reinstate the work area.	Observation with Questions
S18	Apply team working principles.	Interview Underpinned by a Portfolio of Evidence

Ref.	Core knowledge, skills and behaviours	Assessment method
S19	Communicate with others to give and receive information. For example, colleagues, customers, and stakeholders.	Observation with Questions
S20	Escalate issues outside limits of responsibility.	Interview Underpinned by a Portfolio of Evidence
S21	Record information.	Observation with Questions
S22	Produce or update documents. For example, handover notes and reports.	Interview Underpinned by a Portfolio of Evidence
S23	Identify and highlight issues (red pen) with technical drawings.	Observation with Questions
S24	Use digital and information technology. For example, databases, data sharing platforms, email, management information systems, and word processing. Follow cyber security and GDPR requirements.	Interview Underpinned by a Portfolio of Evidence
S25	Apply continuous improvement techniques to identify improvement suggestions.	Interview Underpinned by a Portfolio of Evidence
S26	Carry out and record planned and unplanned learning and development activities.	Interview Underpinned by a Portfolio of Evidence

Ref.	Core knowledge, skills and behaviours	Assessment method
B1	Prioritise safe working practices. For example, risk aware, minimise risks, and proactively work towards preventing accidents.	Observation with Questions
B2	Consider sustainability when using resources and carrying out tasks.	Interview Underpinned by a Portfolio of Evidence
B3	Take ownership for the delivery and quality of own work. For example, self-motivated, disciplined in the approach to work tasks, and work carried out in line with standards.	Observation with Questions
B4	Team-focus to meet work goals and support inclusivity. For example, support others, show respect to others, and create and maintain productive working relationships.	Interview Underpinned by a Portfolio of Evidence
B5	Committed to continued professional development to maintain and enhance competence.	Interview Underpinned by a Portfolio of Evidence

Ref.	Electrical engineering maintenance technician knowledge	Assessment method
K33	Electrical. Electricity at Work regulations. IET wiring regulations.	Multiple-choice Test
K34	Electrical. Electrical isolation and deisolation requirements: lockout tagout and testing for dead.	Observation with Questions
K35	Electrical. Principles of single phase and three-phase equipment, plant, and systems, the operation of motors and generators, and the use of monitoring and protection equipment.	Multiple-choice Test
K36	Electrical. Electrical engineering principles: circuit terminology, Ohm's Law, transformer theory, and power calculations.	Multiple-choice Test
K37	Electrical. Functions and applications of electrical circuits.	Multiple-choice Test
K38	Electrical. Types of diagrams used to represent circuits; symbols and abbreviations used to represent components in electrical schematics.	Multiple-choice Test
K39	Electrical. Different types of cables; their specifications and application.	Multiple-choice Test
K40	Electrical. Cable termination methods.	Interview Underpinned by a Portfolio of Evidence
K41	Electrical. Electrical plant, equipment, and systems maintenance requirements: removing and replacing parts, inspecting, testing, setting up, adjusting, cleaning, and functional testing.	Observation with Questions
K42	Electrical. Electrical maintenance tools, measurement, and test equipment application, operation, care and calibration requirements.	Observation with Questions
K43	Electrical. Common electrical plant, equipment, and systems failure modes.	Interview Underpinned by a Portfolio of Evidence

Ref.	Electrical engineering maintenance technician knowledge	Assessment method
K44	Electrical. Electrical fault-finding and rectification techniques; diagnostic equipment.	Interview Underpinned by a Portfolio of Evidence
K45	Electrical. Problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence

Ref.	Electrical engineering maintenance technician skills	Assessment method
S27	Electrical. Confirm safe electrical isolation lockout tagout method has been applied and test for dead.	Observation with Questions
S28	Electrical. Select, check, and use electrical maintenance tools, measurement, and test equipment.	Observation with Questions
S29	Electrical. Use electrical diagnostic equipment and apply fault finding and rectification techniques.	Interview Underpinned by a Portfolio of Evidence
S30	Electrical. Apply problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence
S31	Electrical. Inspect and test electrical aspects of plant. For example, visual checks, insulation and continuity checks, thermographic surveys, and voltage levels.	Observation with Questions
S32	Electrical. Remove and replace electrical parts.	Observation with Questions
S33	Electrical. Prepare and terminate electrical cables.	Interview Underpinned by a Portfolio of Evidence
S34	Electrical. Set up, align and adjust electrical aspects of plant.	Observation with Questions

Ref.	Electrical engineering maintenance technician skills	Assessment method
S35	Electrical. Clean parts. For example, removal of dust and debris.	Observation with Questions
S36	Electrical. Conduct and confirm electrical and connected services deisolation.	Observation with Questions
S37	Electrical. Conduct functional testing.	Observation with Questions

Ref.	Mechanical engineering maintenance technician knowledge and understanding	Assessment method
K61	Mechanical. Electricity at Work regulations.	Multiple-choice Test
K62	Mechanical. Pneumatic and hydraulic system principles: Air compressors, hydraulic pumps, filters, regulators, lubricators.	Multiple-choice Test
K63	Mechanical. Mechanical principles, terminology, and calculations: stress, strains, bending moment, heat transfer, fluid dynamics.	Multiple-choice Test
K64	Mechanical. Function and application of mechanical elements of plant and equipment.	Multiple-choice Test
K65	Mechanical. Different types of mechanical fasteners and their uses.	Multiple-choice Test
K66	Mechanical. Types of diagrams used to represent mechanical installations and assemblies; symbols and abbreviations used to represent parts in diagrams.	Multiple-choice Test
K67	Mechanical. Isolation and deisolation of connected services: considerations and requirements.	Observation with Questions
K68	Mechanical. Mechanical maintenance requirements and techniques: removing and replacing parts, inspecting, testing, setting up, adjusting, cleaning, and lubricating.	Observation with Questions
K69	Mechanical. Mechanical maintenance tools and equipment application, operation, care, and calibration requirements.	Observation with Questions

Ref.	Mechanical engineering maintenance technician knowledge and understanding	Assessment method
K70	Mechanical. Common maintenance problems relating to mechanical aspects of plant and equipment.	Interview Underpinned by a Portfolio of Evidence
K71	Mechanical. Mechanical maintenance fault-finding and rectification techniques; diagnostic equipment.	Interview Underpinned by a Portfolio of Evidence
K72	Mechanical. Problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence
K73	Mechanical. Bench fitting techniques: cutting threads, mechanical fitting, and joining.	Interview Underpinned by a Portfolio of Evidence

Ref.	Mechanical engineering maintenance technician skills	Assessment method
S52	Mechanical. Check and confirm safe isolation of connected services.	Observation with Questions
S53	Mechanical. Select, check, and use mechanical maintenance tools and equipment.	Observation with Questions
S54	Mechanical. Use mechanical diagnostic equipment and apply fault finding and rectification techniques.	Interview Underpinned by a Portfolio of Evidence
S55	Mechanical. Apply problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence
S56	Mechanical. Check condition and operation of mechanical aspects of plant and equipment. For example, pumps.	Observation with Questions
S57	Mechanical. Remove and replace mechanical parts.	Observation with Questions
S58	Mechanical. Examine mechanical parts for defects. For example, pump seals.	Observation with Questions
S59	Mechanical. Set up, align, and adjust mechanical aspects of plant.	Observation with Questions
S60	Mechanical. Clean parts. For example, removal of dust and debris.	Observation with Questions
S61	Mechanical. Lubricate mechanical assemblies.	Observation with Questions

Ref.	Mechanical engineering maintenance technician skills	Assessment method
S62	Mechanical. Confirm electrical and connected services deisolation.	Observation with Questions
S63	Mechanical. Conduct functional testing.	Observation with Questions
S64	Mechanical. Apply bench fitting techniques.	Interview Underpinned by a Portfolio of Evidence

Ref.	Control and instrumentation engineering maintenance technician knowledge and understanding	Assessment method
K46	Control and instrumentation. Electricity at Work regulations. IET wiring regulations.	Multiple-choice Test
K47	Control and instrumentation. Isolation and deisolation of connected services considerations and requirements.	Observation with Questions
K48	Control and instrumentation. Electrical isolation and deisolation requirements: lockout tagout, testing for dead.	Observation with Questions
K49	Control and instrumentation. Control and instrumentation engineering principles, terminology, and calculations.	Multiple-choice Test
K50	Control and instrumentation. Control and instrumentation equipment installation and connection requirements.	Multiple-choice Test
K51	Control and instrumentation. Operating principles of control and instrumentation devices: flow, level, pressure, and temperature instruments, analysers, transducers, transmitters, gauges, and pneumatics.	Multiple-choice Test
K52	Control and instrumentation. Open and closed loop systems. First and second order control systems. Proportional–integral–derivative controller (PID controller or three-term controller).	Multiple-choice Test
K53	Control and instrumentation. Functions and applications of control and instrumentation systems: programmable logic controller (PLC), Direct Digital Control (DDC), Distributed Control System (DCS), and Supervisory Control And Data Acquisition (SCADA).	Multiple-choice Test
K54	Control and instrumentation. Types of control and instrumentation diagrams.	Multiple-choice Test

Ref.	Control and instrumentation engineering maintenance technician knowledge and understanding	Assessment method
K55	Control and instrumentation. Control and instrumentation equipment and control systems maintenance requirements and methods: removing and replacing instruments and sensors, inspecting, testing, cleaning, setting up, calibration, and functional testing.	Observation with Questions
K56	Control and instrumentation. Control and instrumentation maintenance tools and equipment application, operation, care, and calibration requirements.	Observation with Questions
K57	Control and instrumentation. Common control and instrumentation equipment and control system failure modes.	Interview Underpinned by a Portfolio of Evidence
K58	Control and instrumentation. Control and instrumentation maintenance fault-finding and rectification techniques; diagnostic equipment.	Interview Underpinned by a Portfolio of Evidence
K59	Control and instrumentation. Problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence
K60	Control and instrumentation. Different types of cables; their specifications and application.	Observation with Questions

Ref.	Control and instrumentation engineering maintenance technician skills	Assessment method
S38	Control and instrumentation. Conduct and confirm safe isolation of connected services.	Observation with Questions
S39	Control and instrumentation. Confirm safe electrical isolation lockout tagout method has been applied and test for dead.	Observation with Questions
S40	Control and instrumentation. Select, check, and use control and instrumentation maintenance tools, measurement, and test equipment.	Observation with Questions
S41	Control and instrumentation. Use control and instrumentation diagnostic equipment and apply fault finding and rectification techniques.	Interview Underpinned by a Portfolio of Evidence

Ref.	Control and instrumentation engineering maintenance technician skills	Assessment method
S42	Control and instrumentation. Apply problem solving and critical reasoning techniques.	Interview Underpinned by a Portfolio of Evidence
S43	Control and instrumentation. Inspect and test control and instrumentation systems.	Observation with Questions
S44	Control and instrumentation. Check calibration and make adjustments.	Observation with Questions
S45	Control and instrumentation. Check loop function.	Observation with Questions
S46	Control and instrumentation. Set up and adjust control and instrumentation systems.	Observation with Questions
S47	Control and instrumentation. Clean parts. For example, removal of dust and debris.	Observation with Questions
S48	Control and instrumentation. Remove and replace instruments and sensors.	Observation with Questions
S49	Control and instrumentation. Re-connect instrumentation power supply, cables, pipework, and services.	Observation with Questions
S50	Control and instrumentation. Conduct and confirm electrical and connected services deisolation.	Observation with Questions
S51	Control and instrumentation. Conduct functional testing.	Observation with Questions

Overall grade

This EPA is graded fail, pass, merit or distinction. The IEPA will individually grade the Observation with Questions and Interview Underpinned by a Portfolio of Evidence.

Information about how each assessment method is graded can be found in the 'Assessment instructions' sections of this pack. The apprentice will fail an assessment method if they do not meet the criteria.

In order to achieve an overall EPA **pass**, apprentices must achieve a pass in all the assessment methods.

In order to achieve an overall EPA **merit**, apprentices must achieve a distinction in the Observation with Questions and a pass in the Multiple-choice Test and Interview Underpinned by a Portfolio of Evidence.

In order to achieve an overall EPA **distinction**, apprentices must achieve a pass in the Multiple-choice Test and a distinction in both the Observation with Questions and the Interview Underpinned by a Portfolio of Evidence.

Grades from individual assessment methods will be combined in the following way to determine the grade of the EPA as a whole:

700/701/702 Observation with Questions	710/711/712 Interview Underpinned by Portfolio of Evidence	300/301/302 Multiple-choice Test	Overall grading
Any grade	Any grade	Fail	Fail
Any grade	Fail	Any grade	Fail
Fail	Any grade	Any grade	Fail
Pass	Pass	Pass	Pass
Pass	Distinction	Pass	Pass
Distinction	Pass	Pass	Merit
Distinction	Distinction	Pass	Distinction

The overall EPA grade will be capped at a **pass** if the apprentice has had to resit or retake any assessment method, however the grade the apprentice has achieved for each component is not capped and will be identified on the Statement of Achievement.

3. Gateway

The EPA period will only start when the **employer** is satisfied that the apprentice is consistently working at, or above, the level of the Standard. The apprentice must be able to evidence that they fully demonstrate the Occupational Standard and required level of professional competence in an authentic workplace context. In making this decision, the employer could take advice from the provider, but the ultimate decision is made solely by the employer.



If there is a **provider** working alongside the employer, they should support the apprentice's preparation for Gateway.

The apprentice must provide the following at Gateway:

- confirmation that they are ready to take the EPA
- confirmation of the achievement of English and mathematics qualifications in line with the apprenticeship funding rules
- a portfolio of evidence for the Interview Underpinned by a Portfolio of Evidence (accompanied by the signed and dated recording forms).

Any assessment materials relating to national security must not be submitted to City & Guilds.

The following should be completed on Proficient:

- Gateway Declaration Form signed by the apprentice
- Gateway Declaration by the provider, on behalf of the employer and tutor, confirming that the apprentice has completed the minimum time required on-programme, in line with the apprenticeship funding rules
- Gateway questions including initial information about the maintenance task(s) that the apprentice will be undertaking for the Observation with Questions.

City & Guilds will confirm when all the Gateway requirements have been met.

The 'Assessment instructions' sections provide additional details about the evidence which must be submitted at Gateway.

4. Timetable for End-point Assessment



The EPA period is typically completed within four months of the EPA Gateway, starting when City & Guilds has confirmed that all Gateway requirements have been met.

Further information about the booking process and timelines can be found in the [City & Guilds Manual for the End-point Assessment Service](#).

Optional planning meetings will be provided for this Standard. The EPA Partnership Managers can provide additional guidance.

Ongoing during on-programme	Evidence and forms
<p>Provider and employer</p> <ul style="list-style-type: none"> Reviews progress as part of their regular performance management process and ensures apprentice's performance is on track Identifies any gaps and creates a plan with the apprentice Enrols apprentice on Proficient (checking that the apprentice is enrolled onto the correct option and Standard) and provides 'Expected date ready for EPA' 	<p>Completes:</p> <ul style="list-style-type: none"> Gateway questions on Proficient
<p>Apprentice</p> <ul style="list-style-type: none"> Completes training to develop the knowledge, skills and behaviours (KSBs) outlined in the Apprenticeship Standard (Section 2 of this pack) Fulfils the English and Mathematics requirements in line with the apprenticeship funding rules Compiles a portfolio of evidence 	<p>Collates:</p> <ul style="list-style-type: none"> Portfolio of evidence (typically during the last 12 months of the apprenticeship)
Gateway process	Evidence and forms
<p>Employer</p> <ul style="list-style-type: none"> Reviews progress and confirms that the apprentice is ready for EPA Reviews the evidence to confirm that it is appropriate and sufficient to meet the Standard 	<p>Signs:</p> <ul style="list-style-type: none"> Portfolio of evidence reference form and declaration of authenticity Gateway questions on Proficient Apprentice Gateway Declaration

<ul style="list-style-type: none"> Plans the maintenance task(s) to be completed in the observation with questions 	
Apprentice <ul style="list-style-type: none"> Attends the optional EPA planning meeting Must have been on programme for the minimum time required, in line with the apprenticeship funding rules Plans the maintenance task(s) to be completed in the observation with questions Completes and submits evidence and forms 	Submits to provider: <ul style="list-style-type: none"> Apprentice Gateway Declaration Portfolio of evidence Portfolio of evidence reference form and declaration of authenticity
Provider – on Proficient <ul style="list-style-type: none"> Books EPA on Proficient, in line with City & Guilds; booking timelines are in the EPA Manual Makes City & Guilds aware of any additional needs of the apprentice so that they can review reasonable adjustments – see the current policy on the City & Guilds website, under EPA Documents Library Completes Provider Gateway Declaration on behalf of the employer and tutor Uploads evidence and forms onto Proficient 	Complete on Proficient: <ul style="list-style-type: none"> Provider Gateway Declaration Preferred (optional) planning meeting date form (on behalf of the employer) Gateway questions Signs: <ul style="list-style-type: none"> Declaration of authenticity Uploads onto Proficient: <ul style="list-style-type: none"> Apprentice Gateway Declaration Portfolio of evidence, accompanied by the relevant portfolio of evidence reference form and declaration of authenticity forms
City & Guilds EPA Gateway Team <ul style="list-style-type: none"> Formally confirms when all the Gateway requirements have been met 	N/A
City & Guilds EPA Team <ul style="list-style-type: none"> Agrees on a mutually convenient date for the optional EPA planning meeting with the provider and IEPA Agrees on a mutually convenient date for the EPA events with the provider and IEPA 	N/A
Post Gateway	Evidence and forms
<ul style="list-style-type: none"> Employer, provider, apprentice and IEPA attend the (optional) planning meeting 	N/A
End-point Assessment	Evidence and forms
Apprentice <ul style="list-style-type: none"> Completes EPAs 	N/A
Employer <ul style="list-style-type: none"> Ensures the apprentice has access to the resources required for the assessments (see the Resources section) 	N/A
Provider <ul style="list-style-type: none"> Submits evidence and forms 	N/A
IEPA	Completes:

<ul style="list-style-type: none"> • Reviews the portfolio of evidence prior to the interview assessment • Carries out EPAs • Marks each assessment, communicates the results to the LIEPA • Provides feedback for assessments in Proficient 	<ul style="list-style-type: none"> • IEPA recording forms • Overall grade recording form • Feedback form
<p>LIEPA</p> <ul style="list-style-type: none"> • Samples and quality-assures the assessments 	<p>Reviews:</p> <ul style="list-style-type: none"> • IEPA recording forms • Overall grade recording form • Feedback form
<p>City & Guilds EPA Team</p> <ul style="list-style-type: none"> • Communicates the results to the provider via Proficient • Processes the overall result if the apprentice has passed all the assessments and advises Skills England, who issue the certificate. The data will be provided to Skills England. 	<p>N/A</p>

Summary timescales

Readers should check the previous Timetable and the Assessment Instruction sections of this document for the detailed requirements for each stage.

Further information on EPA Service Timelines can be found on www.cityandguilds.com.

