BRITISH FLUID POWER ASSOCIATION QUALIFICATIONS

PNEUMATICS & CONTROL PROGRAMME (P3)

CETOP PASSPORT OCCUPATIONAL LEVEL 3

Issue 2
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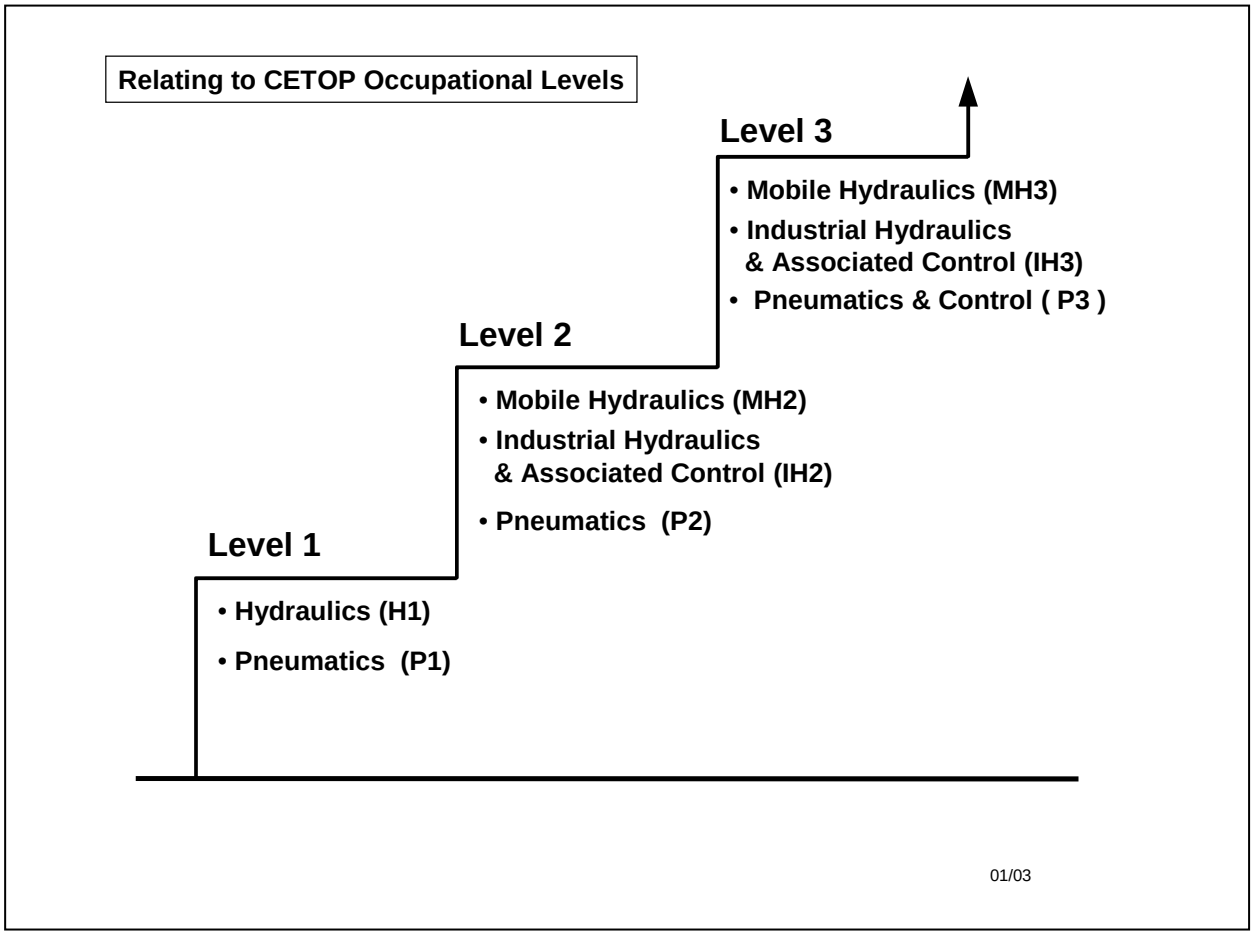
FOREWORD

These Competence Based Qualifications have been developed by members of the BFPA Education and Training Committee, to meet the CETOP occupational levels of those people involved in the maintenance and management of fluid power systems and cover the specific subjects of mobile hydraulics, industrial hydraulics, pneumatics and associated control systems.

They form a structure for progressive learning and the acquisition of a range of competence assessed skills. They have now been accepted by CETOP as industry standard qualifications forming part the harmonisation programme and the proposed passport for Europe within this sector of engineering.



