BRITISH FLUID POWER ASSOCIATION QUALIFICATIONS

INDUSTRIAL HYDRAULICS & ASSOCIATED CONTROL PROGRAMME (IH3)

CETOP (PASSPORT) OCCUPATIONAL LEVEL 3

Issue 2
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FOREWORD

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

They are intended for those personnel involved in the maintenance and management of industrial hydraulic 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", "APPLICATION", "CONTROL" and "SPECIFICATION".

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
PROACTIVE 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 centres but it is envisaged that distance learning supported by a series of centre based modules will be the normal system used.

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.

Final assessment for the knowledge-based units will be via a written examination of $2^1/_2$ hours duration.

This will be prepared by 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 1 – 2 (but this does depend upon previous experience and the learning mode devised by the centre) years and 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 Level 3 Industrial Hydraulics and Associated Control Qualification Certificate. Candidates successfully completing only one unit will receive a BFPA Unit Certificate.

Reference should be made to the Guideline Document to Qualification BFPA/Q1 for further details.

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. E-mail: enquiries@bfpa.co.uk

PRACTICAL TASK ASSESSMENT (IH3)

Assessment Requirements

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

Assessed Ability

IH3.1 Interpret hydraulic and electro-hydraulic circuit diagrams applicable to selected systems (against recommended specification) and prepare a schematic representation of the system

Evidence Required

IH3.1.1 Machine function and operating principles identified.
IH3.1.2 Components correctly identified.
IH3.1.3 Function and operation of individual sub-circuits correctly identified.
IH3.1.4 Machine control inputs and outputs identified.

Assessed Ability

IH3.2 Assemble electro-hydraulic system involving on-off control and proportional control from given information

Evidence Required

IH3.2.1 Components selected and conformance checked against system specification.
IH3.2.2 Installation/Action plan prepared.
IH3.2.3 System assembled in a safe and efficient manner.
IH3.2.4 Setting up/commissioning procedures followed in accordance with technical specification.
IH3.2.5 Start up procedures correctly specified and followed.
IH3.2.6 System operated according to specification.
IH3.2.7 Establish predictive maintenance procedures to be followed, including:
(i) component performance testing
(ii) fluid sampling and assessment of contamination level against target level
(iii) electrical input and output signals involving on/off and proportional control systems

Assessed Ability

IH3.3 Carry out effective fault diagnosis and rectification

Evidence Required

IH3.3.1 Nature of fault correctly identified.
IH3.3.2 Fault, cause, remedy checklist prepared.
IH3.3.3 Diagnostics used to locate fault ensuring safety at all stages.
IH3.3.4 Safe working practices followed at all times.
IH3.3.5 Faulty component replaced, adjusted or repaired in line with planned procedures.
IH3.3.6 Cause and effect of faults assessed.
IH3.3.7 System re-commissioned in accordance with set procedures.
IH3.3.8 System operated according to machine specification.

Assessed Ability

IH3.4 Establish documented procedures and carry out predictive maintenance and monitoring of electro-hydraulic systems

Evidence Required

IH3.4.1 System assessed to determine service/maintenance schedule requirements.
IH3.4.2 System assessed to determine routine monitoring requirements.
IH3.4.3 Documented system established including safety requirements/risk assessment.
IH3.4.4 Performance testing carried out and results recorded.
IH3.4.5 Electrical input and output signals involving on-off and proportional control systems checked and recorded.
IH3.4.6 Fluid sampling carried out and contamination levels assessed against target cleanliness and result recorded.
IH3.4.7 Manufacturers recommendations and specifications checked against results.
IH3.4.8 Safe working practices followed at all times.

Note: Preparation for practical task assessment can be a group activity but the final practical task assessment will 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 (IH3)

CONTENTS

KNOWLEDGE BASED UNIT – WRITTEN EXAMINATION SPECIFICATION

The examination paper will contain 8 questions integrating the above 18 sections

- Examination duration will be 2½ consecutive hours
- Candidates will be expected to attempt 5 questions
- Each question will have equal weighting (20%)
- 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.

INDUSTRIAL HYDRAULICS PROGRAMME - (Knowledge Based Unit)

Fundamental and Scientific Principles

IH3.5.1 Describe the fundamental principles of power transmission by hydraulics and associated scientific principles underlying their use.

(a) List the basic building blocks and describe their function:
- (i) prime movers, pumps, reservoirs, fluids, control valves, filters, coolers, pipework and manifold blocks.

(b) Know the cause and effect of pressure generation, pressure losses, heat generation, fluid leakage, cavitation, aeration, noise and vibration.

(c) Know the difference between laminar and turbulent flow, and their effect on system performance.

(d) Know the meaning of the term 'Reynolds Number' and use the associated formula.

(e) Know the difference between static and dynamic pressure.

(f) Know the quantities and units:
- (i) pressure, force, area, displacement, flow rate, speed/velocity, torque and power.

(g) Know the formulae relating to:
pressure, force, area, displacement, flow rate, speed/velocity, torque and power.