On programme	Enrol apprentice on Proficient, including 'expected date ready for EPA' Collate portfolio of evidence
Gateway process	Provider submits required evidence and forms on Proficient Portfolio of evidence submitted Completes Gateway questions
Gateway	Assessment components can only be booked after Gateway has been approved
Planning meeting	(Optional) planning meeting takes place a minimum of ten working days after Gateway
Observation with Questions	City & Guilds must give the apprentice 2 weeks' notice of the observation with questions
Interview Underpinned by a Portfolio of Evidence	City & Guilds must give the apprentice 2 weeks' notice of the interview
Multiple-choice Test	The apprentice must be given at least 2 weeks' notice of the date and time of the multiple-choice test

End-point Assessment completed

5. End-point Assessment resources

Assessment method	Resources required
Observation with Questions	<p>Realistic working environment reflecting typical working conditions on actual plant and equipment with normal personnel available, eg operators, manager/supervisors.</p> <p>Under exceptional circumstances, the Observation with Questions can be carried out in a simulated environment. This must be agreed with the City & Guilds EPA Operations team.</p> <p>The environment should include sufficient space for the City & Guilds IEPA to observe and take notes.</p> <p>A separate room must be made available for the IEPA which is free from distractions and interruptions.</p> <p>Any organisation/task-specific PPE must be made available to the IEPA.</p>
Interview Underpinned by a Portfolio of Evidence	<p>A quiet room, free from distractions and interruptions. It must be away from the pressures of work activities, in a controlled environment. This will be on either the employer's or provider's premises.</p> <p>Access to water and cups.</p> <p>Where applicable, internet access and suitable equipment for remote assessment, as outlined in the EPA Manual.</p>
Multiple-choice Test	<p>IT systems set up to receive e-volve tests, as set out in the EPA Manual.</p> <p>An invigilator.</p> <p>A suitably controlled and invigilated environment that is a quiet room, free from distractions and influence. It must be away from the pressures of work activities. This will be on either the employer's or provider's premises.</p>

6. Assessment information: 300/301/302 Multiple-choice Test

Overview

The Multiple-choice Test gives the apprentice the opportunity to demonstrate the knowledge mapped to this assessment method. Apprentices will complete one Multiple-choice Test covering knowledge for the **core** and their selected **option**.

Rationale

This assessment method is being used because it can assess knowledge, is easy to administer and can be conducted remotely and administered to multiple apprentices at the same time, potentially reducing cost.

Number of questions	40
Marks available	40
Grading	P/X To achieve a pass , the apprentice must achieve a minimum of 28 marks (70%)
Type of questions	Multiple choice
Duration	60 minutes
Marking	The test will be carried out online and marked electronically
Permitted materials	Closed book: This means the apprentice cannot refer to reference books or materials during the test
Equipment	Scientific calculator
Location	A suitably controlled and invigilated environment that is a quiet room, free from distractions and influence

Assessment specifications

9331-300 Electrical engineering maintenance technician

KSB	KSB statement	Questions	%
K6	Core: Equipment life cycle considerations.	1	2.5%
K7	Core: Maintenance strategies: planned preventative maintenance (PPM), condition-based maintenance (CBM), scheduled maintenance, total productive maintenance (TPM), breakdown and run to failure maintenance.	2	5%
K8	Core: Health and safety regulations – key features and impact on role: ATEX - safety requirements for workplaces and equipment used in explosive atmospheres, Control of Asbestos Regulations, Control of Major Accident Hazards (COMAH) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Display Screen Equipment Regulations (DSE), Health and Safety at Work Act (HASAWA), Lifting Operations and Lifting Equipment Regulations (LOLER), Management of Health and Safety at Work, Manual Handling Operations Regulations, Personal Protective Equipment (PPE) at Work Regulations, Provision and Use of Work Equipment Regulations (PUWER), The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Working at Height Regulations, Working in Confined Spaces Regulations, Workplace (health, safety, and welfare) Regulations.	4	10%
K13	Core: Environmental regulations and standards – impact on role: Environmental Management Systems standard, Environmental Protection Act, and Hazardous Waste Regulations.	2	5%
K17	Core: Algebraic methods. Trigonometric methods and standard formulae to determine areas and volumes. Statistical methods to display data (mean, mode, median). Elementary calculus techniques: coefficient, gradient of a curve, rate of change.	2	5%
K18	Core: Properties of engineering materials and impact on use.	2	5%
K21	Core: Engineering representations, sketches, drawings, and graphical information conventions.	2	5%

KSB	KSB statement	Questions	%
K32	Core: Industry 4.0 - the integration of physical systems with internet connectivity and cloud computing: technologies, systems, and benefits.	3	7.5%
S13	Core: Use mathematical principles and formulae to support engineering maintenance.	2	5%
K33	Electrical: Electricity at Work regulations. IET wiring regulations.	3	7.5%
K35	Electrical: Principles of single phase and three-phase equipment, plant, and systems, the operation of motors and generators, and the use of monitoring and protection equipment.	4	10%
K36	Electrical: Electrical engineering principles: circuit terminology, Ohm's Law, transformer theory, and power calculations.	4	10%
K37	Electrical: Functions and applications of electrical circuits.	3	7.5%
K38	Electrical: Types of diagrams used to represent circuits; symbols and abbreviations used to represent components in electrical schematics.	3	7.5%
K39	Electrical: Different types of cables; their specifications and application.	3	7.5%
	Total	40	100%

9331-301 Mechanical engineering maintenance technician

KSB	KSB statement	Questions	%
K6	Core: Equipment life cycle considerations.	1	2.5%
K7	Core: Maintenance strategies: planned preventative maintenance (PPM), condition-based maintenance (CBM), scheduled maintenance, total productive maintenance (TPM), breakdown and run to failure maintenance.	2	5%
K8	Core: Health and safety regulations – key features and impact on role: ATEX - safety requirements for workplaces and equipment used in explosive atmospheres, Control of Asbestos Regulations, Control of Major Accident Hazards (COMAH) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Dangerous	4	10%

KSB	KSB statement	Questions	%
	Substances and Explosive Atmospheres Regulations (DSEAR), Display Screen Equipment Regulations (DSE), Health and Safety at Work Act (HASAWA), Lifting Operations and Lifting Equipment Regulations (LOLER), Management of Health and Safety at Work, Manual Handling Operations Regulations, Personal Protective Equipment (PPE) at Work Regulations, Provision and Use of Work Equipment Regulations (PUWER), The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Working at Height Regulations, Working in Confined Spaces Regulations, Workplace (health, safety, and welfare) Regulations.		
K13	Core: Environmental regulations and standards – impact on role: Environmental Management Systems standard, Environmental Protection Act, and Hazardous Waste Regulations.	2	5%
K17	Core: Algebraic methods. Trigonometric methods and standard formulae to determine areas and volumes. Statistical methods to display data (mean, mode, median). Elementary calculus techniques: coefficient, gradient of a curve, rate of change.	2	5%
K18	Core: Properties of engineering materials and impact on use.	2	5%
K21	Core: Engineering representations, sketches, drawings, and graphical information conventions.	2	5%
K32	Core: Industry 4.0 - the integration of physical systems with internet connectivity and cloud computing: technologies, systems, and benefits.	3	7.5%
S13	Core: Use mathematical principles and formulae to support engineering maintenance.	2	5%
K61	Mechanical. Electricity at Work regulations.	2	5%
K62	Mechanical. Pneumatic and hydraulic system principles: Air compressors, hydraulic pumps, filters, regulators, lubricators.	4	10%
K63	Mechanical. Mechanical principles, terminology, and calculations: stress, strains, bending moment, heat transfer, fluid dynamics.	4	10%
K64	Mechanical. Function and application of mechanical elements of plant and equipment.	4	10%

KSB	KSB statement	Questions	%
K65	Mechanical. Different types of mechanical fasteners and their uses.	3	7.5%
K66	Mechanical. Types of diagrams used to represent mechanical installations and assemblies; symbols and abbreviations used to represent parts in diagrams.	3	7.5%
	Total	40	100%

9331-302 Control and instrumentation engineering maintenance technician

KSB	KSB statement	Questions	%
K6	Core: Equipment life cycle considerations.	1	2.5%
K7	Core: Maintenance strategies: planned preventative maintenance (PPM), condition-based maintenance (CBM), scheduled maintenance, total productive maintenance (TPM), breakdown and run to failure maintenance.	2	5%
K8	Core: Health and safety regulations – key features and impact on role: ATEX - safety requirements for workplaces and equipment used in explosive atmospheres, Control of Asbestos Regulations, Control of Major Accident Hazards (COMAH) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Display Screen Equipment Regulations (DSE), Health and Safety at Work Act (HASAWA), Lifting Operations and Lifting Equipment Regulations (LOLER), Management of Health and Safety at Work, Manual Handling Operations Regulations, Personal Protective Equipment (PPE) at Work Regulations, Provision and Use of Work Equipment Regulations (PUWER), The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Working at Height Regulations, Working in Confined Spaces Regulations, Workplace (health, safety, and welfare) Regulations.	4	10%
K13	Core: Environmental regulations and standards – impact on role: Environmental Management Systems standard, Environmental Protection Act, and Hazardous Waste Regulations.	2	5%
K17	Core: Algebraic methods. Trigonometric methods and standard formulae to determine areas and	2	5%

KSB	KSB statement	Questions	%
	volumes. Statistical methods to display data (mean, mode, median). Elementary calculus techniques: coefficient, gradient of a curve, rate of change.		
K18	Core: Properties of engineering materials and impact on use.	2	5%
K21	Core: Engineering representations, sketches, drawings, and graphical information conventions.	2	5%
K32	Core: Industry 4.0 - the integration of physical systems with internet connectivity and cloud computing: technologies, systems, and benefits.	3	7.5%
S13	Core: Use mathematical principles and formulae to support engineering maintenance.	2	5%
K46	Control and instrumentation. Electricity at Work regulations. IET wiring regulations.	3	7.5%
K49	Control and instrumentation. Control and instrumentation engineering principles, terminology, and calculations.	3	7.5%
K50	Control and instrumentation. Control and instrumentation equipment installation and connection requirements.	3	7.5%
K51	Control and instrumentation. Operating principles of control and instrumentation devices: flow, level, pressure, and temperature instruments, analysers, transducers, transmitters, gauges, and pneumatics.	3	7.5%
K52	Control and instrumentation. Open and closed loop systems. First and second order control systems. Proportional–integral–derivative controller (PID controller or three-term controller).	2	5%
K53	Control and instrumentation. Functions and applications of control and instrumentation systems: programmable logic controller (PLC), Direct Digital Control (DDC), Distributed Control System (DCS), and Supervisory Control And Data Acquisition (SCADA).	3	7.5%
K54	Control and instrumentation. Types of control and instrumentation diagrams.	3	7.5%
	Total	40	100%

Assessment instructions

Delivery

The Multiple-choice Test is structured to give the apprentice the opportunity to demonstrate the knowledge mapped to this assessment method to the highest available grade. The test is computer-based via City & Guilds' e-volve platform.

A minimum of two questions will be included that assess S13 'Use mathematical principles and formulae to support engineering maintenance'. These questions will be scenario based to assess the application of mathematical principles and formulae in an engineering maintenance context.

The apprentice must be given at least two weeks' notice of the date and time of the test.

Administration

The apprentice must have 60 minutes to complete the test. The test is closed book which means that the apprentice cannot refer to reference books or materials whilst completing the test. A scientific calculator is allowed to be used during the test.

Assessment location

The apprentice must take the test in a suitably controlled and invigilated environment that is a quiet room, free from distractions and influence.

KSBs and amplification

In order to support teaching and learning, knowledge statements assessed through the multiple-choice tests have been amplified. The full amplification can be found in **Appendix 1**.

Grading

The Multiple-choice Test will be graded fail or pass.

Grade	Marks	%
Fail	27	67.5
Pass	28	70

7. Assessment information: 700/701/702 Observation with Questions

Overview

The IEPA will observe the apprentice in their workplace and will ask questions, giving the apprentice the opportunity to demonstrate the KSBs mapped to this assessment method.

The apprentice will complete their day-to-day duties under normal working conditions. The assessment will take place in a realistic working environment that does not require special clearance.

Rationale

This assessment method is being used because it is a practical role and the assessment can take place in a real work setting, giving employers assurance about an apprentice's competence. The familiar setting should also allow apprentices to perform at their best whilst allowing for holistic assessment of the KSBs. This assessment method is cost effective and tasks completed during assessment should contribute to workplace productivity, making use of the employer's resources and equipment.

Number of questions	The IEPA will ask a minimum of four questions.
Grading	P/D/X To achieve a pass the apprentice must demonstrate all of the pass grading descriptors. To achieve a distinction , the apprentice must demonstrate all of the pass descriptors and all of the distinction descriptors.
Type of assessment	Observation with Questions
Duration	Four hours. The IEPA can increase the time by up to 10%
Permitted materials	Apprentices are allowed access to the documentation that they would usually use in their daily work. This includes organisation-specific work instructions and job cards where required.
Location	The Observation with Questions will be conducted face to face at the apprentice's normal place of work.
Resources	Apprentices must have access to the resources they use to complete their usual daily work activities.

Assessment specifications

The apprentice will be assessed against the **core** and one **option**.

9331-700 Electrical engineering maintenance technician

Description	Coverage	KSBs	Grade
Observation with Questions	Core – Organising own work	K4, K5, S2, S3	P/D/X
	Core – Maintaining workplace health, safety, security and environmental compliance	K9, K10, K11, K12, K15, S7, S8, S9, S12, B1	
	Core – Using work information and following working practices	K19, K20, K22, K23, K24, S1, S5, S6, S14 S15, S16, S17, S23, B3	
	Core – Completing work records	K25, S21	
	Core – Communicating with others	K29, S19	
	Electrical – Conducting planned electrical maintenance	K34, K41, K42, S27, S28, S31, S32, S34, S35, S36, S37	

9331-701 Mechanical engineering maintenance technician

Description	Coverage	KSBs	Grade
Observation with Questions	Core – Organising own work	K4, K5, S2, S3	P/D/X
	Core – Maintaining workplace health, safety, security and environmental compliance	K9, K10, K11, K12, K15, S7, S8, S9, S12, B1	
	Core – Using work information and following working practices	K19, K20, K22, K23, K24, S1, S5, S6, S14 S15, S16, S17, S23, B3	

Description	Coverage	KSBs	Grade
	Core – Completing work records	K25, S21	
	Core – Communicating with others	K29, S19	
	Mechanical – Conducting planned mechanical maintenance	K67, K68, K69, S52, S53, S56, S57, S58, S59, S60, S61, S62, S63	

9331-702 Control and instrumentation engineering maintenance technician

Description	Coverage	KSBs	Grade
Observation with Questions	Core – Organising own work	K4, K5, S2, S3	P/D/X
	Core – Maintaining workplace health, safety, security and environmental compliance	K9, K10, K11, K12, K15, S7, S8, S9, S12, B1	
	Core – Using work information and following working practices	K19, K20, K22, K23, K24, S1, S5, S6, S14 S15, S16, S17, S23, B3	
	Core – Completing work records	K25, S21	
	Core – Communicating with others	K29, S19	
	Control and instrumentation – Conducting planned control and instrumentation maintenance	K47, K48, K55, K56, K60, S38, S39, S40, S43, S44, S45, S46, S47, S48, S49, S50, S51	

Assessment instructions

Duration

The Observation with Questions will take four hours. The IEPA may increase the time of the assessment by up to 10% to allow the apprentice to complete a task or respond to a question if necessary. The time for questioning is included in the overall assessment time.

The apprentice may choose to end the assessment method early, but the apprentice must be confident they have demonstrated competence against the assessment requirements for the assessment method. The IEPA cannot suggest or choose to end the assessment early, unless in an emergency. The IEPA will explain to the apprentice the implications of ending the assessment early or may suggest that the assessment continues. The IEPA will record the apprentice's request to end the assessment early.

Delivery

The IEPA will observe one apprentice at a time to ensure quality and rigour of the assessment and will be as unobtrusive as possible.

Assessment location

The Observation with Questions must take place at the apprentice's normal place of work, for example the employer's or a customer's premises. In **exceptional circumstances**, ie where national security clearance, nuclear licensed clearance or live gas site safety concerns prevent the IEPA from being able to access an employer's or customer's premises, the IEPA will take advice from the City & Guilds EPA team on access arrangements and how to record assessment evidence in line with the employer's requirements. In these circumstances, it may be necessary for the assessment to take place in a simulated environment, eg a training provider's premises, a training facility in the employer's premises, a test centre or a similar simulated environment.

In all cases where a simulated environment is requested, it must relate to the apprentice's natural work environment and must be agreed with the City & Guilds EPA team prior to the assessment taking place.

Resources

The apprentice will need access to the documentation and resources they use in their daily work. Equipment and resources needed for the observation must be confirmed to be available prior to the assessment and must be in good and safe working condition. Please ensure that any specific PPE required for the premises is provided to the IEPA on the day of the assessment.

Administration

The City & Guilds EPA team will arrange the date and time of the Observation with Questions with the employer/provider and apprentice.

Prior to the assessment

Planning

The provider, employer and apprentice must plan the maintenance task(s)/work to be undertaken, ensuring that the tasks/work will enable the apprentice to demonstrate the KSBs and grading descriptors in the specification, within the four hour (+10%) assessment time.

The provider must also complete the Gateway questions that relate to:

- the assessment location/venue, eg access requirements such as site induction, where the assessment will be carried out and if there are any exceptional circumstances that may necessitate a simulated environment
- details of the planned maintenance task(s), eg the nature of the task(s) and if there are likely to be any pre-installed aspects (n.b. only certain skills statements are allowed to have pre-installed aspects, see as follows).

It is strongly recommended a planning meeting is arranged with the employer, apprentice and IEPA present. Suggested dates for the planning meeting must be provided at Gateway.

An optional planning document is provided in **Appendix 4** to support employers/providers and apprentices to plan the maintenance tasks. If a planning meeting has been arranged, this document can be used to support the discussion with the IEPA in the meeting.

Pre-installed aspects

If demonstration of the following skills will not naturally occur in the work/tasks the apprentice will be undertaking, then it is possible to include minimal pre-installed aspects to replicate real scenarios. Skills where pre-installed aspects are permissible are as follows:

- S32 Electrical: Remove and replace electrical parts
- S44 Control and instrumentation: Check calibration and make adjustments
- S46 Control and instrumentation: Set up and adjust control and instrumentation systems
- S48 Control and instrumentation: Remove and replace instruments and sensors
- S57 Mechanical: Remove and replace mechanical parts
- S59 Mechanical: Set up, align, and adjust mechanical aspects of plant

Any pre-installed aspects relating to these skills must be communicated and agreed with the IEPA prior to the start of the assessment (the planning document can be used to capture this information).

During the assessment

The IEPA will observe the apprentice undertaking planned maintenance task(s) that demonstrate the **core** and relevant **option** requirements:

Core requirements

- Organising own work
- Maintaining workplace health, safety, security and environmental compliance
- Using work information and following working practices
- Completing work records
- Communicating with others

Electrical engineering maintenance technician apprentices must cover the core requirements and:

- safe electrical isolation and de-isolation procedures
- selecting, checking and using tools and equipment in line with task requirements
- inspecting and testing electrical aspects of plant
- removing and replacing electrical parts
- setting up and adjusting electrical aspects of plant and equipment
- cleaning parts
- conducting functional testing.