Each level can be considered as a **stand-alone qualification and level of achievement**. However, each level progresses to a higher level of knowledge, understanding and application. In all cases candidates should ensure that they have the appropriate knowledge and experience to commence the qualification level chosen

Level 1 programmes provide a foundation of knowledge with emphasis placed upon fundamental principles, component functionality, operation and recognition together with an understanding of fluid power systems at a basic level

The level 2 programmes ensure component functionality, operation and application are fully understood. These programmes have a higher technical content than the level 1 programmes and provide a more in-depth approach to function, operation, application and the interpretation of circuitry

The level 3 programmes place emphasis on complex systems, integrated operations and their associated controls including the electrical/electronic interface. They involve technical specifications and the development of greater in-depth knowledge associated with component characteristics, system performance and interpretation.

Each level involves calculations and the use of formulae, emphasis is also placed upon the ability to read and interpret circuit diagrams. The development of diagnostic skills and the ability to act accordingly is involved at every level thereby applying a fault-cause-remedy approach throughout.

Where the same subjects appear at more than one level they are dealt with at the appropriate depth and in a manner that meets the requirements of that level.

It is advisable in all cases to study the content of the previous levels before taking a higher level. This will ensure that your prior theoretical knowledge and application experience is sufficient for you to proceed.

You should seek advice from your nearest Approved Centre and if in doubt arrange a formal meeting with a tutor to carryout an analysis to identify your strengths and weakness and jointly establish a plan for your progression.

For further details of these industry standard qualifications and approved centres visit the BFPA website: www.bfpa.co.uk.

INTRODUCTION

Developed by the BFPA Education and Training Committee, this programme represents one of a range of new competence-based qualifications launched in 2002.

It is intended for those personnel involved in the maintenance and management of industrial pneumatic systems and associated controls who require knowledge and competence based skills to support such work based activities as: planning and preparation, interpreting and using technical information, devising and following sound procedures associated with installation, commissioning, testing, fault diagnosis, rectification, maintenance, servicing and re-establishing a machine "fit for purpose".

Throughout the programme, emphasis will be placed upon the development of knowledge relating to “FUNCTION”, “OPERATION” and “APPLICATION”.

The knowledge-based section will support the development and effective application of Practical Skills necessary to carry out in a safe and effective manner that of:

INSTALLATION
COMMISSIONING
PERFORMANCE TESTING
PREDICTIVE MAINTENANCE AND MACHINE MANAGEMENT
SERVICING
COMPONENT REMOVAL AND REPLACEMENT

The development of Planning and Preparatory Skills, the use of technical information and specifications and the formulation and implementation of safe working procedures will be emphasised throughout all aspects of this programme.

Methodology and Assessment

The programme can be offered via a range of learning modes devised by the approved centers. Distance learning supported by a series of centre-based modules can also be considered.

Candidates will be expected to complete a series of assignments throughout the programme of study to reinforce the learning process and attend the programme of centre-based modules or short courses.

Final assessment for the knowledge-based units will be via a written examination of 2½ hours duration.

This will be prepared by the BFPA and offered at approved centres in June each year.

The pass mark for the written examination will be 70%.

The expected completion time for this competence based programme is 2 years and will depend upon the centers mode of attendance. In all cases it will require a high level of personal commitment to study and research the subjects within the syllabus.

Practical task preparation and competence based unit assessment will be carried out by arrangement with the approved centre during the year. Final assessment will be carried out on a “one to one” basis, candidate to tutor, and the outcome will be pass or fail.

Successful completion of both the knowledge based and competence based units will result in the award of a BFPA/CETOP Level 3 Pneumatics & Control Qualification Certificate (P3). Candidates successfully completing only one unit will receive a BFPA/CETOP Unit Certificate.

Further copies of this document can be obtained from The British Fluid Power Association, Cromwell Park, Chipping Norton, Oxon OX7 5SR. Tel: 01608 647900. Fax: 01608 647919.

PRACTICAL TASK ASSESSMENT (P3)

Assessment Requirements

In practical tasks, candidates must on at least two occasions, prove their ability to carry out the following:

Assessed Ability

P3.1 Interpret pneumatic, electro-pneumatic, electrical/electronic control circuit diagrams relating to selected systems and prepare schematic representation of the system.

Evidence Required

P3.1.1 Machine function and operating principles identified.
P3.1.2 Components correctly identified.
P3.1.3 Function and operation of individual sub-circuits correctly identified.
P3.1.4 Machine control inputs and outputs identified.

Assessed Ability

P3.2 Assemble pneumatic/electro-pneumatic system from given information.