(h) Know the principles of heat dissipation and temperature control:
- (i) heat sinks within a system (reservoirs, pipework and coolers)
- (ii) effects of ambient conditions and working cycle

(i) State and use the relationship between:
- (i) pressure, force and area
- (ii) pressure, torque and displacement per revolution for pumps and motors

(j) State and use the relationship between:
- (i) flow, area and velocity for cylinders
- (ii) flow, displacement per revolution and shaft speeds for pumps and motors

(k) Know the relationship between:
- (i) input and output powers of pumps and motors and the causes of volumetric and mechanical inefficiencies.

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

(iii) pneumatic systems

Application of the Fundamental Principles

IH3.5.2 Describe the application of the fundamental principles relating to:

(a) Relationship between flow rate, pressure drop, restriction, power and heat.

(b) Control of pressure

- pressure generation
- pressure limiting
- pressure unloading
- pressure reducing
- pressure intensification

(c) Control of flow

- non-compensated flow control
- pressure compensated flow control
- temperature compensated flow control
- flow dividing
- regenerative flow
- damping
- meter-in, meter-out and by-pass flow control

(d) Control of movement

- acceleration and deceleration control
- stopping or preventing movement
- changing direction

Hydraulic Fluids

IH3.5.3 Describe the application and selection of fluids for use in industrial hydraulic systems relating to:

(a) Functions

- power transmission
- lubrication.
- cooling

(b) Characteristics and properties: (behaviour and effect on system performance):

- viscosity
- viscosity index
- lubricity
- thermal stability (oxidation)
- pour point
- demulsibility
- shear stability
- compressibility
- material compatibility
- foaming and aeration resistance

- filterability
- specific gravity
- fire-resistance

(c) Types of fluids in common use in industrial applications
- classifications to ISO 6743-4
- ISO viscosity grades

(d) Fluid selection for typical applications (factors to be considered)
- environmental considerations
- fire resistance
- toxicity
- water separation
- filterability

(e) Fluid storage, handling and transfer:
- explain the need for correct storage, handling, cleanliness control and transfer systems to be in place and controlled by working procedures
- know the requirements associated with COSHH regulations

Explain the need for cleanliness control systems to be in place and associated fluid analysis procedures and monitoring (ISO 4406 and NAS 1638)

Valve Mounting Styles/Configurations

IH3.5.4 Describe valve mounting styles, standardised interfaces, sizes, flow rates, port layouts and sealing arrangements, relating to:
- pipe/line mounting
- sub-plate mounting
- manifold mounting
- stack, mounting
- flange mounted valves
- screw in cartridge
- slip in cartridge
- ISO interface valves

Hydraulic System Components

IH3.5.5 Describe the function, operation and application of control valves and interpret their graphical symbols. (control features to include mechanical, solenoid and solenoid pilot).

(a) Flow control devices: (fixed and adjustable)
- non-compensated flow control devices (orifices and throttle valves)
- pressure and temperature compensated flow control valves

- hydrostats and application with proportional control valves

- spool flow dividers
- rotary flow dividers

(b) Pressure control devices:

(i) pressure limiting
- single stage, relief valves
- two stage, pilot operated relief valves
- unloading valves

(ii) control features
- vent
- remote control
- load sensing
- pressure sensing (application of pressure switches)

(iii) pressure reducing
- single stage and two stage pressure reducing valves with relieving function

(c) Load Holding and Motion Control:
- pilot operated check valves
- counterbalance with internal and external pilot control (including the effect of pilot ratios)

(d) Direction control devices:
- check valves
- pilot operated check
- spool valves
- ball valves
- poppet valves
- sequence valves

control features to include - on-off and proportional control

Slip-in Logic Cartridge Valves

IH3.5.6 Describe the function, operation and application Slip-in (logic) cartridge elements
- construction and manifold assembly
- sizes and associated flow rates
- operating principles
- application for pressure, flow and direction control including associated control methods

Fundamental Electrical Principles

IH3.5.7 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

IH3.5.8 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
- tacho-generator

Proportional Valve Technology

IH3.5.9 Describe the principles of proportional valve technology

- list the potential benefits compared to application of "bang - bang" operated systems
- describe the difference in performance of a proportional solenoid to that of a standard solenoid
- describe the application of proportional control to pressure, flow and direction control. (including feedback and non-feedback valves, direct and two stage versions)
- describe, in block diagram form the control components of a typical proportional valve electronic amplifier
- explain the meaning of the terms: gain adjustment, dead band compensation, ramp control, dither and pulse width modulation and demonstrate an understanding of their effects on system performance
- explain the recommended practices for installing proportional electronic control in terms of: power supply requirements, enable signals, input signal generation, cable shielding, earthing and interface with PLCs

Pumps and Associated Control Systems

IH3.5.10 Describe the function and operation of hydraulic pumps and associated control features:

(a) Pumps:
- external gear
- internal gear
- vane, (fixed and variable)
- radial piston (fixed and variable)
- axial piston (fixed and variable)
- bent axis piston (fixed and variable)
- multiple pumps

(b) Control features:
- fixed pumps with relief valve and unloading systems
- mechanical/hydraulic servo displacement
- electro-hydraulic proportional displacement
- pressure compensation with and without remote pressure control
- load sensing
- constant power