Control and instrumentation engineering maintenance technician apprentices must cover the core requirements and:

- safe electrical isolation and de-isolation procedures including re-connecting instrumentation power supply, cables, pipework and services
- selecting, checking and using tools and equipment in line with task requirements
- inspection and testing
- checking calibration and loop function
- removing and replacing instruments and systems
- setting up, aligning and adjusting plant and equipment
- cleaning parts
- conducting functional testing.

Mechanical engineering maintenance technician apprentices must cover the core requirements and:

- checking and confirming safe isolation and de-isolation

- selecting, checking and using mechanical maintenance tools and equipment in line with task requirements
- checking the operation and condition of mechanical aspects of plant and equipment
- examining mechanical parts for defects
- setting up and adjusting mechanical aspects of plant and equipment
- cleaning parts, lubricating mechanical assemblies
- conducting functional testing.

It is important that employers/providers and apprentices refer to the assessment specification found in this section and the relevant core and option KSBs and grading descriptors in **Appendix 2** when planning the work to be undertaken.

Photographs

If the IEPA intends to take photographs during the observation, eg of the various stages of the work being carried out, then permission will be sought from both the employer and apprentice prior to the assessment.

Questioning

The IEPA will ask the apprentice at least four questions as part of the assessment, ensuring that they do not disrupt the apprentice's flow as they are completing the task(s). If questioning occurs after the observation, then this will take place in a quiet room, free from distractions and influence. The IEPA's questions will be included in the overall four hours of assessment time.

Grading

The Observation with Questions will be graded fail, pass or distinction. The IEPA is fully responsible for making the grading decision. The results will not be shared with you on the day of the assessment.

8. Assessment information: 710/711/712 Interview Underpinned by a Portfolio of Evidence

Overview

In the interview, the IEPA asks the apprentice questions giving them the opportunity to demonstrate the KSBs mapped to this assessment component. The apprentice can refer to and illustrate their answers with evidence from their submitted portfolio of evidence.

The City & Guilds EPA team will arrange the dates and times for the interview with the employer/provider and apprentice.

Rationale

This assessment method is being used because it allows for the holistic assessment of KSBs that do not occur on a predictable or regular basis. It also allows for the assessment of responses where there are a range of potential answers. The interview can be conducted remotely if required.

Number of questions	<p>The IEPA will ask a minimum of nine questions. Follow-up questions may be asked where clarification is required.</p> <p>Whilst the portfolio of evidence is not directly assessed, the IEPA will use it to prepare their questions and guide the interview.</p>
Grading	<p>Pass/Fail/Distinction</p> <p>The apprentice must demonstrate all the pass grading descriptors to achieve a pass.</p> <p>The apprentice must demonstrate all the pass and distinction grading descriptors to achieve a distinction.</p>
Type of assessment	Interview Underpinned by a Portfolio of Evidence
Duration	75 minutes. The IEPA can increase the time by 10% if required.
Permitted materials	Portfolio of evidence
Location	Employer or provider premises, in a quiet room free from distractions. The interview can be conducted face to face or by video conferencing.

Resources

A suitable room for the interview to take place that is quiet and free from distractions and influence.

Seating area or room for any other apprentices to wait (if appropriate).

Access to water and cups.

Internet access and suitable equipment such as use of video link. If a video link is used appropriate measures must be in place to ensure that City & Guilds is satisfied that the responses given are those of the apprentice, eg use of a 360-degree camera to allow the assessor to look around the room during the interview.

Assessment specifications

The apprentice will be assessed on the core and one option.

710 Electrical engineering maintenance technician

Description	Coverage	KSBs	Grade
Interview Underpinned by a Portfolio of Evidence	Core – Impact of the sector on maintenance activities	K1	X/P/D
	Core – Role and responsibilities	K2, K3, K16, S4, S10, S20	
	Core – Working sustainably	K14, S11, B2	
	Core – Participating in continuous improvement	K26, S25, S26, B5	
	Core – Teamworking	K27, K28, S18, B4	
	Core – Produce written documents	K30, S22	
	Core – Digital and information technology	K31, S24	
	Electrical maintenance problem solving and fault finding	K43, K44, K45, S29, S30	
	Cable installation and termination	K40, S33	

711 Mechanical engineering maintenance technician

Description	Coverage	KSBs
Interview Underpinned by a Portfolio of Evidence	Core – Impact of the sector on maintenance activities	K1
	Core – Role and responsibilities	K2, K3, K16, S4, S10, S20
	Core – Working sustainably	K14, S11, B2

Description	Coverage	KSBs
	Core – Participating in continuous improvement	K26, S25, S26, B5
	Core – Teamworking	K27, K28, S18, B4
	Core – Produce written documents	K30, S22
	Core – Digital and information technology	K31, S24
	Mechanical maintenance problem solving and fault finding	K70, K71, K72, S54, S55
	Bench fitting techniques	K73, S64

712 Control and instrumentation engineering maintenance technician

Description	Coverage	KSBs
Interview Underpinned by a Portfolio of Evidence	Core – Impact of the sector on maintenance activities	K1
	Core – Role and responsibilities	K2, K3, K16, S4, S10, S20
	Core – Working sustainably	K14, S11, B2
	Core – Participating in continuous improvement	K26, S25, S26, B5
	Core – Teamworking	K27, K28, S18, B4
	Core – Produce written documents	K30, S22
	Core – Digital and information technology	K31, S24
	Control and instrumentation maintenance problem solving and fault finding	K57, K58, K59, S41, S42

Assessment instructions

Duration

The interview must last for 75 minutes. The IEPA can increase the time of the interview by up to 10% to allow the apprentice to respond to a question if necessary.

The apprentice may choose to end the assessment method early but must be confident they have demonstrated competence against the assessment requirements for the assessment method. The IEPA cannot suggest or choose to end the assessment early, unless in an emergency. The IEPA will explain to the apprentice the implications of ending the assessment early or may suggest that the assessment continues. The IEPA will record the apprentice's request to end the assessment early.

Delivery

The interview will be structured to give the apprentice the opportunity to demonstrate the KSBs mapped to this assessment method to the highest available grade. During the interview, the IEPA will ask the apprentice at least nine questions based on the apprentice's submitted portfolio of evidence and the grading descriptors. The purpose of the questions is to assess the apprentice's competence against the required core and option themes. Coverage of the themes is shown in the assessment specification for this assessment method.

Assessment location

The interview may be conducted in person or remotely. The interview must take place in a suitable venue, for example, the employer's or provider's premises. The assessment location will be agreed by the City & Guilds EPA team. The employer/provider is responsible for ensuring that the assessment can take place in appropriate surroundings which are free from distractions and influence. This could include ensuring that appropriate signposting and other arrangements are in place to maintain a suitable environment throughout the duration of the assessment activity.

The IEPA will verify the identity of the apprentice and ensure the apprentice is not being aided during the interview.

Administration

The date and time of the interview must be planned in advance to ensure that the apprentice has sufficient time to prepare. The apprentice must have at least two weeks' notice of the date of the interview.

Portfolio of Evidence requirements (including authentication of)

The apprentice will compile their portfolio during the on-programme period of the apprenticeship, usually towards the end of the apprenticeship in the last 12 months. The evidence can be produced in electronic format or scanned/photographed to give a clear electronic representation, as it must be submitted electronically for End-point Assessment.

The apprentice's portfolio of evidence must only contain evidence related to the KSBs that will be assessed during the interview assessment.

Evidence must be mapped against the KSBs and can demonstrate more than one KSB; a qualitative as opposed to quantitative approach is suggested.

Types of evidence

The portfolio of evidence should cover the specific activities/jobs the apprentice has undertaken which demonstrate the KSBs mapped to this assessment component. It is recommended that a maximum of three activities/jobs will be covered by the portfolio of evidence. These activities/'jobs' can be evidenced in a variety of ways and will typically include 10 pieces of discrete evidence, for example:

- workplace documentation and records: for example maintenance records, fault investigation reports
- witness statements, eg from a manager or a customer
- annotated photographs, eg of a specific activity carried out
- video clips with a maximum total duration of 10 minutes; the apprentice must be in view and identifiable.

This is not a definitive list and other evidence sources can be included.

The portfolio of evidence should not include reflective accounts or any methods of self-assessment. Any employer contributions should focus on direct observation of performance, for example, witness statements, rather than opinions.

All evidence must be of the apprentice's own work and, for any group work, must clarify and focus only on their contribution.

Where necessary, confidentiality and data protection requirements must be adhered to, eg permissions for use of video/images containing identifiable third parties (eg clients), anonymised documentation and permissions from clients when submitting designs and plans commissioned by them.

Selecting evidence

Before selecting the evidence to form the portfolio, the apprentice should review the assessment requirements and specification to confirm:

- the KSBs to be covered by the portfolio
- the type of evidence that can be presented (see above)
- the amount of evidence that should be presented

- the period of time from which the evidence should have originated (usually this will be towards the end of the apprenticeship).

To assemble their portfolio, the apprentice should consider all the evidence they have available that shows they have met the requirements being assessed. Evidence collected towards the end of their apprenticeship programme, as they become independent in their work, is likely to provide the most holistic evidence – ie covering a number of criteria at once. From this, they should select evidence that **most efficiently** meets all the relevant criteria and which demonstrates their **best performance**. While there may be some overlap between the evidence collected, multiple pieces of evidence showing coverage of the same criteria should not normally be submitted for End-point Assessment.

There are two questions that an apprentice should consider when selecting work to form their portfolio:

1. *Which pieces holistically (most efficiently) give evidence that together cover all of the relevant criteria?*
2. *Is this the **best** evidence I have, showing that I have met all of the requirements for the higher grade?*

Confirming the evidence selection

When the apprentice has selected the evidence to form their portfolio, this must be reviewed by the employer/provider to ensure:

- all assessment requirements have been met
- there is no unnecessary duplication of evidence against the same criteria
- the work selected represents the best evidence available in relation to grading requirements
- the clarity of any images or scanned evidence is sufficient to determine the quality of the original evidence
- authenticity of evidence has been established.

The provider/employer is responsible for providing guidance to the apprentice on compiling the portfolio of evidence whilst on programme. The employer should provide suitable work for the apprentice to apply themselves to and discuss at interview.

The provider/employer is responsible for the review of the portfolio of evidence and if, in its entirety, it does not contain sufficient evidence to meet the Standard then it will be deemed not yet ready to submit. The apprentice must be advised by the employer/provider about the shortfalls in evidence and how this can be addressed.

A portfolio of evidence checklist has been provided in **Appendix 5** to support the apprentice and employer/provider in the preparation and submission of the portfolio of evidence.

Preparing the portfolio of evidence for submission

The portfolio of evidence and completed **portfolio of evidence reference form** must be reviewed by the employer/provider and the apprentice to ensure it meets the requirements of the Standard and to confirm that the apprentice is ready for EPA.

The evidence will not be directly assessed but the IEPA will use the information provided to base their questions on. The City & Guilds EPA team may ask for further clarification if required.

The evidence provided must be valid and attributable to the apprentice and the submitted portfolio must be accompanied by the signed **declaration of authenticity**. In the cases of national security, arrangements may be made between City & Guilds and the employer for the redaction of information in the evidence, as per the employer's security policy, or where this is not possible, on-site reviewing of the evidence prior to the interview taking place.

Submission to City & Guilds

The following documents must be submitted to City & Guilds at Gateway:

- portfolio of evidence
- declaration of authenticity (signed by the apprentice, provider and employer representative)
- portfolio of evidence reference form.

KSBs and grading descriptors

A mapping table detailing KSBs assessed using this method and grading descriptors can be found in **Appendix 2**.

Grading

The interview will be graded fail, ass or distinction. The IEPA is fully responsible for making the grading decision. The results will not be shared with you on the day of the assessment.

9. Resits and retakes

Apprentices who fail one or more assessments will be offered the opportunity for a resit or retake at their employer's discretion.

- A resit is where the apprentice takes the assessment again without the need for new learning.
- A retake is where the employer determines new learning is needed first.

The employer and City & Guilds will agree the timescale for a resit or retake. A resit is typically taken within two months of the EPA outcome notification. The timescale for a retake is dependent on how much re-training is required and is typically taken within four months of the EPA outcome notification.

Any failed assessment method must be resat or retaken within a six-month period from the EPA outcome notification, otherwise the entire EPA will need to be resat or retaken in full.

Resits or retakes must not be offered to an apprentice wishing to move from pass to a higher grade.

The overall EPA grade will be capped at a pass if the apprentice has had to resit or retake any assessment method, however the grade the apprentice has achieved for each component is not capped and will be identified on the statement of achievement.

300/301/302 Multiple-choice Test

If the retake or resit relates to the multiple-choice test, the apprentice will be presented with a new randomised online multiple-choice test.

700/701/702 Observation with Questions

If the resit or retake relates to the observation with questions, the IEPA will observe the apprentice under the same circumstances.

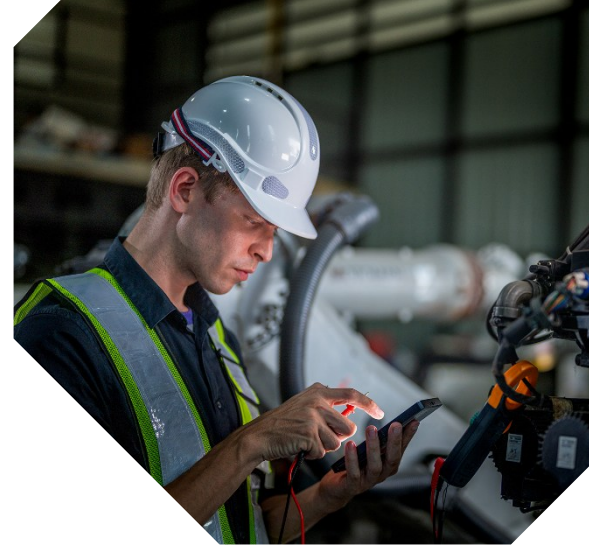
710/711/712 Interview Underpinned by a Portfolio of Evidence

If the resit or retake relates to the interview underpinned by a portfolio of evidence, the IEPA will question the apprentice on the same subject area but using a different set of questions.

The interview will be carried out in the same way as the original assessment. The IEPA may review the portfolio of evidence again to ensure all the KSBs are evidenced.

Submission must include

An updated portfolio reference form if required. These must refer to the version of recording forms originally submitted.



10. Security, confidentiality and copyright of End-point Assessment materials

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- provide access, on request, to City & Guilds to any system(s) on which any EPA Assessment Materials appear, are stored or delivered from time to time.

Appendix 1 – KSB amplification for 300/301/302 Multiple-Choice Tests

K6 Equipment life cycle considerations

Topic	Content – What needs to be covered
6.1 Stages of equipment life cycle	6.1.1 Stages of equipment life cycle <ul style="list-style-type: none"> a) Concept and planning: Identifying requirements, feasibility studies and risk assessments b) Design and procurement: Material selection, specification writing and supplier evaluation c) Installation and commissioning: Site preparation, alignment and initial testing d) Operation and utilisation: Day-to-day use, performance monitoring and minor adjustments e) Maintenance and renewal: Applying strategies to preserve or restore functionality f) Decommissioning and disposal: Safe shutdown, dismantling, recycling or scrapping
6.2 Factors for equipment life cycle	6.2.1 Factors for equipment life cycle <ul style="list-style-type: none"> a) Cost-effectiveness <ul style="list-style-type: none"> i) Total cost of ownership (TCO): Balancing upfront cost of initial investment against ongoing expense of maintenance and operational costs b) Reliability and availability <ul style="list-style-type: none"> i) Mean time between failures (MTBF) ii) Redundancy iii) Critical analysis c) Technology life cycle planning <ul style="list-style-type: none"> i) Obsolescence ii) Upgradability iii) Artificial intelligence (AI) d) Net zero targets, energy efficiency, carbon footprint and net zero impacts e) Health and safety integration <ul style="list-style-type: none"> i) Compliance with health and safety regulations ii) Risk mitigation strategies

K7 Maintenance strategies: planned preventative maintenance (PPM), condition-based maintenance (CBM), scheduled maintenance, total productive maintenance (TPM), breakdown and run to failure maintenance

Topic	Content – What needs to be covered
7.1 Maintenance strategy methods	7.1.1 Maintenance strategies and systematic methods used to manage the reliability, availability and performance of plant, equipment and systems

	<ul style="list-style-type: none"> a) Planned preventive maintenance (PPM): Time- or usage-based routines performed at fixed intervals to prevent failure b) Condition-based maintenance (CBM): Triggered by monitored data indicating degradation c) Total productive maintenance (TPM): Holistic, collaborative approach aiming for zero defects and breakdowns <ul style="list-style-type: none"> i) Daily checks ii) Autonomous maintenance iii) Focused improvement iv) Training d) Breakdown or run-to-failure maintenance: Reactive approach where maintenance is only performed after equipment failure e) Scheduled maintenance: Calendar- or meter-based overhauls, often overlapping with PPM
<p>7.2 Selecting suitable strategies for equipment optimisation</p>	<p>7.2.1 Factors influencing the selection of maintenance strategies</p> <ul style="list-style-type: none"> a) Use failure modes and effects analysis (FMEA) or risk matrices and risk scoring to determine appropriate strategies to maintain the upkeep of critical assets b) Cost-benefit analysis: Comparison of strategy costs versus potential downtime, repair and safety impacts c) Technology and data requirements: CBM requires sensors and analytics, TPM requires workforce engagement and training d) Life cycle alignment: Strategy selection should correspond to equipment stage – new install vs ageing asset e) Regulatory and safety compliance: Maintenance must meet legal standards and reduce risk to personnel and environment

K8 Health and safety regulations – key features and impact on role: ATEX - safety requirements for workplaces and equipment used in explosive atmospheres, Control of Asbestos Regulations, Control of Major Accident Hazards (COMAH) Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Display Screen Equipment Regulations (DSE), Health and Safety at Work Act (HASAWA), Lifting Operations and Lifting Equipment Regulations (LOLER), Management of Health and Safety at Work, Manual Handling Operations Regulations, Personal Protective Equipment (PPE) at Work Regulations, Provision and Use of Work Equipment Regulations (PUWER), The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Working at Height Regulations, Working in Confined Spaces Regulations, Workplace (health, safety, and welfare) Regulations

Topic	Content – What needs to be covered
<p>8.1 Features of health and safety legislations and</p>	<p>8.1.1 Hazardous environments and substances</p>