Evidence Required

P3.2.1 Components selected and conformance checked against system specification.
P3.2.2 Installation/Action plan prepared.
P3.2.3 System assembled in safe and efficient manner and complying with European Directives and safety standards (reference P3.7.18).
P3.2.4 Setting up/commissioning procedures followed in accordance with technical specification.
P3.2.5 Start up procedures correctly specified.
P3.2.6 System operated according to specification.

Assessed Ability

P3.3 Construct and commission 'PLC' controlled electro-pneumatic system from given information.

Evidence Required

P3.3.1 PLC program correctly designed.
P3.3.2 Components correctly selected for application.
P3.3.3 System assembled in safe and efficient manner.
P3.3.4 Applies monitoring and editing features to correct or modify the program as necessary.
P3.3.5 System operated according to specification.

Assessed Ability

P3.4 Identify and rectify faults in pneumatic/electro-pneumatic systems.

Evidence Required

P3.4.1 Malfunction correctly identified.
P3.4.2 Correct procedures used for fault finding.
P3.4.3 Systems correctly and safely isolated.
P3.4.4 Faulty component(s) correctly identified, repaired/replaced and correctly adjusted as necessary.
P3.3.5 Cause and effect correctly assessed.

Assessed Ability

P3.5 Establish documented procedures and carry out preventative maintenance and monitoring of pneumatic/electro-pneumatic systems.

Evidence Required

P3.5.1 System assessed to determine service/maintenance schedule requirements.
P3.5.2 System assessed to determine routine monitoring requirements.
P3.5.3 Documented system established including safety requirements/risk assessment.
P3.5.4 Performance testing carried out and results recorded.
P3.5.5 Pneumatic and electrical input/output signals checked and recorded.
P3.5.6 Manufacturers recommendations and specifications checked against results.
P3.5.7 Safe working practices followed at all times.

Assessed Ability

P3.6 Identify and apply relevant regulations for the safe installation and operation of pneumatic/electro-pneumatic circuits.

Evidence Required

P3.6.1 Legal Regulations: Machinery Directive (EU), EMC, ATEX…
P3.6.2 List basic safety principles and components.
P3.6.3 Safety related parts of power and control systems.

Note: Preparation for practical task assessment can be a group activity but the final practical task assessment shall be carried out on a "one to one" basis between the candidate and the assessor. Evidence will be obtained by non-intrusive observation, questioning or written and verbal reports.

KNOWLEDGE BASED UNIT (P3)

CONTENTS

KNOWLEDGE BASED UNIT - WRITTEN EXAMINATION SPECIFICATION

- The examination paper will contain 8 questions integrating the above 14 sections
- Examination duration will be 2½ consecutive hours
- Candidates will be expected to attempt 5 questions
- Each question will carry equal marks
- Pass mark will be 70%
- Where calculations and formulae are involved, all progressive stages of the calculation together with the corresponding units must be shown

POWER PNEUMATICS AND CONTROL - (Knowledge Based Unit)

Fundamental and Scientific Principles

P3.7.1 Describe the fundamental principles of power transmission by pneumatics and associated scientific principles underlying their use:

(a) List the basic components and describe their function
- i) prime movers, compressor, coolers, air receiver, dryers and pipework

(b) Know the quantities and units
- i) pressure, force, area, air consumption, flow rate, speed/velocity, torque and power
- ii) conversion of units

(c) Know the formulae relating to:
- i) pressure, force, area, air consumption, flow rate, speed/velocity, torque and power

(d) State and use the relationship between:
- i) pressure, force and area

(e) List the advantages and disadvantages of pneumatic systems compared to:
- i) mechanical systems
- ii) electrical systems
- iii) hydraulic systems

Application of the Fundamental Principles

P3.7.2 Describe the application of the fundamental principles relating to:

(a) Relationship between flow rate, pressure drop, pipe size and length
- using a P/V diagram, state the relationship between pressure, volume and temperature and work done for isothermal, polytropic and adiabatic compression of air
- define the term relative humidity and explain the effect it has when air is compressed and when compressed air passes through a system

(b) Control of pressure
- distinguish between gauge pressure and absolute pressure
- compression ratio
- pressure relief
- pressure reduction
- pressure measurement

(c) Control of flow
- directional
- soft start/dump
- flow control, bi-directional
- flow control with by-pass
- non-return
- flow coefficients and conversion

(d) Control of movement
- speed
- stopping or preventing movement
- changing direction

Fundamental Electrical Principles

P3.7.3 Describe the fundamental principles and control, applicable to the use and application of electrical/electronic technology:

- state and use the relationship between voltage, current, resistance and power
- state the relationship between movement, magnetism and current
- meaning of the term inductance and its effect upon DC circuits
- meaning of the term capacitance and its effect upon DC circuits
- meaning of the terms amplitude, frequency, periodic time and RMS
- define the terms digital and analogue associated with control systems
- describe the fundamental principles of open and closed loop control

Electrical/Electronic Components

P3.7.4 Describe the function and application of electrical/electronic components:

- resistors
- capacitors
- potentiometers
- transformers
- diodes
- switches (two way and three way)
- relays
- proximity and limit switches
- pressure switches
- position sensors

Solenoid Valves

P3.7.5 Describe the function, operating principles, application and mounting arrangements of solenoid operated valves:

(a) Types of solenoids
- i) switching (AC and DC)
- ii) proportional

(b) Solenoid features
- i) manual over-ride
- ii) explosion proof (reference to intrinsically safe)

(c) Types of valve
- i) direct operated
- ii) internal pilot operated
- iii) external pilot operated

(d) Types of solenoid suppression
- i) AC circuits
- ii) DC circuits

Electro-pneumatic Systems

P3.7.6 Describe the function, applications and mounting:

(a) valve terminal

(b) island

Proportional Valve Technology

P3.7.7 Describe the fundamental principles of proportional valve technology:

(a) List its potential applications compared to solenoid switching valve techniques

(b) Describe the operation of proportional valves
- i) pressure control
- ii) flow control

(c) Describe in block diagram form, the components of a typical proportional valve electronic amplifier and explain the meaning of:
- i) gain adjustment
- ii) deadband compensation
- iii) ramp controls
- iv) dither
- v) pulse width modulation

(d) Explain the recommended practices for installing proportional electronic control in terms of:
- i) power supply requirements
- ii) enable signals
- iii) input signal generation
- iv) cable shielding
- v) earthing
- vi) interfacing to PLC’s

Electrical Noise/Suppression

P3.7.8 (a) State the causes and possible effects of electrical noise in electrical/electronic systems and identify the standard precautions for eliminating the effects
- i) correct earthing and screening
- ii) correct location of sensitive components
- iii) use of opto-isolators
- iv) use of filters to suppress electro-magnetic generated noise
- v) effects of ground loops

(b) Identify the degrees of ingress protection applied to enclosures ('IP' codes)

Pneumatic Control Systems

P3.7.9 Describe the control methods and applications used to achieve sequential control:

(a) Methods
- i) cascade
- ii) pneumatic logic
- iii) pneumatic sequencer

(b) Applications
- i) simple application
- ii) complex application
- iii) 'hazardous area' application

Digital Control Circuits

P3.7.10 Prepare/describe digital control circuit diagrams using graphical symbols for listed circuitry:

(a) Manual control

(b) Automatic control

(c) Sequence control (timebased and feedback)

(d) Automatic control incorporating fail safe techniques

Relay Ladder Circuit Diagram

P3.7.11 Prepare/describe relay ladder circuit diagrams incorporating the following terms:

(a) 'AND', 'OR', 'NOT' and 'MEMORY'

(b) Latching and unlatching

Programmable Logic Controller (PLC)

P3.7.12 Describe the function and operating principles of a Programmable Logic Controller (PLC) in the control of Electro-Pneumatic systems:

(a) Outline the concept of a PLC

(b) List the advantages compared with relay circuits

(c) Describe typical PLC hardware and give examples of its use relating to:
- i) an installation with a simple program
- ii) an installation with an enhanced program
- iii) programming devices
- iv) memory systems
- v) analogue to digital and digital to analogue conversion
- vi) data acquisition
- vii) monitoring

(d) Describe using block diagrams and symbols a simple PLC controlled Electro-pneumatic system including:
- i) power supply
- ii) fusing
- iii) coil suppression
- iv) emergency stop switching

(e) Describe using ladder logic diagrams basic program functions:
- i) single and multiple 'AND' and 'NAND'
- ii) single and multiple 'OR' and 'NOR'
- iii) single and multiple latching
- iv) timing
- v) counting
- vi) flags/markers
- vii) shift register
- viii) jumps and loops

(f) Describe the use of a PLC used to control:
- i) automatic time based sequence control of two or more actuators
- ii) automatic sequence control of two or more actuators using proof of position feedback

(g) Describe using block diagrams the following programme types:
- i) alternative (stored in memory simultaneously)
- ii) parallel
- iii) multi-tasking