(c) Relationship between pressure and flow (QP) characteristics

Hydraulic Actuators (Motors and Cylinders)

IH3.5.11 Describe the function, operation and application of hydraulic actuators, including control features:

(a) Motors:
- gear
- gerotor/orbit
- vane
- radial piston
- axial piston (swash plate)
- bent axis
- cam/roller types

} Including variable and dual displacement control features and associated torque speed characteristics

(b) Motor features:
- pressure control (pressure compensation)
- displacement (torque/speed control)
- parking brake
- dynamic braking (use of counterbalance valves)

(c) Motor performance:
- series circuitry
- parallel circuitry

(d) Cylinders, mounting arrangements and construction:
- single acting
- double acting
- through rod
- sealing
- cushioning
- mounting arrangements
- position monitoring

(e) Semi-rotary actuators:
- rack and pinion type
- vane type

Close-Loop Hydrostatic Transmissions

IH3.5.12 Describe the function, operation and application of hydraulic components associated with closed loop hydrostatic transmission systems:

(a) Basic configuration:
- pump and motor layout and associated control elements

(b) Over-centre piston pumps:
- basic construction (axial, bent axis and radial)
- control methods
- mechanical
- mechanical servo
- pilot pressure
- electronic servo
- pressure/limitation and displacement control

(c) Charge pump:
- construction
- charge pump circuitry
- case flushing (including cooling and heating functions)

(d) Control valves:
- hot oil shuttle valves
- cross-line relief valves
- counterbalance valves

- free-wheel by-pass valves

Reservoirs, Conditioning and Auxiliary Components

IH3.5.13 Describe the purpose of the system reservoir and associated fluid conditioning equipment and auxiliary components.

(a) Outline a typical system reservoir in terms of:
- size, with reference to oil and air space and changes in level
- general construction (internal/external), including return line and port arrangements to minimize aeration
- filling connections
- sampling points
- level/temperature indication
- air and oil filtration
- pressurised reservoirs
- use of bladder and diaphragm separators

(b) Describe the use of hydraulic fluid cooling systems:
- reservoirs (size, siting and layout)
- air blast coolers
- water coolers

(c) Describe the function, operation and application of auxiliary components:
- bladder type (bag) accumulators
- piston and diaphragm accumulators
- associated safety and control features
- pressure switches

Pipes and Hoses – Installation and Commissioning Procedures

IH3.5.14 Describe installation and commissioning procedures for pipes, hoses and seals, and associated selection process and sizing relating to application:

(a) Determine from pipe sizing charts and manufacturers' catalogues, suitable pipe/hose diameters associated with flow rates, velocities and acceptable pressure drops.

(b) Describe the types and application of seals used in hydraulic systems, with specific reference to:
- static and dynamic seals

- cylinder seals
- pump and motor shaft seals
- seal materials, selection and compatibility
- replacement methods and care to be taken during installation

(c) State the factors that effect system pressure drop:

- pipe/hose dimensions
- pipe work/manifold block configuration
- flow rate
- fluid viscosity and density
- component size/design

(d) Hoses types and application:

- wire braided
- 2-wire braided
- spiral wire
- thermo-plastic
- high temperature and protective sleeved.(abrasion resistant)
- low temperature

(e) Hose/pipe fitting and assembly procedures:

- use of adaptors and unions
- use of bite compression fittings
- use of 'O-ring' fittings
- use of flange type fittings
- use of formed fittings
- use of welded connections

(f) Hydraulic hose failures relating to:

- poor installation procedures
- failure to meet required working specification
- system performance
- pipework installations
- layout fastenings
- leakage prevention

Contamination Control

IH3.5.15 Describe Contamination Control Methods associated with:

- ingression of contamination and the nature of the contaminant
- preventative measures to reduce ingression to an acceptable level
- establishing a suitable cleanliness target, achieving and maintaining a cleanliness target (ISO 4406 and NAS 1638)
- measuring and monitoring cleanliness levels
- remedial actions

- filter types, rating, location and performance

Circuitry and Control Features (Recognition and use of symbols – hydraulic and electrical)

IH3.5.16 Describe and interpret hydraulic circuits and associated methods of control, including fail safe methods:

- Recognise and use current graphical hydraulic and electrical symbols

Installation and Commissioning Procedures

IH3.5.17 Describe installation and commissioning procedures to be followed:

- planning work to be done and listing necessary resources
- checking component conformance against technical specification
- following manufacturers' 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/component(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

IH3.5.18 Describe maintenance, monitoring and fault-finding procedures:

(a) Outline a 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
- leakage detection methods

(b) List the common faults encountered in hydraulic systems and associated components and state the possible causes and effects on system performance relating to:

- excessive noise

- vibration
- system temperature/component temperature high
- erratic operation
- leakage
- pressure too high
- pressure too low
- incorrect actuator speed
- incorrect pump flow rate
- incorrect sequence of operations
- loads lowering/failure to hold position

- hose and pipe failure (Section IH3.5.14(f))
- contamination level too high

(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-establishing work place - “fit for purpose”
- completion of all necessary reports/documentation