<p>regulations relevant to engineering maintenance</p>	<ul style="list-style-type: none"> a) ATEX – Equipment and safety in explosive atmospheres; requires identification of hazardous zones and compliant systems b) DSEAR – Management of flammable/explosive substances; requires risk controls and safe storage c) COSHH – Control of hazardous substances; requires safe handling, PPE and exposure monitoring <p>8.1.2 Workplace safety and general duties</p> <ul style="list-style-type: none"> a) HSWA – Primary legislation that sets overarching duties for health, safety and welfare at work b) Management of Health and Safety at Work Regulations – Requires risk assessments and health and safety arrangements <p>8.1.3 Equipment and operational safety</p> <ul style="list-style-type: none"> a) PUWER – Ensures work equipment is suitable, maintained and safely operated b) LOLER – Regulates lifting equipment and operations; requires inspection and safe use <p>8.1.4 Manual tasks and ergonomics</p> <ul style="list-style-type: none"> a) Manual Handling Regulations – Prevents injury from lifting/moving loads; requires risk assessment and training b) Display Screen Equipment (DSE) Regulations – Covers safe use of screens; requires workstation assessments <p>8.1.5 Incident and emergency management</p> <ul style="list-style-type: none"> a) RIDDOR – Requires reporting of injuries, diseases and dangerous occurrences b) COMAH – Controls major accident hazards; requires emergency planning and risk control <p>8.1.6 Working conditions and environments</p> <ul style="list-style-type: none"> a) Working at Height Regulations – Requires fall protection and safe access planning b) Confined Spaces Regulations – Requires permits-to-work and emergency procedures c) Workplace (Health, Safety and Welfare) Regulations – Covers ventilation, lighting, cleanliness and welfare facilities d) PPE Regulations – Requires provision, use and maintenance of appropriate protective equipment
<p>8.2 Impact of health and safety regulations on engineering maintenance roles</p>	<p>8.2.1 Hazardous environments and substances</p> <ul style="list-style-type: none"> a) ATEX and DSEAR <ul style="list-style-type: none"> i) Hazardous zones and equipment compliance ii) Conditions for working with explosive or flammable substances b) COSHH <ul style="list-style-type: none"> i) Exposure risks and control measures for hazardous substances ii) PPE requirements and chemical system considerations

	<p>8.2.2 Workplace safety and general duties</p> <ul style="list-style-type: none"> a) HSWA and Management of Health and Safety Regulations <ul style="list-style-type: none"> i) Safety responsibilities of employers and employees ii) Risk management expectations iii) Workplace conditions and behavioural standards <p>8.2.3 Equipment and operational safety</p> <ul style="list-style-type: none"> a) Inspection and maintenance expectations for work equipment (PUWER) b) Lifting equipment safety and operational standards (LOLER) c) Documentation and compliance requirements (PUWER, LOLER) <p>8.2.4 Manual tasks and ergonomics</p> <ul style="list-style-type: none"> a) Manual handling risk factors and control measures (Manual Handling Regulations) b) Ergonomic setup and screen use considerations (DSE Regulations) c) Training and procedural expectations (Manual Handling, DSE) <p>8.2.5 Incident and emergency management</p> <ul style="list-style-type: none"> a) Reporting obligations and incident categories (RIDDOR, COMAH) b) Emergency planning and escalation procedures (COMAH) c) Risk reduction and compliance monitoring (RIDDOR, COMAH) <p>8.2.6 Working conditions and environments</p> <ul style="list-style-type: none"> a) Fall protection and access planning (Working at Height Regulations) b) Permit-to-work systems and confined space entry protocols (Confined Spaces Regulations) c) Environmental safety expectations (Confined Spaces Regulations) <p>8.2.7 PPE use and maintenance</p> <ul style="list-style-type: none"> a) PPE Regulations <ul style="list-style-type: none"> i) PPE types and suitability for tasks ii) Inspection and maintenance standards for PPE iii) Storage and usage expectations
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K13 Environmental regulations and standards – impact on role: Environmental Management Systems standard, Environmental Protection Act, and Hazardous Waste Regulations

Topic	Content – What needs to be covered
13.1 Features of environmental regulations and standards	<p>13.1.1 Scope, purpose and key requirements of environmental regulations and standards</p> <ul style="list-style-type: none"> a) Environmental Management Systems standard (ISO 14001) <ul style="list-style-type: none"> i) Environmental management framework for continual improvement

	<ul style="list-style-type: none"> ii) Sets expectations for monitoring, reporting and compliance b) Environmental Protection Act (EPA) <ul style="list-style-type: none"> i) UK legislation for pollution control and waste management ii) Defines responsibilities for waste producers and handlers iii) Awareness of statutory nuisance and proper waste handling c) Hazardous Waste Regulations <ul style="list-style-type: none"> i) Governs classification and disposal of hazardous waste ii) Required documentation and safe handling procedures iii) Responsibilities for waste segregation and record-keeping d) Waste Electrical and Electronic Equipment (WEEE) <ul style="list-style-type: none"> i) Disposal and documentation of electrical/electronic waste
13.2 Application of environmental regulations and standards in engineering maintenance	13.2.1 Environmental practices and procedures in engineering maintenance <ul style="list-style-type: none"> a) Environmental impacts of maintenance work <ul style="list-style-type: none"> i) Emissions ii) Waste b) Sustainable practices <ul style="list-style-type: none"> i) Energy-efficient methods c) Recycling and segregation of materials e) Procedures for managing loss of containment (spill response) f) Maintaining records <ul style="list-style-type: none"> i) Waste transfer notes ii) Audit logs

K17 Algebraic methods Trigonometric methods and standard formulae to determine areas and volumes. Statistical methods to display data (mean, mode, median). Elementary calculus techniques: coefficient, gradient of a curve, rate of change

Topic	Content – What needs to be covered
17.1 Algebraic and trigonometric methods in engineering maintenance	17.1.1 Use of algebraic and trigonometric methods to support engineering calculations <ul style="list-style-type: none"> a) Types of algebraic expressions <ul style="list-style-type: none"> i) Linear ii) Quadratic iii) Simultaneous equations b) Methods of rearranging and solving equations c) Use of substitution and factorisation d) Trigonometric functions in right-angled triangles <ul style="list-style-type: none"> i) Sine ii) Cosine

	<ul style="list-style-type: none"> iii) Tangent e) Use of Pythagoras' theorem f) Standard area and volume formulae for common shapes
17.2 Statistical methods to display data	<p>17.2.1 Use of statistical techniques to interpret and present engineering data</p> <ul style="list-style-type: none"> a) Definitions and uses of mean, mode and median b) Methods of presenting data (tables, bar charts, histograms) c) Purpose of statistical analysis in engineering (identifying trends in failure rates)
17.3 Elementary calculus in engineering contexts	<p>17.3.1 Use of basic calculus concepts to understand change and trends in engineering systems</p> <ul style="list-style-type: none"> a) Concept of a coefficient and its role in equations b) Gradient of a curve: interpretation and calculation c) Rate of change: understanding variable changes over time or distance

K18 Properties of engineering materials and impact on use

Topic	Content – What needs to be covered
18.1 Properties of engineering materials	<p>18.1.1 Types and effects of material properties and failure modes</p> <ul style="list-style-type: none"> a) Chemical properties: <ul style="list-style-type: none"> i) corrosion resistance ii) reactivity with other substances b) Electrical properties: <ul style="list-style-type: none"> i) conductivity ii) resistivity iii) dielectric strength c) Mechanical properties: <ul style="list-style-type: none"> i) tensile strength ii) hardness iii) ductility iv) toughness d) Physical properties: <ul style="list-style-type: none"> i) density ii) melting point iii) opacity iv) magnetism e) Thermal properties: <ul style="list-style-type: none"> i) thermal conductivity ii) expansion iii) heat resistance
18.2 Material properties and impact on use	<p>18.2.1 Material properties and impact on use</p> <ul style="list-style-type: none"> a) Identifying material suitability – matching material properties to operational requirements during part replacement or fault diagnosis b) Identifying degradation factors:

	<ul style="list-style-type: none"> i) environmental exposure (moisture, temperature, UV) ii) mechanical stress iii) chemical exposure iv) fatigue c) Considerations for selection: <ul style="list-style-type: none"> i) cost ii) availability iii) sustainability iv) compatibility with existing systems d) Examples of poor material selection: <ul style="list-style-type: none"> i) corrosion due to incompatible metals ii) premature wear due to incorrect hardness iii) deterioration due to environmental factors
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K21 Engineering representations, sketches, drawings, and graphical information conventions

Topic	Content – What needs to be covered
21.1 Types and purposes of engineering drawings	21.1.1 Types and uses of engineering representations and graphical formats <ul style="list-style-type: none"> a) Assembly drawings: show how components fit together; used for installation and maintenance reference b) Detail drawings: provide dimensions, tolerances and material specifications for specific individual parts c) General arrangement (GA) drawings: show the overall layout of systems or equipment in context d) Isometric sketches: represent 3D objects in 2D; useful for visualising components and assemblies e) Orthographic projections: 2D views: include front, top and side f) Piping and instrumentation diagrams (P&ID): show process flow, instrumentation and control systems g) Schematics: represent electrical or fluid systems using standard symbols and connections h) Circuit diagrams: show electrical connections and component layout for building and troubleshooting circuits.
21.2 Conventions and interpretation of engineering drawings	21.2.1 Conventions and interpretation of engineering drawings <ul style="list-style-type: none"> a) Common line types and their meanings <ul style="list-style-type: none"> i) Hidden ii) Centre iii) Cutting plane b) Use of scale, dimensions and tolerances c) Common standard symbols used in mechanical, electrical and fluid systems – standard reference IEC 60617 / BS8888 / ISO1219 <ul style="list-style-type: none"> i) Diameter

	<ul style="list-style-type: none"> ii) Straightness iii) Perpendicularity iv) Parallelism v) Concentricity vi) Switch vii) Resistor viii) Lamp ix) Motor x) Solenoid xi) Valve xii) Cylinder xiii) Compressor xiv) Pump xv) Reservoir <p>d) Title blocks, revision history and drawing numbering systems</p>
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K32 Industry 4.0 - the integration of physical systems with internet connectivity and cloud computing: technologies, systems, and benefits

Topic	Content – What needs to be covered
32.1 Principles and benefits of Industry 4.0	<p>32.1.1 Key principles of Industry 4.0 in engineering environments</p> <ul style="list-style-type: none"> a) Cyber-physical systems (CPS): physical equipment integrated with digital control and monitoring b) Internet of Things (IoT): connected sensors and devices that share data in real time c) Cloud computing: remote access to data and systems for monitoring and diagnostics d) Real-time data: live system feedback used for performance monitoring and fault detection e) Predictive maintenance: using data to anticipate and prevent equipment failures f) Interconnectivity: systems, machines and people linked for improved communication and control g) Technician awareness: understanding how these principles affect maintenance tasks and system reliability <p>32.1.2 Benefits of Industry 4.0 in engineering environments</p> <ul style="list-style-type: none"> a) Reduced downtime: predictive tools identify faults before failure b) Improved efficiency: automation and data feedback streamline operations c) Remote access: technicians can monitor and diagnose systems off-site d) Faster fault response: real-time alerts enable quicker interventions e) Informed decisions: access to live and historical data supports maintenance planning

	<ul style="list-style-type: none"> f) Enhanced safety: automated systems detect hazards and reduce manual checks g) Digital records: maintenance activities and system status are logged automatically
32.2 Technologies and systems enabling Industry 4.0	<p>32.2.1 Key technologies and systems enabling Industry 4.0</p> <ul style="list-style-type: none"> a) Sensors and IoT devices: collect and transmit operational data b) Edge computing: processes data locally for faster response times c) Automation systems: programmable logic controllers (PLCs) and robotics d) AI and machine learning: analyse data trends to support predictive maintenance e) Human-machine interfaces (HMIs): allow technicians to interact with smart systems f) Integrated software platforms: link maintenance, operations and data analytics
32.3 Connectivity and cloud computing in Industry 4.0	<p>32.3.1 Role of internet connectivity and cloud platforms in integration</p> <ul style="list-style-type: none"> a) Internet connectivity: enables machines, sensors and systems to share data in real time b) Cloud platforms: store and process equipment data remotely for analysis and monitoring c) Digital twins: virtual models simulate asset performance and support planning d) Cloud-based analytics: support predictive maintenance by identifying trends and risks e) Remote diagnostics: technicians access system data off-site to identify faults f) CMMS tools: cloud-based systems used to log faults, schedule tasks and track asset history g) Technician awareness: understanding how connectivity and cloud systems improve fault detection and maintenance efficiency

S13 Use mathematical principles and formulae to support engineering maintenance

Topic	Content – What needs to be covered
13.1 Mathematical methods used in engineering maintenance	<p>13.1.1 Mathematical principles and formulae used to support engineering maintenance within typical engineering context</p> <ul style="list-style-type: none"> a) Algebraic applications: Rearranging equations to isolate unknowns in maintenance calculations <ul style="list-style-type: none"> i) Ohm's Law ($V = I \times R$) used to find voltage, current or resistance in a circuit ii) Force over Area ($P=F/A$) iii) Torque formula ($T = F \times r$) for mechanical assemblies or tightening electrical connections b) Statistical applications: Interpreting results for decision-making <ul style="list-style-type: none"> i) Mean (average: $\sum x/n$)

	<ul style="list-style-type: none"> ii) Mode (most frequent value) iii) Median (middle value after sorting) iv) Basic variability (range as max-min; standard deviation as $\sqrt{[\sum(x-\mu)^2/n]}$; outliers as values >3 SD from mean) <ul style="list-style-type: none"> c) Trigonometric applications: <ul style="list-style-type: none"> i) Use of sine, cosine and tangent to resolve forces and angles ii) Bolt preload force components in angled flanges iii) Shim sizing for machinery levelling based on misalignment angles d) Performing calculations during preparation, fault diagnosis, testing or improvement maintenance e) Rounding appropriately and cross-checking results against tolerances or historical data
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K33 Electrical. Electricity at Work regulations. IET wiring regulations

Topic	Content – What needs to be covered
33.1 Roles and responsibilities under electrical regulations	<p>33.1.1 Employer roles and responsibilities</p> <ul style="list-style-type: none"> a) Provide appropriate training for the task(s). b) Ensure that all workplace electrical equipment and systems are safe and maintained correctly to prevent accidents c) Conduct risk assessment on a regular basis to identify potential electrical hazards d) Arrange routine inspections, testing and maintenance of electrical equipment (portable appliance testing (PAT)) <p>33.1.2 Employee roles and responsibilities</p> <ul style="list-style-type: none"> a) Follow employer’s safety procedures when working with electrical systems b) Complete safety training as required by employer c) Report any electrical faults, damage or unsafe conditions immediately d) Never attempt to repair an electrical system or equipment unless qualified to do so <p>33.1.3 Self-employed roles and responsibilities</p> <ul style="list-style-type: none"> a) Self-employment status is not exempt from health and safety laws b) Take reasonable care for own safety and the safety of others c) Report any electrical faults, damage or unsafe conditions immediately d) Conduct risk assessment to identify potential electrical hazards
33.2 Compliance with electrical regulations	<p>33.2.1 Regulation compliance</p> <p>An awareness of the contents of the EAWR and IET wiring regulations to ensure compliance when completing maintenance activities:</p> <ul style="list-style-type: none"> a) Electricity at Work Regulations (EAWR)

	<ul style="list-style-type: none"> i) Installation, maintenance and inspection of electrical systems ii) Isolation procedures and prevention of danger from live conductors iii) Emphasis on competence, testing and risk assessment before commencing work <p>b) IET wiring regulations (BS 7671)</p> <ul style="list-style-type: none"> i) Role in ensuring electrical safety and system reliability ii) Used as a reference during installation, maintenance, testing and certification iii) Installation characteristics and selection of equipment iv) Environments (internal, external, moisture/IP considerations) v) Importance of updates and periodic revisions vi) IET On-site Guide (OSG) <p>33.2.2 Documentation and record keeping</p> <ul style="list-style-type: none"> a) Electrical installation certificates b) Portable appliance test (PAT) c) Permit to work d) Risk assessment e) Test records and maintenance logs f) Audit trails for compliance g) Consequences of non-compliance <ul style="list-style-type: none"> i) Legal penalties and enforcement actions ii) Increased risk of electric shock, arc flash, fire and fatalities iii) Impact on business reputation, insurance and operational continuity
33.3 Application and scope of IET wiring regulations	<p>33.3.1 Relationship between BS 7671 and EAWR</p> <ul style="list-style-type: none"> a) BS 7671 provides technical standards supporting EAWR compliance b) EAWR is statutory law; BS 7671 is a code of practice <p>33.3.2 Protective measures</p> <ul style="list-style-type: none"> a) Protection against electric shock: automatic disconnection, insulation, barriers b) Protection against thermal effects: overload protection, fire prevention <p>33.3.3 Cable selection and installation</p> <ul style="list-style-type: none"> a) Use of BS 7671 tables for current-carrying capacity and voltage drop b) Selection of protective devices <ul style="list-style-type: none"> i) Fuses ii) Circuit breakers iii) Residual Current Device (RCDs) iv) Arc Fault Detection Devices (AFDDs) c) Earthing requirements and bonding methods d) Installation methods suitable for environment and load <p>33.3.4 Inspection, testing and certification</p>

	<ul style="list-style-type: none"> a) Initial verification and periodic inspection b) Functional testing and fault diagnosis c) Completion of electrical installation certificates and test records
33.4 Safe use of electrical systems	<ul style="list-style-type: none"> 33.4.1 Electrical hazards and risk awareness <ul style="list-style-type: none"> a) Electric shock b) Arc flash c) Fire d) Burns e) Equipment failure risks f) Hazard identification g) Risk assessment and control measures <ul style="list-style-type: none"> i) Barriers ii) Insulation iii) Enclosures iv) Automatic disconnection 33.4.2 Safe working practices and emergency response <ul style="list-style-type: none"> a) Safe isolation (lockout/tagout procedures, verification of dead circuits using approved test equipment) b) Permit-to-work systems (when and why permits are required) c) Maintaining a safe working environment <ul style="list-style-type: none"> i) Clear access ii) Dry conditions iii) Adequate lighting iv) Adequate ventilation v) Clear signage d) Emergency response procedures for electric shock and fire incidents 33.4.3 Safe use of tools and equipment <ul style="list-style-type: none"> a) Insulated tools b) Condition monitoring 33.4.4 Protective equipment <ul style="list-style-type: none"> a) Insulating gloves b) Arc-rated clothing c) Eye protection d) Safety footwear

K35 Electrical. Principles of single phase and three-phase equipment, plant, and systems, the operation of motors and generators, and the use of monitoring and protection equipment

Topic	Content – What needs to be covered
35.1 Single-phase systems	35.1.1 Characteristics of single-phase systems and equipment <ul style="list-style-type: none"> a) Series and parallel AC circuits b) Typical applications c) Voltage and frequency standards d) Waveform characteristics e) Advantages and disadvantages
35.2 Three-phase systems	35.2.1 Characteristics of three-phase systems and equipment <ul style="list-style-type: none"> a) Series and parallel AC circuits b) Typical applications c) Voltage and frequency standards d) Waveform characteristics e) Advantages and disadvantages f) Balanced vs unbalanced loads
35.3 Electrical machines	35.3.1 Transformers <ul style="list-style-type: none"> a) Principle of operation b) Turns ratio and its effect on voltage/current 35.3.2 Motors and generators <ul style="list-style-type: none"> a) Operation of three-phase induction motors b) Star/delta starting methods c) Basic generator principles
35.4 Monitoring and protective equipment	35.4.1 Measurement tools <ul style="list-style-type: none"> a) Multimeters <ul style="list-style-type: none"> i) Voltage ii) Current iii) Resistance b) Oscilloscopes (waveform analysis) c) Clamp meters and insulation testers 35.4.2 Fault detection and safety <ul style="list-style-type: none"> a) Testing procedures for single- and three-phase circuits b) Electrical hazards and shock protection <ul style="list-style-type: none"> i) Electrostatic Discharge (ESD) Straps ii) Grounding iii) RCD types (AC,C,F, B and S)

c) Safe isolation procedures

K36 Electrical. Electrical engineering principles: circuit terminology, Ohm's Law, transformer theory, and power calculations