Field Bus Systems

P3.7.13 Describe the principles and characteristics of Field Bus Systems as applied to control technology:

(a) Outline the concept of Field Bus Systems

(b) Identify different methods of transmitting data (protocols)
- i) Profibus 'DP'
- ii) Device Net
- iii) ASI
- iv) Interbus 'S'
- v) FIPIO
- vi) CANopen

(c) Describe typical Field Bus compatible hardware
- i) valve islands
- ii) valve/sensor return islands
- iii) input/output modules, nodes
- iv) gateways

(d) Describe the programming concept used with Field Bus Systems

Vacuum Technology

P3.7.14 (a) Describe the fundamental and scientific principles relating to vacuum pressure
- vacuum definition, technical data, thermodynamic topic
- know the relating to flow rate in relation to vacuum pressure

(b) List of vacuum circuit components and describe their functions
- vacuum generators: Venturi principle, pumps
- vacuum actuators: Suction cups (material, shapes, size) modular vacuum grippers
- specific components adapted for vacuum control (valves, sensors)
- piping of a vacuum circuit (diameter, length, material)

(c) Applications
- how can vacuum be used?
- describe applications using vacuum technology

(d) Calculation
- force on a vacuum gripper
- force on a suction cup, friction factor
- evacuation time, ejector pulse, air saving
- efficiency of a vacuum generator
- energy cost

Circuit and Control Features (Recognition and use of Pneumatic, Electro-pneumatic, Electrical and Electronic Symbols)

P3.7.15 Describe and interpret electro-pneumatic circuits and associated methods of control, including handling systems, positioning systems, fail safe methods:

- recognize and use current graphical pneumatic, electro-pneumatic, electrical and electronic symbols (EN 60617 ; ISO 1219/1)
- use methods to describe the running: Functional diagram or function chart for sequential process (ISO Standard IEC1131)

Installation and Commissioning Procedures

P3.7.16 Describe installation and commissioning procedures to be followed:

- planning work to be done and listing necessary resources
- checking component conformance against technical specification
- following manufacturer's recommendations for installation of a particular component/s
- outline commissioning procedures to be followed, taking into consideration: safety/risk assessment; operational specification; technical specification and start up procedures
- outline the procedures to be followed to ensure that system/components/s operates at a satisfactory level of performance

- outline the procedure to be followed to ensure that the work place is re-established 'fit for purpose'
- completion of all necessary reports/documentation

Maintenance, Monitoring and Fault Finding Procedures

P3.7.17 Describe maintenance, monitoring and fault-finding procedures:

(a) Outline the maintenance scheme, involving performance and health monitoring in terms of:
- maintaining cleanliness standard
- regular use of diagnostic and test equipment
- analysis of results and actions to be taken (prognosis)
- keeping up to date records and information systems
- establishing safe working practices and step by step procedures when dealing with system breakdowns/component failures/replacement/re-commissioning start up and testing

(b) List the common faults encountered in Electro-Pneumatic systems and associated components and state possible causes and effects on system performance relating to:
- incorrect sequence of operations
- incorrect sensor setting
- low air supply pressure
- air starvation
- incorrect air preparation
- erratic operation
- loads lowering/failure to hold position

(c) Describe procedures to follow when carrying out fault finding, in terms of:
- identifying and determining the nature of the fault
- planning stages
- safe working practices to be followed and associated risk assessment
- information necessary to effectively carry out fault diagnosis and rectification process
- application of FAULT-CAUSE-REMEDY procedures
- use of diagnostic equipment and recording results
- procedures to follow to rectify problems (adjustments, replacements, repair and re-commissioning)
- establishing system re-start procedures
- re-establish work place 'fit for purpose'
- completion of all necessary reports/documentation

Safety of Machinery Pneumatic/Electro-pneumatic Equipment on Machines Conforming to European Directives and Standards

P3.7.18 Describe:

(a) <u>Safety requirements for fluid power systems and pneumatic components</u>
- interpret the essential safety requirements in order to achieve conformity with European Legislation on machinery safety
- identity and prevent hazards from pneumatic and electro-pneumatic equipment and give the solutions for:
  i) isolation and purging
  ii) separation of energy sources

iii) reinstating of energy sources
iv) general stop
v) emergency stop
vi) manual starting

(b) Emergency fail-safe and safety system

In accordance with the Machinery In Directive, describe emergency fail-safe and safety systems

- differentiate between ‘emergency’ and ‘fail-safe’
- outline emergency stop procedures using:
  i) interlocks
  ii) fail-safe systems

(c) Risk analysis in accordance with the Machinery Directive

- compliance with ATEX Directive