Topic	Content – What needs to be covered
36.1 Circuit terminology	<p>36.1.1 Fundamental electrical quantities</p> <ul style="list-style-type: none">a) Definition of voltage (potential difference), current and resistanceb) Explanation of charge, energy and power in electrical systemsc) Relationship between conductors, insulators and semiconductorsd) Units of electrical measurement (volt, ampere, ohm, watt, coulomb, SI units) <p>36.1.2 Circuit components and configuration</p> <ul style="list-style-type: none">a) Identification and function of resistors, capacitors, inductors, sources and switchesb) Series and parallel connections – effect on total resistance, current and voltagec) Distinction between open circuits, short circuits and loaded circuitsd) Concept of nodes, branches and loops in circuit analysis
36.2 Ohms Law and circuit relationships	<p>36.2.1 Application of Ohm's Law</p> <ul style="list-style-type: none">a) Relationship between voltage (V), current (I) and resistance (R): $V = I \times R$b) Practical examples in series and parallel resistive circuitsc) Impact of changing resistance or voltage on current flow
36.3 Transformer theory	<p>36.3.1 Basic operating principles</p> <ul style="list-style-type: none">a) Principle of electromagnetic inductionb) Function of primary and secondary windingsc) Concept of mutual induction and magnetic coupling <p>36.3.2 Transformer types and construction</p> <ul style="list-style-type: none">a) Identification of step-up and step-down transformersb) Core materials and their influence on efficiencyc) Importance of laminated cores and lamination thickness to reduce eddy current lossesd) Importance of transformer coolinge) Insulation methods
36.4 Power calculations	

	<p>36.4.1 Electrical power</p> <ul style="list-style-type: none"> a) DC power formula: $P = V \times I$ b) AC power components: <ul style="list-style-type: none"> i) Active (real) power ($P = V \times I \times \cos \phi$) ii) Reactive power ($Q = V \times I \times \sin \phi$) iii) Apparent power ($S = V \times I$) c) Use of power factor to assess circuit efficiency
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K37 Electrical. Functions and applications of electrical circuits

Topic	Content – What needs to be covered
37.1 Circuit configurations and principles	<p>37.1.1 Types of circuit configurations</p> <ul style="list-style-type: none"> a) Series circuits <ul style="list-style-type: none"> i) Characteristics and current flow ii) Voltage distribution and limitations b) Parallel circuits <ul style="list-style-type: none"> i) Characteristics and load sharing ii) Fault tolerance and redundancy c) Series-parallel combinations <ul style="list-style-type: none"> i) Typical applications <p>37.1.2 Impact of configuration on performance</p> <ul style="list-style-type: none"> a) Voltage and current relationships b) Load balancing and energy efficiency c) Safety considerations for each configuration
37.2 Practical applications of electrical circuits	<p>37.2.1 Industrial and commercial systems</p> <ul style="list-style-type: none"> a) Distribution boards b) Motor Control Centres (MCCs) c) Control circuits for <ul style="list-style-type: none"> i) Lighting ii) Heating iii) Motor drives <p>37.2.2 Low-voltage and extra-low-voltage systems</p> <ul style="list-style-type: none"> a) Typical uses in automation b) Safety systems and compliance <p>37.2.3 Integration with other technologies</p> <ul style="list-style-type: none"> a) Electrical circuits combined with <ul style="list-style-type: none"> i) Mechanical systems ii) Pneumatic systems iii) Electronic systems
37.3 Electrical components and their functions	<p>37.3.1 Active components</p> <ul style="list-style-type: none"> a) Semiconductors <ul style="list-style-type: none"> i) Diodes – rectification ii) Transistors – switching and amplification <p>37.3.2 Passive components</p> <ul style="list-style-type: none"> a) Resistors – current control b) Capacitors – energy storage and filtering

	<ul style="list-style-type: none"> c) Inductors – magnetic energy storage
	<p>37.3.3 Control and protection devices</p> <ul style="list-style-type: none"> a) Circuit breakers – overload protection b) Fuses – short-circuit protection c) Relays – switching control
	<p>37.3.4 Transformers and contactors</p> <ul style="list-style-type: none"> a) Voltage regulation b) Motor control applications
	<p>37.3.5 Impact of component selection</p> <ul style="list-style-type: none"> a) Performance implications b) Reliability and safety considerations

K38 Electrical. Types of diagrams used to represent circuits; symbols and abbreviations used to represent components in electrical schematics

Topic	Content – What needs to be covered
38.1 Types and purpose of electrical diagrams	<p>38.1.1 Purpose of diagrams</p> <ul style="list-style-type: none"> a) Illustrate electrical systems and component relationships b) Communicate design intent for installation and maintenance c) Accurate representation for design, fault diagnosis and maintenance d) Comparison between functional, schematic and pictorial diagrams <p>38.1.2 Types of electrical diagrams</p> <ul style="list-style-type: none"> a) Circuit (schematic) diagrams – show electrical connections and logic flow b) Wiring diagrams – indicate physical wiring routes, conductor types and terminal points c) Layout diagrams – depict physical placement of components in panels or assemblies d) Orthographic diagrams – represent components in three standard views for fabrication or mounting e) Block diagrams – provide simplified overview of system operation and component interaction
38.2 Symbols and abbreviations in electrical schematics	<p>38.2.1 Standard electrical symbols – standard reference IEC 60617</p> <ul style="list-style-type: none"> a) Resistors <ul style="list-style-type: none"> i) Fixed ii) Variable b) Capacitors c) Inductors d) Diodes e) Transistors <ul style="list-style-type: none"> i) NPN ii) PNP f) Transformers

	<ul style="list-style-type: none"> g) Relays h) Switches <ul style="list-style-type: none"> i) SPST ii) SPDT iii) DPST iv) DPDT i) Fuses j) Motors <ul style="list-style-type: none"> i) AC ii) DC iii) Servo iv) Stepper k) Light Emitting Diodes (LED) l) Sensors <ul style="list-style-type: none"> i) Light dependent resistor (LDR) ii) Thermistor <p>38.2.2 Symbols for system elements</p> <ul style="list-style-type: none"> a) Power sources <ul style="list-style-type: none"> i) AC supply ii) DC supply iii) Battery b) Ground connections <ul style="list-style-type: none"> i) Protective earth ii) Chassis ground iii) Signal ground c) Measurement points <ul style="list-style-type: none"> i) Ammeter ii) Voltmeter <p>38.2.3 Line types and notations</p> <ul style="list-style-type: none"> a) Indicating connections, junctions and crossovers <p>38.2.4 Abbreviations and annotation</p> <ul style="list-style-type: none"> a) R = resistor, L = inductor, SW = switch, M = motor b) Labelling conventions for terminal points, wire numbers, reference designators c) Common conventions for labelling, routing and earthing
<p>38.3 Interpretation of diagrams and documentation</p>	<p>38.3.1 Reading and cross-referencing</p> <ul style="list-style-type: none"> a) Circuit, wiring, and layout diagrams for complete system understanding <p>38.3.2 Recognising system function</p> <ul style="list-style-type: none"> a) Signal flow, power distribution and control sequences <p>38.3.3 Linking diagrams to SOPs</p> <ul style="list-style-type: none"> a) Role of SOPs in guiding safe and consistent electrical work

	<ul style="list-style-type: none"> b) Document control systems for revision management and traceability c) Understand title blocks, borders and revision codes for traceability <p>38.3.4 Compliance and safety</p> <ul style="list-style-type: none"> a) Accurate interpretation ensures compliance with standards and safe working practices b) Apply British Standards for technical documentation, including line types, scales, tolerances and revision control c) Importance of standardisation for clarity and troubleshooting
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K39 Electrical. Different types of cables; their specifications and application

Topic	Content – What needs to be covered
39.1 Cable selection and practical applications	<p>39.1.1 Cable types and their applications</p> <ul style="list-style-type: none"> a) Single core: A single insulated conductor, typically PVC or XLPE insulated <ul style="list-style-type: none"> i) Commercial and industrial distribution circuits installed in containment (tray, trunking, conduit) ii) Switchgear and control panels iii) Circuits requiring good heat dissipation and straightforward grouping b) Multi-core: Multiple insulated conductors contained within one sheath <ul style="list-style-type: none"> i) Control, signalling and instrumentation systems ii) Multi-phase power circuits in industrial environments iii) Situations requiring compact routing with reduced cable clutter c) Flexible cords: Fine-stranded conductors with flexible insulation and sheathing (PVC or rubber/EPR) <ul style="list-style-type: none"> i) Portable, movable or vibrating industrial equipment ii) Machinery and tools that require repeated flexing iii) Temporary connections where flexing is expected (where permitted) d) Steel Wire Armoured (SWA): Power cables with galvanised steel wire armour, its primary function is mechanical protection <ul style="list-style-type: none"> i) External, exposed or buried commercial/industrial installations

- ii) Distribution circuits requiring impact, crushing or abrasion protection
- iii) Environments where mechanical resilience is critical

e) Mineral Insulated Copper Cable (MICC): Copper conductors embedded in compressed magnesium oxide, with a copper sheath and optional LSF jacket

- i) Fire survival circuits (emergency lighting, alarms, life safety systems)
- ii) High temperature industrial environments
- iii) Installations requiring long-term reliability and chemical/heat resistance

39.1.2 Voltage classification

- a) Extra low voltage (ELV): Typically used for signalling, control, instrumentation and other low-energy systems
- b) Low voltage (LV): Up to 1000 V AC, used widely in commercial and industrial electrical distribution
- c) Medium voltage (MV): General industrial site distribution and large equipment feeds
- d) High voltage (HV): Used for transmission networks and high-power industrial processes

39.1.3 Materials

a) Conductors

- i) Copper: High conductivity, excellent mechanical strength, widely used in most cable types
- ii) Aluminium: Lightweight and cost effective; commonly used in larger power-distribution cables

b) Insulation

- i) PVC: General purpose insulation
- ii) XLPE: Higher temperature rating and improved current-carrying capacity
- iii) Rubber (EPR): Enhanced flexibility and heat resistance for flexible cords or harsh environments

39.1.4 Cable components

- a) Conductor
- b) Insulation
- c) Sheath
- d) Armour
- e) Outer jacket

39.1.5 Cable identification

	<ul style="list-style-type: none"> a) Reading cable designations (6242Y, NYY, SY, CY, SWA) b) Colour coding of conductors according to harmonised standards c) Importance of correct identification for maintenance and safety <p>39.1.6 Selection Criteria</p> <ul style="list-style-type: none"> a) Determination of cable type and size based on: <ul style="list-style-type: none"> i) Load current ii) Voltage drop iii) Short-circuit capacity iv) Environmental and installation conditions b) Consideration of derating factors and future load growth c) Selection for flexibility, mechanical protection, and thermal performance d) Use of manufacturer data sheets and regulatory tables for design verification
39.2 Cable specifications and regulatory standards	<p>39.2.1 Specification parameters</p> <ul style="list-style-type: none"> a) Current-carrying capacity b) Voltage rating c) Temperature rating d) Insulation resistance and mechanical protection <p>39.2.2 Cable sizing</p> <ul style="list-style-type: none"> a) Use of derating factors and installation conditions <p>39.2.3 Regulatory compliance</p> <ul style="list-style-type: none"> a) Application of BS 7671 / IET Wiring Regulations for cable selection and installation b) Use of manufacturer data and certification for conformity
39.3 Cable installation methods	<p>39.3.1 Installation practices</p> <ul style="list-style-type: none"> a) Routing and securing of cables to prevent strain, heat buildup or interference b) Installation zones and routing requirements c) Use of glands, bushings and sealing devices for entry points and junctions d) Inspection, testing and certification following installation

K46 Control and instrumentation. Electricity at Work regulations. IET wiring regulations

Topic	Content – What needs to be covered
46.1 Roles and Responsibilities under Electricity at Work Regulations	<p>46.1.1 Employer roles and responsibilities</p> <ul style="list-style-type: none"> a) Provide appropriate training for the task(s) b) Ensure that all workplace electrical equipment and systems are safe and maintained correctly to prevent accidents c) Conduct risk assessment on a regular basis to identify potential electrical hazards

	<ul style="list-style-type: none"> d) Arrange routine inspections, testing and maintenance of electrical equipment (portable appliance testing – PAT) <p>46.1.2 Employee roles and responsibilities</p> <ul style="list-style-type: none"> a) Follow the employer’s safety procedures when working with electrical systems b) Complete safety training as required by employer c) Report any electrical faults, damage or unsafe conditions immediately d) Never attempt to repair an electrical system or equipment unless qualified to do so <p>46.1.3 Self-employed roles and responsibilities</p> <ul style="list-style-type: none"> a) Self-employment status is not exempt from health and safety laws b) Take reasonable care for own safety and the safety of others c) Report any electrical faults, damage or unsafe conditions immediately d) Conduct risk assessment to identify potential electrical hazards
<p>46.2 Compliance with electrical regulations</p>	<p>46.2.1 Regulation compliance</p> <p>An awareness of the contents of the EAWR and IET wiring regulations to ensure compliance when completing maintenance activities:</p> <ul style="list-style-type: none"> a) Electricity at Work Regulations (EAWR) <ul style="list-style-type: none"> i) Installation, maintenance and inspection of electrical systems ii) Isolation procedures and prevention of danger from live conductors iii) Emphasis on competence, testing and risk assessment before commencing work b) IET wiring regulations (BS 7671) <ul style="list-style-type: none"> vii) Role in ensuring electrical safety and system reliability <ul style="list-style-type: none"> i) Used as a reference during installation, maintenance, testing and certification ii) Installation characteristics and selection of equipment iii) Environments (internal, external, moisture/IP considerations) iv) Importance of updates and periodic revisions v) IET On-site Guide (OSG) <p>46.2.2 Documentation and record keeping</p> <ul style="list-style-type: none"> a) Electrical installation certificates b) Portable appliance test (PAT) c) Permit to work d) Risk assessment e) Test records and maintenance logs

	<ul style="list-style-type: none"> f) Audit trails for compliance g) Consequences of non-compliance <ul style="list-style-type: none"> i) Legal penalties and enforcement actions ii) Increased risk of electric shock, arc flash, fire and fatalities h) Impact on business reputation, insurance and operational continuity
<p>46.3 Application and scope of IET wiring regulations</p>	<p>46.3.1 Relationship between BS 7671 and EAWR</p> <ul style="list-style-type: none"> a) BS 7671 provides technical standards supporting EAWR compliance b) EAWR is statutory law; BS 7671 is a code of practice <p>46.3.2 Protective measures</p> <ul style="list-style-type: none"> a) Protection against electric shock: automatic disconnection, insulation, barriers b) Protection against thermal effects: overload protection, fire prevention <p>46.3.3 Cable selection and installation</p> <ul style="list-style-type: none"> a) Use of BS 7671 tables for current-carrying capacity and voltage drop b) Selection of protective devices <ul style="list-style-type: none"> i) Fuses ii) Circuit breakers iii) Residual Current Device (RCDs) iv) Arc Fault Detection Devices (AFDDs) c) Earthing requirements and bonding methods d) Installation methods suitable for environment and load <p>46.3.4 Inspection, testing and certification</p> <ul style="list-style-type: none"> a) Initial verification and periodic inspection b) Functional testing and fault diagnosis c) Completion of electrical installation certificates and test records
<p>46.4 Safe working practices</p>	<p>46.4.1 Electrical hazards and risk awareness</p> <ul style="list-style-type: none"> a) Electric shock b) Arc flash c) Fire d) Burns e) Equipment failure risks f) Hazard identification g) Risk assessment and control measures <ul style="list-style-type: none"> i) Barriers ii) Insulation iii) Enclosures h) Automatic disconnection <p>46.4.2 Safe working practices and emergency response</p>

	<ul style="list-style-type: none"> a) Safe isolation (lockout/tagout procedures, verification of dead circuits using approved test equipment) b) Permit-to-work systems (when and why permits are required) c) Method statements for electrical maintenance <ul style="list-style-type: none"> i) Verification process ii) Checking for dead iii) Task completion d) Maintaining a safe working environment <ul style="list-style-type: none"> i) Clear access ii) Dry conditions iii) Adequate lighting iv) Adequate ventilation v) Clear signage e) Emergency response procedures for electric shock and fire incidents <p>46.4.3 Safe use of tools and equipment</p> <ul style="list-style-type: none"> a) Insulated tools b) Condition monitoring <p>46.4.4 Protective equipment</p> <ul style="list-style-type: none"> a) Insulating gloves b) Arc-rated clothing c) Eye protection d) Safety footwear
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K49 Control and instrumentation. Control and instrumentation engineering principles, terminology, and calculations

Topic	Content – What needs to be covered
49.1 Control and instrumentation engineering principles	<p>49.1.1 Core principles</p> <ul style="list-style-type: none"> a) Force <ul style="list-style-type: none"> i) Definition: Push or pull acting on an object (Newton’s laws) ii) Units: Newton (N) iii) Application: Actuator sizing, valve operation b) Stress <ul style="list-style-type: none"> i) Formula: $\sigma = F/A$ (force per unit area) ii) Importance in sensor housings and mounting brackets c) Conductivity <ul style="list-style-type: none"> i) Electrical and thermal conductivity in sensor materials ii) Impact on signal integrity and heat dissipation d) Power <ul style="list-style-type: none"> i) Electrical power: $P = V \times I$ ii) Mechanical power in actuators and drives e) Current and voltage

	<ul style="list-style-type: none"> i) Role in signal transmission and control circuits ii) Safe operating ranges for instrumentation devices f) Feedback loop controls <ul style="list-style-type: none"> i) Open-loop vs closed-loop systems ii) PID control principles (Proportional, Integral, Derivative) iii) Application in temperature and pressure control. g) System integration <ul style="list-style-type: none"> i) Linking sensors, controllers and actuators ii) Communication protocols (4–20 mA, Modbus) h) Signal processing <ul style="list-style-type: none"> i) Filtering, amplification and conversion (analogue to digital) ii) Importance for accurate measurement iii) Reliability and robustness iv) Factors affecting system uptime v) Redundancy and fail-safe design i) Algorithms <ul style="list-style-type: none"> i) Control logic for automated systems ii) Examples: PID tuning, adaptive control j) Locking and interlocking <ul style="list-style-type: none"> i) Safety interlocks for hazardous operations ii) Mechanical vs electrical interlocks k) Measurement and calibration <ul style="list-style-type: none"> i) Importance of calibration for accuracy ii) Traceability and standards (ISO, BS) l) Efficiency and performance <ul style="list-style-type: none"> i) Energy efficiency in control systems ii) Performance metrics (response time, accuracy) m) Safety <ul style="list-style-type: none"> i) Safe isolation and emergency shutdown systems ii) Hazard analysis for instrumentation loops
<p>49.2 Terminology</p>	<p>49.2.1 Key terminology used in control and instrumentation systems</p> <ul style="list-style-type: none"> a) Sensor and transducer <ul style="list-style-type: none"> i) Sensor: Detects physical, electrical and mechanical quantity ii) Transducer: Converts one form of energy to another b) Actuator <ul style="list-style-type: none"> i) Converts control signal into mechanical movement ii) Types: Pneumatic, hydraulic, electric actuators c) Analogue vs digital signals <ul style="list-style-type: none"> i) Analogue: Continuous signal, voltage or current variation ii) Digital: Discrete signal, binary representation iii) Impact on system design: Accuracy, noise immunity, compatibility d) Control loop parameters <ul style="list-style-type: none"> i) Setpoint: Desired value for process variable

	<ul style="list-style-type: none"> ii) Process variable: Actual measured value iii) Error signal: Difference between setpoint and process variable e) Hysteresis and deadband <ul style="list-style-type: none"> i) Hysteresis: Lag between input change and output response ii) Deadband: Range where no control action occurs f) Instrument performance terms <ul style="list-style-type: none"> i) Resolution: Smallest detectable change in measurement ii) Accuracy: Closeness to true value iii) Repeatability: Ability to produce consistent results under same conditions g) Calibration and zeroing <ul style="list-style-type: none"> i) Calibration: Adjusting instrument to known standard ii) Zeroing: Setting baseline reference point h) Control loop components <ul style="list-style-type: none"> i) Controller: Compares setpoint and process variable ii) Sensor: Measures process variable iii) Final control element: Actuator or valve that adjusts process i) Communication protocols <ul style="list-style-type: none"> i) Common examples: 4–20 mA current loop, Modbus, Profibus
49.3 Calculations	<p>49.3.1 Engineering calculations</p> <ul style="list-style-type: none"> a) Power and energy <ul style="list-style-type: none"> i) Electrical power: $P = V \times I$ ii) Mechanical power: $P = (\text{torque} \times \text{speed}) / \text{constant}$ b) Pressure and force <ul style="list-style-type: none"> i) Pressure = Force / Area ii) Application in pneumatic/hydraulic loops c) Flow rate and volume <ul style="list-style-type: none"> i) $Q = A \times v$ (area \times velocity) ii) Application in fluid control loops d) Temperature and heat transfer <ul style="list-style-type: none"> i) Conduction, convection and radiation principles ii) Sensor compensation for thermal effects e) Trigonometry and geometry <ul style="list-style-type: none"> i) Used for sensor placement and alignment f) Friction <ul style="list-style-type: none"> i) Impact on valve actuation and energy loss g) SI units <ul style="list-style-type: none"> i) Correct conversions for documentation

K50 Control and instrumentation. Control and instrumentation equipment installation and connection requirements

Topic	Content – What needs to be covered
50.1 Control and instrumentation equipment	50.1.1 Equipment <ul style="list-style-type: none"> a) Sensors and transmitters <ul style="list-style-type: none"> i) Pressure ii) Temperature iii) Time iv) Fluid flow v) Heat vi) Level vii) PH value b) Controllers <ul style="list-style-type: none"> i) Proportional Integral Derivative (PID) ii) Programmable Logic Controllers (PLCs) iii) Programmable Automation Controllers (PACs) iv) Distributed Control Systems (DCS) c) Actuators <ul style="list-style-type: none"> i) Control valves ii) Motor control units d) Meters <ul style="list-style-type: none"> i) Analogue ii) Digital e) Monitoring <ul style="list-style-type: none"> i) Human Machine Interface (HMI) ii) DATA acquisition iii) Digital indicators iv) Supervisory Control and Data Acquisition (SCADA) f) Enclosures g) Cables h) Conduit i) Safety detection <ul style="list-style-type: none"> i) Flame ii) Gas iii) Smoke
50.2 Installation and connection requirements	50.2.1 Safety <ul style="list-style-type: none"> a) Safe use of equipment b) Lockout/tagout c) Risk assessments d) Permit to work e) Method statements f) Standard Operating Procedure (SOP) g) Cable routing and strain relief techniques h) Environmental protection (IP ratings, hazardous area considerations) i) Earthing and shielding for instrumentation cables j) Compliance with IEC standards for installation 50.2.2 Connection procedures <ul style="list-style-type: none"> a) Lockout/tagout b) ESD precautions c) Dismantling techniques d) Reassembly e) Calibration

	<ul style="list-style-type: none"> f) Testing
	<ul style="list-style-type: none"> 50.2.3 Connection methods and fittings <ul style="list-style-type: none"> a) Mechanical fittings <ul style="list-style-type: none"> i) Compression ii) Threaded iii) Pneumatic b) Electrical connections <ul style="list-style-type: none"> i) Terminals <ul style="list-style-type: none"> • Fork • Ring • Spade • Bullet ii) Crimps iii) Solder c) Electrical insulation <ul style="list-style-type: none"> i) Polytetrafluorethylene (PTFE) ii) Polyvinyl Chloride (PVC) iii) Polyethylene (PE) iv) Silicone
	<ul style="list-style-type: none"> 50.2.4 Cable types <ul style="list-style-type: none"> a) Multicore b) Multipair c) Fibre-optic d) Data e) Coaxial
	<ul style="list-style-type: none"> 50.2.5 Cable construction <ul style="list-style-type: none"> a) Steel Wire Armoured (SWA) b) PVC c) Polyethene d) Fire resistance

K51 Control and instrumentation. Operating principles of control and instrumentation devices: flow, level, pressure, and temperature instruments, analysers, transducers, transmitters, gauges, and pneumatics

Topic	Content – What needs to be covered
51.1 Operating principles of measurement and monitoring	<ul style="list-style-type: none"> 51.1.1 Pressure instrument <ul style="list-style-type: none"> a) Types <ul style="list-style-type: none"> i) Gauge ii) Absolute iii) Differential pressure b) Sensing principles <ul style="list-style-type: none"> i) Bourdon tube (mechanical deflection under pressure) ii) Diaphragm/capsule (elastic deformation) iii) Strain gauge (resistance change under strain) iv) Piezoelectric (voltage generation under pressure)

51.1.2 Temperature instruments

- a) Sensing principles
 - i) Resistance Temperature Detector (RTD)
Resistance increases with temperature (Pt100/Pt1000)
 - ii) Thermocouples: Seebeck effect – voltage generated at junction of dissimilar metals
 - iii) Thermistors: Resistance increases with temperature (NTC/PTC)
 - iv) Infrared sensors: Detect thermal radiation for non-contact measurement

51.1.3 Flow instruments

- a) Operating principles
 - i) Differential Pressure (DP): Based on Bernoulli's principle – pressure drop across restriction (orifice, venturi, nozzle)
 - ii) Magnetic Flowmeter: Faraday's Law – voltage induced in conductive fluid moving through magnetic field
 - iii) Coriolis Flowmeter: Detects mass flow via tube vibration and phase shift
 - iv) Ultrasonic Flowmeter: Measures transit-time or Doppler shift of sound waves in fluid
 - v) Vortex Flowmeter: Detects vortices shed by bluff body proportional to flow velocity

51.1.4 Level instruments

- a) Operating principles
 - i) Hydrostatic: Pressure at bottom of tank proportional to liquid height (ρgh)
 - ii) Differential Pressure: Measures pressure difference between top and bottom of vessel
 - iii) Ultrasonic: Time-of-flight of sound waves reflected from liquid surface
 - iv) Radar (FMCW or pulse): Electromagnetic waves reflected from surface; unaffected by vapour/dust
 - v) Capacitive: Change in capacitance as level changes between probe and tank wall
 - vi) Displacer: Buoyancy principle – force on displacer changes with liquid level

51.1.5 Analysers

- a) Liquid analysis
 - i) pH: Potential difference across glass electrode and reference electrode
 - ii) Conductivity: Measures ionic concentration via electrical conductance
 - iii) Dissolved oxygen: Polarographic or optical sensing of oxygen in liquid
 - iv) Turbidity: Light scattering by suspended particles
- b) Gas analysis

	<ul style="list-style-type: none"> i) Non-Dispersive Infrared (NDIR): Absorption of IR radiation by gas molecules ii) Paramagnetic O₂: Magnetic susceptibility of oxygen compared to other gases iii) Electrochemical cells: Voltage/current generated by chemical reaction with target gas <p>51.1.6 Transducers</p> <ul style="list-style-type: none"> a) Principle: Convert one form of energy to another (mechanical displacement – electrical signal). b) Examples <ul style="list-style-type: none"> i) Linear Variable Differential Transformer (LVDT): Converts linear motion to electrical signal ii) Strain Gauge: Converts strain into resistance change iii) Piezoelectric: Converts pressure or vibration into voltage c) Role: Often paired with transmitters for signal conditioning <p>51.1.7 Transmitters</p> <ul style="list-style-type: none"> a) Principle: Convert sensor signal into standardised output for control systems b) Signal standards <ul style="list-style-type: none"> i) Analogue: 4–20 mA current loop, 1–5 V ii) Digital: HART, Foundation Fieldbus, Profibus PA c) Function: Scaling, damping, diagnostics, communication with control system <p>51.1.8 Gauges</p> <ul style="list-style-type: none"> a) Pressure gauges: Bourdon tube, diaphragm, capsule types; mechanical indication b) Temperature gauges: Bimetallic strip, liquid-filled systems, expansion principles c) Role: Local indication for operators; accuracy classes defined by standards <p>51.1.9 Pneumatics</p> <ul style="list-style-type: none"> a) Signal standard: 3–15 psi (0.2–1.0 bar) pneumatic control signals b) Components and principles <ul style="list-style-type: none"> i) I/P Converter: Converts electrical signal (current) to pneumatic pressure ii) Positioner: Pneumatic feedback device for accurate valve positioning iii) Actuators: Pneumatic cylinders or diaphragms convert air pressure to mechanical motion iv) Air preparation: Filter–Regulator–Lubricator (FRL) ensures clean, dry air supply
51.2 Operating principles of control devices	<p>51.2.1 Signal conditioning and transmission</p> <ul style="list-style-type: none"> a) Transmitters: Standardise and transmit signal to control system

	<ul style="list-style-type: none"> b) Displays/gauges: Provide local indication of process variables <p>51.2.2 Control and logic devices</p> <ul style="list-style-type: none"> a) Controllers: Implement control algorithms (PID basics) b) Logic solvers: Safety Instrumented Systems (SIS) for shutdown logic <p>51.2.3 Output elements</p> <ul style="list-style-type: none"> a) Actuators: Convert control signal to mechanical movement (valves, dampers) b) Valves: Control flow using throttling or on/off action; pneumatic/electric actuation <p>51.2.4 Analytical devices</p> <ul style="list-style-type: none"> a) Analysers: Measure chemical/physical properties for process control
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K52 Control and instrumentation. Open and closed loop systems. First and second order control systems. Proportional–integral–derivative controller (PID controller or three-term controller)

Topic	Content – What needs to be covered
52.1 Operating principles of open and closed loop systems	<p>52.1.1 Open loop systems</p> <ul style="list-style-type: none"> a) Control system that operates without feedback b) Key components (sensors, actuators) c) Performance <ul style="list-style-type: none"> i) speed ii) reliability iii) accuracy <p>52.1.2 Closed loop systems</p> <ul style="list-style-type: none"> a) Control system uses feedback to compare the actual output b) Key components (sensors, controllers, feedback elements) c) Performance <ul style="list-style-type: none"> i) speed ii) reliability iii) accuracy
52.2 Control systems	<p>52.2.1 First order system</p> <ul style="list-style-type: none"> a) System type b) Applications c) Characteristics <ul style="list-style-type: none"> i) Transfer ii) Response iii) Time

	<p>52.2.2 Second order system</p> <ul style="list-style-type: none"> a) System type b) Applications c) Characteristics <ul style="list-style-type: none"> i) Transfer ii) Response iii) Time
52.3 PID controller applications	<p>52.3.1 Controller types</p> <ul style="list-style-type: none"> a) Proportional Integral Derivative (PID) – (also referred to as three-term controller) <ul style="list-style-type: none"> i) System type ii) Applications iii) Function iv) System isolation v) Effects b) Real-world examples in process industries <ul style="list-style-type: none"> i) Temperature control ii) Flow regulation

K53 Control and instrumentation. Functions and applications of control and instrumentation systems: programmable logic controller (PLC), Direct Digital Control (DDC), Distributed Control System (DCS), and Supervisory Control And Data Acquisition (SCADA)

Topic	Content – What needs to be covered
53.1 Functions of control and instrumentation systems	<p>53.1.1 Programmable Logic Controller (PLC)</p> <ul style="list-style-type: none"> a) Purpose: Discrete and sequential control b) Characteristics <ul style="list-style-type: none"> i) Modular design ii) Real-time operation c) Methods of programming <ul style="list-style-type: none"> i) Ladder logic ii) Text-based iii) Flow charts iv) Function blocks d) Typical uses <ul style="list-style-type: none"> i) Machine automation ii) Production iii) Safety interlocks <p>53.1.2 Direct Digital Control (DDC)</p> <ul style="list-style-type: none"> a) Purpose: HVAC and building automation b) Characteristics <ul style="list-style-type: none"> i) Digital signal processing ii) Centralised control

	<ul style="list-style-type: none"> c) Typical uses <ul style="list-style-type: none"> i) Temperature ii) Humidity iii) Energy management <p>53.1.3 Distributed Control System (DCS)</p> <ul style="list-style-type: none"> a) Purpose: Process control in large-scale plants b) Characteristics <ul style="list-style-type: none"> i) Hierarchical architecture ii) Redundancy iii) Scalability c) Typical uses <ul style="list-style-type: none"> i) Chemical ii) Oil and gas iii) Power generation <p>53.1.4 Supervisory Control And Data Acquisition (SCADA)</p> <ul style="list-style-type: none"> a) Purpose: Remote monitoring and supervisory control b) Characteristics <ul style="list-style-type: none"> i) HMI interfaces ii) Telemetry iii) Data logging c) Typical uses <ul style="list-style-type: none"> i) Water treatment ii) Energy grids iii) Pipelines <p>53.1.5 Integration principles</p> <ul style="list-style-type: none"> a) How PLC, DDC, DCS and SCADA interact in hybrid systems b) Communication protocols (Modbus, Profibus, Ethernet/IP)
<p>53.2 Application of control and instrumental systems</p>	<p>53.2.1 Sectors</p> <ul style="list-style-type: none"> a) Oil and gas <ul style="list-style-type: none"> i) Pipeline monitoring via SCADA b) Chemical c) Pharmaceutical <ul style="list-style-type: none"> i) Batch control using DCS d) Automotive <ul style="list-style-type: none"> i) Robotic assembly lines with PLCs e) Energy infrastructure f) Healthcare g) Food and beverages <p>53.2.2 Emerging trends</p> <ul style="list-style-type: none"> a) IIoT (Industrial Internet of Things) integration b) Cloud-based SCADA solutions c) Cyber security measures for industrial control systems
<p>53.3 Cyber security, maintenance, and performance of control and</p>	<p>53.3.1 Cyber security and data integrity</p> <ul style="list-style-type: none"> a) Risks in networked control systems b) Common mitigation strategies <ul style="list-style-type: none"> i) Firewalls ii) Passwords

instrumentation systems	<ul style="list-style-type: none"> iii) Antivirus iv) Encryption v) Role-based access <p>53.3.2 Maintenance and life cycle considerations</p> <ul style="list-style-type: none"> a) Firmware updates and patching b) Backup and disaster recovery planning c) Obsolescence management
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K54 Control and instrumentation. Types of control and instrumentation diagrams

Topic	Content – What needs to be covered
54.1 Types of control and instrumentation diagrams	<p>54.1.1 Types and purpose of diagrams</p> <ul style="list-style-type: none"> a) Process and Instrument Diagram (PID) <ul style="list-style-type: none"> i) Process flow ii) Instrumentation details iii) Feedback loops b) Schematic diagrams <ul style="list-style-type: none"> i) Fault finding and troubleshooting c) Block diagrams <ul style="list-style-type: none"> i) High-level representation of groups of system components and signal flow d) Pipework and piping <ul style="list-style-type: none"> i) Illustrate physical routing of pipes and connections e) Wiring and circuit diagrams <ul style="list-style-type: none"> i) Electrical connections ii) Cable positioning f) Logic diagrams <ul style="list-style-type: none"> i) Cause and effect ii) Function block iii) Ladder logic g) Control system architecture diagrams <ul style="list-style-type: none"> i) Show overall control system structure and hierarchy h) Detail drawings <ul style="list-style-type: none"> i) Provide fine details for fabrication or assembly i) Component drawings <ul style="list-style-type: none"> i) Dimensions and tolerances ii) Operation j) General assembly (GA) drawings <ul style="list-style-type: none"> i) Physical layout and assembly k) Instrumentation index <ul style="list-style-type: none"> i) List of instruments <p>54.1.2 Documentation and reference materials</p> <ul style="list-style-type: none"> a) Standard Operating Procedures (SOPs) – document operational steps b) Method statements – describe work execution approach c) Data charts and handbooks – provide reference data and standards <p>54.1.3 Differences</p> <ul style="list-style-type: none"> a) Functional vs physical representation b) Use in design, installation and maintenance

	<p>54.1.4 Symbols and abbreviations – standard reference ISO1219/IEC 60617</p> <ul style="list-style-type: none"> a) Valve symbols <ul style="list-style-type: none"> i) Pressure relief ii) Check iii) Flow b) Line symbols <ul style="list-style-type: none"> i) Solid thick line ii) Solid thin line iii) Dashed line iv) Solid line with perpendicular marks c) Instrument identification <ul style="list-style-type: none"> i) Circle ii) Square iii) Hexagon iv) Diamond inside a square d) Centre line
54.2 Documentation and revision control	<p>54.2.1 Interpretation and compliance</p> <ul style="list-style-type: none"> a) Interpretation of title blocks <ul style="list-style-type: none"> i) drawing title ii) drawing number iii) scale iv) project v) revision status b) Revision codes and change tracking c) Compliance with ISO/IEC standards for technical documentation d) Linking diagrams to SOPs, method statements and maintenance records

K61 Mechanical. Electricity at Work regulations

Topic	Content – What needs to be covered
61.1 Roles and responsibilities under the Electricity at Work Act	<p>61.1.1 Employer roles and responsibilities</p> <ul style="list-style-type: none"> a) Provide appropriate training for the task(s) b) Ensure that all workplace electrical equipment and systems are safe and maintained correctly to prevent accidents c) Conduct risk assessment on a regular basis to identify potential electrical hazards d) Arrange routine inspections, testing and maintenance of electrical equipment (portable appliance testing – PAT) <p>61.1.2 Employee roles and responsibilities</p> <ul style="list-style-type: none"> a) Follow the employer’s safety procedures when working with electrical systems b) Complete safety training as required by employer c) Report any electrical faults, damage or unsafe conditions immediately d) Never attempt to repair an electrical system or equipment unless qualified to do so

	<p>61.1.3 Self-employed roles and responsibilities</p> <ul style="list-style-type: none"> a) Self-employment status is not exempt from health and safety laws b) Take reasonable care for own safety and the safety of others c) Report any electrical faults, damage or unsafe conditions immediately d) Conduct risk assessment to identify potential electrical hazards
61.2 Safe working practices and procedures	<p>61.2.1 Working practices</p> <ul style="list-style-type: none"> a) Safe isolation (lockout/tagout) b) Risk assessment <p>61.2.2 Safety procedures</p> <ul style="list-style-type: none"> a) Lockout/tagout (LOTO) b) Approval process c) Permit to Work (PTW) <p>61.2.3 Verification processes</p> <ul style="list-style-type: none"> a) Legal requirements b) Enforcement of regulations c) Consequences of non-compliance

K62 Mechanical. Pneumatic and hydraulic system principles: Air compressors, hydraulic pumps, filters, regulators, lubricators

Topic	Content – What needs to be covered
62.1 Principles of pneumatic and hydraulic systems	<p>62.1.1 Principles of hydraulic systems</p> <ul style="list-style-type: none"> a) Fluid pressure and flow <ul style="list-style-type: none"> i) Pascal’s Law and its application in hydraulic systems ii) Relationship between pressure, force and area b) Return path <ul style="list-style-type: none"> i) Closed-loop circulation of hydraulic fluid ii) Reservoir function and fluid recovery c) Control <ul style="list-style-type: none"> i) Directional control valves ii) Flow control for speed regulation d) System applications <ul style="list-style-type: none"> i) Lifting equipment, presses, injection moulding machines brakes, steering systems e) Open loop vs closed loop systems <ul style="list-style-type: none"> i) Characteristics, advantages and limitations <p>62.1.2 Principles of pneumatic systems</p> <ul style="list-style-type: none"> a) Air flow principles <ul style="list-style-type: none"> i) Compressibility of air and its effect on system design ii) Pressure-volume relationship (Boyle’s Law) iii) Pascal’s Law and its application in pneumatic systems b) Return path (exhaust) <ul style="list-style-type: none"> i) Venting and exhaust systems c) Control

	<ul style="list-style-type: none"> i) Directional valves, speed control via flow regulators d) System applications <ul style="list-style-type: none"> i) Robotics, material handling, packaging machinery, air brakes, industrial automation systems e) Open loop vs closed loop systems <ul style="list-style-type: none"> i) Energy efficiency and control precision
<p>62.2 Components of pneumatic and hydraulic systems</p>	<p>62.2.1 Air compressors</p> <ul style="list-style-type: none"> a) Types <ul style="list-style-type: none"> i) Reciprocating piston ii) Rotary screw iii) Centrifugal b) Characteristics <ul style="list-style-type: none"> i) Pressure range ii) Flow rate iii) Duty cycle c) Application <ul style="list-style-type: none"> i) Automation ii) Robotics iii) HVAC iv) Spray painting v) Powered tooling d) Maintenance <ul style="list-style-type: none"> i) Sensory inspection ii) Planned maintenance iii) System diagnostics iv) Lubrication checks v) Filter cleaning and replacement vi) Condensate drainage <p>62.2.2 Hydraulic pumps</p> <ul style="list-style-type: none"> a) Main types <ul style="list-style-type: none"> i) Gear pumps ii) Vane pumps iii) Piston pumps b) Characteristics <ul style="list-style-type: none"> i) Flow rate ii) Pressure capability iii) Efficiency c) Applications <ul style="list-style-type: none"> i) Presses ii) Lifting equipment iii) Mobile plant iv) Brakes v) Steering systems vi) Air brakes vii) Industrial automation systems d) Maintenance <ul style="list-style-type: none"> i) Seal inspection ii) Fluid level checks iii) Contamination control/condition monitoring

	<ul style="list-style-type: none"> e) Safety <ul style="list-style-type: none"> i) Avoid overpressure ii) Correct coupling alignment
	<p>62.2.3 Hydraulic and pneumatic accumulators</p> <ul style="list-style-type: none"> a) Types <ul style="list-style-type: none"> i) Bladder ii) Piston iii) Diaphragm b) Applications <ul style="list-style-type: none"> i) Shock absorption ii) Emergency power supply iii) Load balancing and pressure holding c) Maintenance <ul style="list-style-type: none"> i) Pressure checks ii) Seal integrity d) Safety <ul style="list-style-type: none"> i) Controlled charging and discharging
	<p>62.2.4 Reservoir (tank)</p> <ul style="list-style-type: none"> a) Characteristics <ul style="list-style-type: none"> i) Capacity ii) Material construction b) Maintenance <ul style="list-style-type: none"> i) Cleanliness ii) Fluid level monitoring
	<p>62.2.5 Lubricators</p> <ul style="list-style-type: none"> a) Purpose <ul style="list-style-type: none"> i) Introduce controlled lubrication into pneumatic systems b) Types <ul style="list-style-type: none"> i) Oil mist lubricators c) Characteristics <ul style="list-style-type: none"> i) Adjustable oil feed ii) Compatibility with system d) Applications <ul style="list-style-type: none"> i) Extend life of pneumatic tools and actuators e) Maintenance <ul style="list-style-type: none"> i) Refill oil ii) Clean sight glass f) Safety <ul style="list-style-type: none"> i) Avoid over-lubrication to prevent contamination
	<p>62.2.6 Valves</p> <ul style="list-style-type: none"> a) Purpose <ul style="list-style-type: none"> i) Isolation ii) Control (speed) iii) Direction flow b) Types and applications <ul style="list-style-type: none"> i) Flow control valves

- ii) Directional control valves
- iii) Pressure control valves
- iv) Relief valves
- v) Sequencing valves
- vi) Counterbalance valves
- vii) Check valves (non-return valve)
- viii) Solenoid valves
- ix) Manually operated valves

62.2.7 Pressure regulators

a) Types

- i) Direct acting
- ii) Pilot-operated
- iii) Self-relieving

b) Characteristics

- i) Adjustable range
- ii) Response time

c) Applications

- i) Control pressure for actuators and tools

d) Maintenance

- i) Calibration
- ii) Leak checks

62.2.8 Filters

a) Types

- i) Inline filters
- ii) Return line filters
- iii) Suction filters
- iv) Combined filter/regulators devices

b) Characteristics

- i) Micron rating
- ii) Flow capacity
- iii) Applications
- iv) Protect valves and actuators from wear

c) Maintenance

- i) Regular replacement
- ii) Monitoring differential pressure

d) Safety

- i) Ensure correct installation to prevent leaks

62.2.9 Pipework and fittings

a) Connect system components

b) Materials

- i) Steel
- ii) Copper
- iii) Brass
- iv) Flexible hoses

	<p>62.2.10 Air coolers and water separators</p> <ul style="list-style-type: none"> a) Purpose <ul style="list-style-type: none"> i) Remove moisture and cool compressed air b) Applications <ul style="list-style-type: none"> i) Improve system efficiency c) Maintenance <ul style="list-style-type: none"> i) Drain water traps ii) Clean cooling fins <p>62.2.11 Gauges and measurement</p> <ul style="list-style-type: none"> a) Types <ul style="list-style-type: none"> i) Pressure gauges ii) Flow meters iii) Temperature indicators b) Applications <ul style="list-style-type: none"> i) System performance monitoring c) Maintenance <ul style="list-style-type: none"> i) Calibration ii) Visual inspection
<p>62.3 Safety and maintenance practices for pneumatic and hydraulic systems</p>	<p>62.3.1 Safety precautions</p> <ul style="list-style-type: none"> a) Safe isolation procedures: Lockout/tagout for hydraulic and pneumatic systems b) Depressurisation: Controlled release of stored energy c) Securing components: Prevent accidental movement of actuators d) Working in confined spaces: Ventilation and monitoring e) Waste disposal and environmental considerations: Disposal of oils and filters in compliance with environmental standards <p>62.3.2 Maintenance procedures and good practices</p> <ul style="list-style-type: none"> a) Cleanliness standards: Importance of contamination control b) Use of appropriate tools and equipment: Torque wrenches, pressure gauges c) Safe equipment handling: Lifting and moving heavy components d) Safety precautions during maintenance: PPE, hazard awareness e) Change management: Documenting modifications and updates f) Proof marking: Marking the orientation of components in an assembly g) Pressure/force assembly and release h) Destructive removal: Drilling, cutting, grinding, filing i) Torque: Correct sequence of removing and assembling mechanical fasteners

K63 Mechanical. Mechanical principles, terminology, and calculations: stress, strains, bending moment, heat transfer, fluid dynamics

Topic	Content – What needs to be covered
63.1 Mechanical principles, terminology and techniques	<p>63.1.1 Principles of mechanical systems</p> <ul style="list-style-type: none"> a) Laws of motion b) Conservation of energy c) Conservation of momentum d) Heat transfer e) Fluid dynamics f) Bending moments g) Friction h) Power i) Forces j) Thermal expansion and contraction k) Mechanical advantage <p>63.1.2 Key terminology used in mechanical systems</p> <ul style="list-style-type: none"> a) Acceleration b) Velocity c) Friction d) Force e) Stress (including tensile, compressive and shear) f) Strain g) Torque h) Power i) Pressure j) Thermal/heat
63.2 Mechanical calculations	<p>63.2.1 Mechanical calculations and applications</p> <ul style="list-style-type: none"> a) Stress and strain <ul style="list-style-type: none"> i) Calculate tensile stress in loaded components ii) Calculate compressive stress in loaded components iii) Determine stress and strain in structural components during operation iv) Assess material suitability for given load conditions b) Fluid dynamics <ul style="list-style-type: none"> i) Calculate flow rate in pipes and hydraulic circuits ii) Determine pressure drop across valves and fittings iii) Apply Bernoulli's principle for energy balance in fluid systems c) Bending moments <ul style="list-style-type: none"> i) Calculate bending moments in structural components ii) Determine maximum deflection for structural integrity iii) Apply calculations to machine frames and supports d) Power <ul style="list-style-type: none"> i) Calculate energy and power required for pumps, compressors and motors ii) Determine torque and speed relationships in drive systems iii) Assess energy efficiency in mechanical systems e) Heat transfer

	<ul style="list-style-type: none"> i) Calculate heat dissipation in bearings and gearboxes ii) Cooling requirements for hydraulic systems
	<ul style="list-style-type: none"> f) SI units <ul style="list-style-type: none"> i) Ensure correct unit conversions in calculations ii) Apply standard units for force, pressure and energy, power, temperature, torque, distance, time, velocity, acceleration iii) Maintain consistency in technical documentation

K64 Mechanical. Function and application of mechanical elements of plant and equipment

Topic	Content – What needs to be covered
64.1 Functions of mechanical components	<p>64.1.1 Function of mechanical components</p> <ul style="list-style-type: none"> a) Gears: Transmit torque/power and change speed/direction <ul style="list-style-type: none"> i) Gear ratio principles ii) Backlash iii) Lubrication requirements iv) Common failure modes b) Belts and pulleys: Transfer motion between shafts <ul style="list-style-type: none"> i) Belt tensioning ii) Slip prevention iii) Material selection for durability c) Shafts: Transmits torque/power and rotation <ul style="list-style-type: none"> i) Load capacity ii) Alignment iii) Fatigue considerations d) Chains: Transmit power with positive engagement <ul style="list-style-type: none"> i) Chain pitch ii) Lubrication iii) Wear inspection e) Levers: Amplify force <ul style="list-style-type: none"> i) Pivot point design f) Linkages: Convert motion types <ul style="list-style-type: none"> i) Four-bar linkage principles ii) Tolerance control g) Bearings: Reduce friction and support loads <ul style="list-style-type: none"> i) Types (ball, roller, plain) ii) Lubrication systems iii) Failure analysis h) Springs: Absorb shock and store energy <ul style="list-style-type: none"> i) Spring rate ii) Fatigue life iii) Material properties i) Cylinders: Provide linear motion <ul style="list-style-type: none"> i) Pneumatic vs hydraulic cylinders ii) Sealing integrity iii) Stroke length j) Valves and actuators: Control fluid flow and movement <ul style="list-style-type: none"> i) Actuation methods (manual, electric, pneumatic) ii) Response time

	<ul style="list-style-type: none"> iii) Safety interlocks k) Cams and followers: Convert rotary to reciprocating motion <ul style="list-style-type: none"> i) Cam profile design ii) Follower wear iii) Lubrication
<p>64.2 Applications of mechanical components</p>	<p>64.2.1 Applications</p> <ul style="list-style-type: none"> a) Locking devices <ul style="list-style-type: none"> i) Positive restraint: Split pins, tab washers, locking wire ii) Frictional restraint: Adhesive, nylon insert, serrated washers, locking nut b) Power transmission <ul style="list-style-type: none"> i) Belts ii) Gears iii) Pulleys iv) Chains and sprockets v) Couplings vi) Shafts c) Motion control <ul style="list-style-type: none"> i) Levers ii) Linkages iii) Cams d) Overload protection <ul style="list-style-type: none"> i) Torque limiter ii) Slip clutch iii) Separation type e) Shock/vibration and flexibility <ul style="list-style-type: none"> i) Springs <p>64.2.2 Mechanisms</p> <ul style="list-style-type: none"> a) Four-bar linkages: Used in robotic arms and presses b) Crank-slider mechanisms: Common in reciprocating pumps and engines c) Cam and follower systems: Found in automated packaging machines d) Ratchet and pawl: Used in lifting devices and indexing systems e) Geneva wheel: Provides intermittent motion in conveyors f) Toggle mechanisms: Used in clamping and press operations
<p>64.3 Sealing and jointing methods used in mechanical assemblies</p>	<p>64.3.1 Types of sealing and jointing methods</p> <ul style="list-style-type: none"> a) Gaskets: Material selection for temperature and pressure conditions b) Bellows: Used for vibration isolation and thermal expansion c) Compression: Common in pipe joints; torque control critical d) Capillary: Brazed joints for leak-proof seals e) Heat-shrink (interference): Used for shaft-hub connections; requires precise tolerances

	<ul style="list-style-type: none"> f) Welding, brazing and soldering: Structural integrity and inspection standards g) O-rings, lip seals, gas seals, mechanical seals, labyrinth seals: Selection based on fluid/gas type, pressure, temperature and speed; failure analysis for leakage prevention
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K65 Mechanical. Different types of mechanical fasteners and their uses

Topic	Content – What needs to be covered
65.1 Mechanical fastener types and applications	65.1.1 Types of mechanical fasteners <ul style="list-style-type: none"> a) Nuts <ul style="list-style-type: none"> i) Hexagon and heavy hexagon ii) Square nuts iii) Flange nuts iv) Lock nuts v) Wing nuts vi) Acorn/cap nuts b) Bolts <ul style="list-style-type: none"> i) Hexagon bolt ii) Eye bolt iii) U-bolt iv) Anchor bolt v) Flange bolt vi) Machine/set bolt vii) Shoulder bolt viii) Stud bolt c) Screws <ul style="list-style-type: none"> i) Machine screw ii) Set/Grub screw iii) Lead screw d) Self-tapping screws <ul style="list-style-type: none"> i) Thread-forming screws ii) Thread-cutting screws iii) Self-drilling screws e) Rivets <ul style="list-style-type: none"> i) Solid rivets ii) Blind rivets (pop rivets) iii) Tubular rivets iv) Split rivets v) Flush rivets (countersunk rivets) vi) Self-piercing rivets f) Washers <ul style="list-style-type: none"> i) Plain washers ii) Spring washers iii) Locking washers g) Snap rings/circlips <ul style="list-style-type: none"> i) Internal types ii) External types

	<p>65.1.2 Application of mechanical fasteners</p> <ol style="list-style-type: none"> a) Joining moving parts (hinges) b) Maintenance and repair (nuts, bolts, screws) c) Permanent joining (rivets) d) Load distribution (washers) <p>65.1.3 Identification, fitting and removal of fasteners</p> <ol style="list-style-type: none"> a) Metric/SI units measurement b) Imperial measurement c) Hand tools <ol style="list-style-type: none"> i) Spanners ii) Sockets iii) Screwdrivers iv) Pliers (including circlip) d) Power tools <ol style="list-style-type: none"> i) Pneumatic ii) Hydraulic iii) Electric (portable drill) e) Torque loading <ol style="list-style-type: none"> i) Where to find fastener torque values ii) Factors that influence torque values
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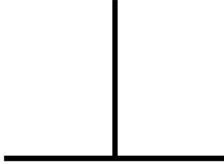

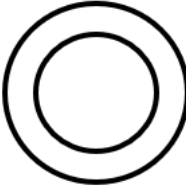


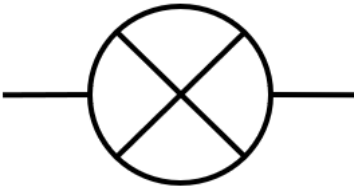

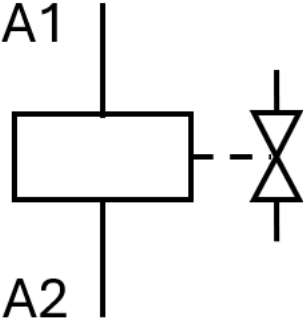

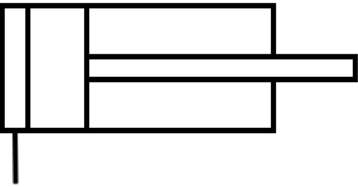
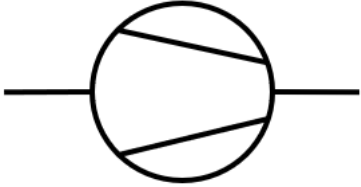
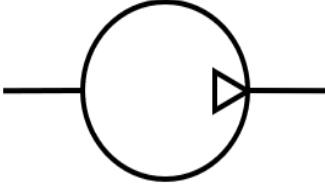

K66 Mechanical. Types of diagrams used to represent mechanical installations and assemblies; symbols and abbreviations used to represent parts in diagrams

Topic	Content – What needs to be covered
66.1 Types of diagrams and technical documentation	<p>66.1.1 Types of diagrams and drawings used in mechanical engineering and their primary uses</p> <ol style="list-style-type: none"> a) Orthographic (1st Angle and 3rd Angle) – used for accurate component views for manufacturing and assembly b) Isometric – used for 3D representation of components c) Oblique – used for pictorial representation d) Schematic diagrams – used for fault finding, troubleshooting, diagnostics e) Exploded diagrams – used to illustrate assemblies and disassembly of components f) General Assembly (GA) – used to represent complete assemblies and their arrangement g) Detail drawings – used for precise component details h) Conventional drawings, sketches and diagrams i) CAD drawings including 3D modelling j) Standard Operating Procedures (SOP) – used for maintenance procedures k) Method statements – used for manufacturing activities l) Manufacturer and data sheets – used for reference during maintenance and assembly


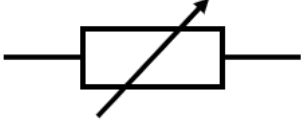
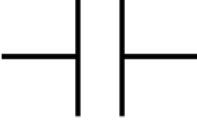

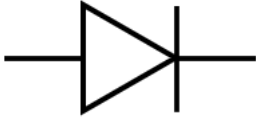
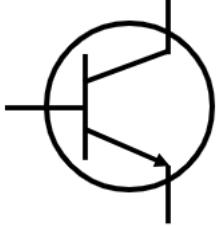
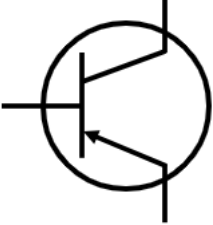
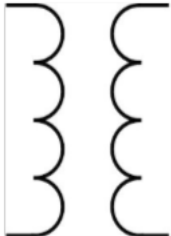
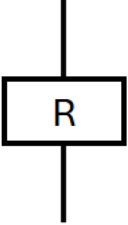

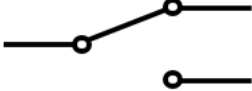
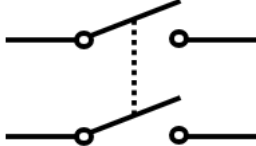
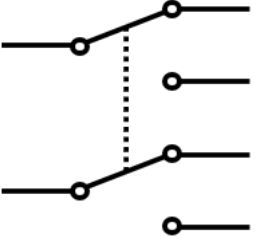
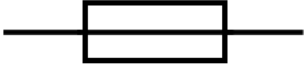



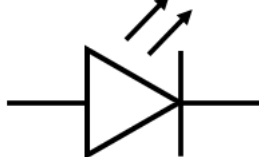
<p>66.2 Symbols and abbreviations used in diagrams</p>	<p>66.2.1 Symbols and abbreviations used in diagrams and drawings – Standard reference BS8888</p> <ul style="list-style-type: none"> a) Tolerance (maximum and minimum values) b) Radius c) Diameter d) Material e) Position f) Threads g) Countersink h) Counter-bore i) Cross-sectional views j) Enlarged views k) Scale (1/1, 2/1, 1/2, 4/1, 10/1, 100/1) l) Surface finish m) Welding <ul style="list-style-type: none"> i) Butt ii) Fillet n) Projection (symbol) o) Geometric <ul style="list-style-type: none"> i) Squareness ii) Flatness iii) Concentricity iv) Parallelism
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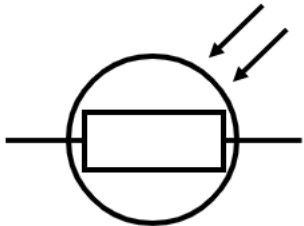
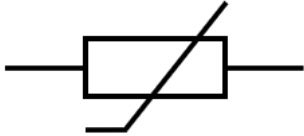
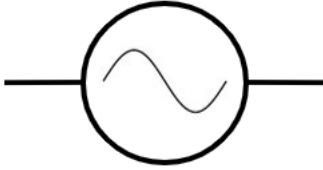
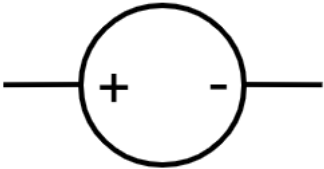
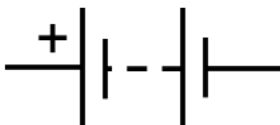

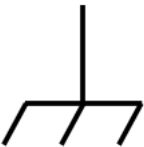



Symbols bank for multiple-choice tests

Core – K21

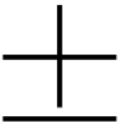


		
Diameter – BS8888	Straightness– BS8888	Perpendicularity– BS8888
		
Parallelism– BS8888	Concentricity– BS8888	Switch- IEC 60617
		
Resistor- IEC 60617	Lamp- IEC 60617	Motor- IEC 60617
		
Solenoid- ISO 1219	Valve- ISO 1219	Cylinder- ISO 1219
		
Compressor- ISO 1219	Pump- ISO 1219	Reservoir- ISO 1219

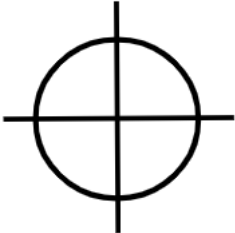
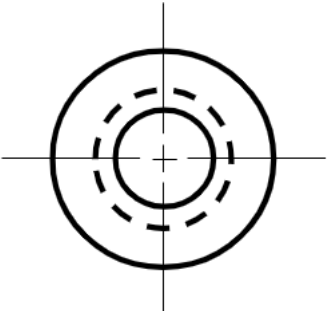
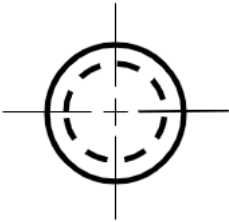




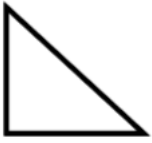
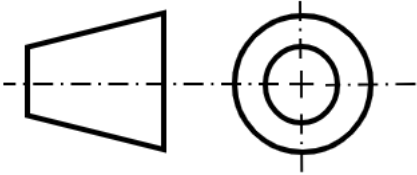
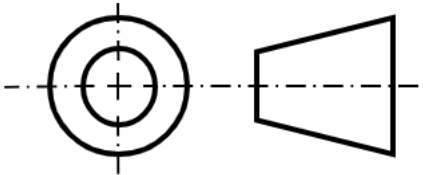
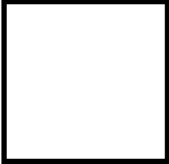

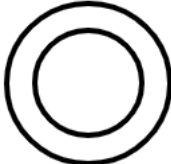

Electrical- K38 – IEC 60617

		
Fixed resistor	Variable resistor	Capacitor
		
Inductor	Diode	NPN transistor
		
PNP transistor	Transformer	Relay
		
SPST switch	SPDT switch	DPST switch
		
DPDT switch	Fuse	AC motor
		
DC/Servo motor	Stepper motor	Light Emitting Diode (LED)

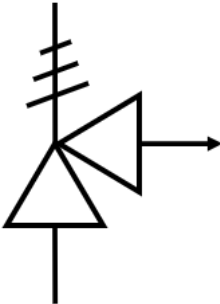
		
Light Dependent Resistor (LDR)	Thermistor	AC supply
		
DC supply	Battery	Protective earth
		
Chassis ground	Signal ground	Measurement point - ammeter
		
Measurement point - voltmeter		

Mechanical- K66 – BS8888

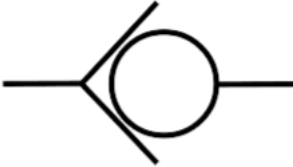
		
Tolerance: plus or minus symbol followed by the acceptable limit	Radius, abbreviation: Letter R followed by the value e.g.R6	Diameter

DIA	MTL	
Diameter alternative, abbreviation	Material, abbreviation	Position (true position)
		
Internal thread	External thread	Countersink
		
Counter-bore	Surface finish	Butt weld
		
Fillet weld	First-angle projection	Third-angle projection
		
Square	Flatness	Concentricity
		
Parallelism		

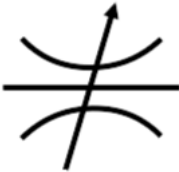
Control and Instrumentation- K54



Pressure relief valve



Check valve



Flow valve



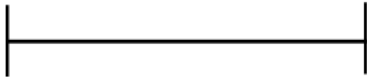
Solid thick line – visible edge, outline



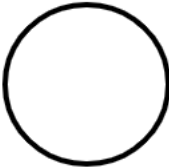
Solid thin line –dimension, extension, leader line



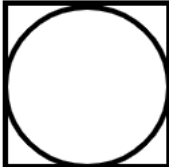
Dashed line – hidden detail



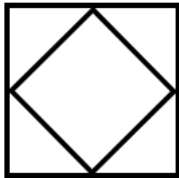
Solid line with perpendicular marks – dimensions



Circle – discrete, stand alone instrument



Circle inside a square -shared display/control instrument



Diamond inside a square – Programmable Logic Controller (PLC)function



Hexagon – computer function



Centre line

Appendix 2 – KSBs and grading descriptors for 700/701/702 Observation with Questions

Theme KSBs	Pass	Distinction	
Core – Organising own work	Uses planning, prioritising, organising and time management techniques and identifies and organises resources required to plan and complete tasks with consideration for quality, cost, delivery and ethical practices. (K4, K5, S2, S3)	Justifies their planning decisions in terms of efficiencies they achieved and the balance of quality, cost, delivery and ethical practice. (K4, K5, S2)	
Core – Maintaining workplace health, safety, security and environmental compliance	Identifies potential hazards and risks in the work environment and applies control measures in line with safe systems of work. (K9, S7)	Explains the importance of applying health, safety and environmental procedures in their work. (K10, S8)	
	Prioritises safe working practices by applying health, safety and environmental procedures in compliance with regulations, standards and guidelines including selection, use and care of personal protective equipment. (K10, K11, S8, B1)		
	Follows asset security procedures in line with task and company requirements. (K12, S9)		N/A
	Segregates items for reuse, recycling and waste in line with the company's recycling and waste management requirements. (K15, S12)		N/A
Core – Using work information and following working practices	Reviews and uses information including engineering information to plan and complete tasks. (K19, S1)	N/A	
	Identifies equipment to work on and checks plant configuration is as defined, identifying and highlighting issues with drawings in line with company procedures. (S5, S23)	N/A	
	Prepares the work area for maintenance to meet task requirements in line with company procedures. (S6)	N/A	

	Takes ownership for the delivery and quality of work by applying BSI and ISO engineering maintenance standards and procedures in line with standard operating procedures (SOPs). (K20, K22, K23, S14, B3)	N/A
	Applies foreign material exclusion procedures in line with task requirements and company procedures. (K24, S15)	N/A
	Follows maintenance tools and equipment control requirements in line with company procedures. (S16)	N/A
	Reinstates the work area in line with task requirements and company procedures. (S17)	N/A
Core – Completing work records	Records information for work tasks in line with their company procedures for documentation control and auditable records. (K25, S21)	N/A
Core – Communicating with others	Uses verbal communication methods and techniques and industry terminology suitable for the context. (K29, S19)	N/A

Electrical engineering maintenance technician grading descriptors

Conducting planned electrical engineering maintenance	Electrical Confirms electrical isolation lockout tagout method has been applied and tests for dead in line with task requirements and company procedures.	Electrical Justifies their approach to planned electrical maintenance. (K41, S31, S32, S34, S35, S37)
	Electrical Conducts and confirms electrical and connected services deisolation in line with task requirements and company procedures. (K34, S27, S36)	
	Electrical Selects electrical maintenance tools, measurement and test equipment to meet task requirements. Checks to ensure functionality and uses in line with operation and care requirements. (K42, S28)	
	Electrical Conducts planned electrical maintenance in line with task requirements and company procedures including inspecting and	

	<p>testing electrical aspects of plant, removing and replacing electrical parts, setting up and adjusting electrical aspects of plant, and cleaning parts.</p> <p>Electrical Conducts functional testing to confirm operation in line with task requirements and company procedures. (K41, S31, S32, S34, S35, S37)</p>	
Control and instrumentation engineering maintenance technician grading descriptors		
Conducting planned control and instrumentation engineering maintenance	<p>C&I Conducts and confirms isolation of connected services in line with task requirements and company procedures.</p> <p>C&I Confirms safe electrical isolation lockout tagout method has been applied and tests for dead in line with task requirements and company procedures.</p>	<p>C&I Justifies their approach to planned control and instrumentation maintenance. (K55, S43, S44, S45, S46, S47, S48, S51)</p>
	<p>C&I Re-connects instrumentation power supply, cables, pipework and services in line with task requirements and company procedures.</p>	
	<p>C&I Conducts and confirms electrical and connected services deisolation (K47, K48, S38, S39, S50)</p>	
	<p>C&I Selects control and instrumentation maintenance tools and equipment suitable for the task. Checks to ensure functionality. Uses in line with operation, care and calibration requirements. (K56, S40)</p>	
	<p>C&I Conducts planned control and instrumentation maintenance in line with task requirements and company procedures including inspecting and testing control and instrumentation systems, checking calibration and making adjustments, checking loop function, setting up and adjusting control and instrumentation systems, cleaning parts and removing and replacing instruments and sensors.</p>	
	<p>C&I Conducts functional testing to confirm operation in line with task requirements and company</p>	

	procedures. (K55, S43, S44, S45, S46, S47, S48, S51)	
Mechanical engineering maintenance technician grading descriptors		
Conducting planned mechanical engineering maintenance	Mechanical Checks and confirms safe isolation of connected services in line with task requirements and company procedures.	Mechanical Justifies their approach to planned mechanical maintenance. (K55, S43, S44, S45, S46, S47, S48, S51)
	Mechanical Confirms electrical and connected services deisolation in line with task requirements and company procedures. (K67, S52, S62)	
	Mechanical Selects mechanical maintenance tools and equipment suitable for the task. Checks to ensure functionality. Uses in line with operation, care and calibration requirements.	
	Mechanical Conducts planned mechanical maintenance in line with task requirements and company procedures including checking condition and operation of mechanical aspects of plant and equipment, removing and replacing mechanical parts, examining mechanical parts for defects, setting up and adjusting mechanical aspects of plant, cleaning parts and lubricating mechanical assemblies.	
	Mechanical Conducts functional testing to confirm operation in line with task requirements and company procedures. (K55, S43, S44, S45, S46, S47, S48, S51)	

Appendix 3 – KSBs and grading descriptors for 710/711/712 Interview Underpinned by a Portfolio of Evidence

Theme KSBs	Pass	Distinction
Core – Impact of sector on maintenance activities	Explains the impact of the sector that they work in on their maintenance activities. (K1)	N/A
Core – Role and responsibilities	Outlines their role as a maintenance technician including their limits of responsibility and how they escalate issues in line with company procedures. (K3, S20)	N/A
	Describes how they respond and adapt to meet demands in their work with different maintenance disciplines and functional areas. (K2, S4)	N/A
	Describes how they have or would respond in an emergency situation in line with their company’s emergency incident procedures. (K16, S10)	N/A
Core – Working sustainably	Describes how they consider and apply principles of sustainability when using resources and carrying out tasks to support the UK’s net zero commitment. (K14, S11, B2)	Justifies their application of sustainability practices in maintenance activities. (K14, S11, B2)
Core – Participating in continuous improvement	Describes how they have applied continuous improvement (CI) techniques to identify viable suggestions in line with the company’s CI processes. (K26, S25)	Justifies the potential impact of their improvement suggestions with consideration to benefits and potential risks. (K26, S25)
	Describes planned and unplanned learning and development activities they have carried out and recorded to meet personal development needs, showing a commitment to future CPD. (S26, B5)	N/A
Core – Teamworking	Describes how they apply team working principles to meet work goals and support inclusivity in line with their company’s policy on equity, diversity and inclusion. (K27, K28, S18, B4)	N/A

Core – Produce written documents	Describes how they apply written communication techniques to produce or update documents in their work that are suitable for the context. (K30, S22)	N/A
Electrical engineering maintenance technician grading descriptors		
Electrical maintenance problem solving and fault finding	Describes how they use electrical diagnostic equipment and apply fault finding, rectification, problem solving and critical reasoning techniques to identify and rectify common electrical plant, equipment and systems failure modes in line with task requirements and company procedures. (K43, K44, K45, S29, S30)	Justifies diagnostic methods they have used in the identification and rectification of faults and system failure modes. (K43, S30)
Cable installation and termination	Describes how they prepare and terminate electrical cables using methods in line with the task requirements and company procedures. (K40, S33)	N/A
Control and instrumentation engineering maintenance technician grading descriptors		
Control and instrumentation maintenance problem solving and fault finding	Describes how they use control and instrumentation diagnostic equipment and apply fault finding, rectification, problem solving and critical reasoning techniques to identify and rectify common control and instrumentation system failure modes in line with task requirements and company procedures. (K57, K58, K59, S41, S42)	Justifies diagnostic methods they have used in the identification and rectification of system failure modes. (K57, S42)
Mechanical engineering maintenance technician grading descriptors		
Mechanical maintenance problem solving and fault finding	Describes how they use mechanical diagnostic equipment and apply fault finding, rectification, problem solving and critical reasoning techniques to identify and rectify common problems relating to mechanical aspects of plant and equipment in line with task requirements and company procedures. (K70, K71, K72, S54, S55)	Justifies diagnostic methods they have used in the identification and rectification of issues relating to mechanical aspects of plant and equipment.
Bench fitting techniques	Describes how they apply bench fitting techniques including cutting threads, mechanical fitting and joining in line with task requirements and company procedures. (K73, S64)	N/A

Appendix 4 9331-11-700/701/702 Observation with Questions – planning checklist/template

This document aims to support employers/providers and apprentices to plan and prepare for the 700/701/702 Observation with Questions assessment. It does not need to be uploaded; however, it may support completion of the Gateway questions and preparation for the (optional) planning meeting.

Option (delete as applicable)	700 Electrical engineering maintenance technician 701 Mechanical engineering maintenance technician 702 Control and instrumentation maintenance technician		
Apprentice name		Enrolment number	
Assessment venue			

You should refer to the assessment specification, KSBs and grading descriptors to ensure that the scope of work will provide the apprentice with the opportunity to demonstrate the KSBs and grading descriptors to the best of their ability.

Observation with Questions

Outline of the maintenance task(s)	
Timings (if applicable); n.b. the planned task(s) must be able to be completed within the four-hour assessment time which will also include IEPA questions.	
Will any of the task(s) require ‘pre-installed’ aspects (ie skills that may not be able to be demonstrated through naturally occurring tasks)?	

<p>n.b. minimal pre-installed aspects are allowed for the following skills but must be agreed with the IEPA:</p> <ul style="list-style-type: none"> • S32 Electrical. Remove and replace electrical parts • S44 Control and instrumentation. Check calibration and make adjustments • S46 Control and instrumentation. Set up and adjust control and instrumentation systems • S48 Control and instrumentation. Remove and replace instruments and sensors • S57 Mechanical. Remove and replace mechanical parts • S59 Mechanical. Set up, align, and adjust mechanical aspects of plant 	
<p>Have you confirmed any additional requirements to the City & Guilds EPA team, eg access requirements for the venue/assessment location, induction training?</p>	
<p>Have you booked/prepared a separate room for the IEPA that will be free from distractions and interruptions?</p>	

Appendix 5 – Portfolio of evidence checklist

Apprentice portfolio of evidence checklist		Tick when confirmed
1.	Is all evidence signed by the apprentice and dated?*	
	E-signatures are also acceptable	
2.	Is all evidence valid, authentic, current and sufficient (VACS)?	
3.	Does evidence clearly show it is the apprentice's individual work (and if involved in teamwork, is it clear what specific contribution the apprentice made)?	
4.	Does the evidence clearly demonstrate the apprentice's relevant knowledge?	
5.	Has the apprentice completed the portfolio reference form? And has all evidence been referenced, where applicable?	
6.	Does it showcase the apprentice's best pieces of work?	
7.	Have duplicate and irrelevant pieces of evidence been removed?	
8.	Is there sufficient evidence to cover the whole of the KSBs and grading descriptors that are referenced?	
9.	Are any witness testimonies or employer references tailored to the apprentice, where applicable?	
10.	Has any client/customer reference information been anonymised?	
11.	Are all external sources of information appropriately documented and referenced to the original source, showing clear understanding of how they relate to the KSBs?	
12.	Has the appropriate stakeholder(s), eg employer/training provider, checked whether the apprentice's portfolio meets all the required KSBs and grading descriptors?	

*Where witness testimonies are included as a piece of evidence, these do not need to be signed by the apprentice but instead must be signed/authenticated.

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