cetop

The Voice of the European Fluid Power Industry

EDUCATION RECOMMENDATIONS

★ ***HYDRAULICS PROGRAMME IH3***
CETOP Passport Occupational Level 3

INDUSTRIAL HYDRAULICS & ASSOCIATED CONTROL PROGRAMME (IH3): RE 2022/06.01 - H

CETOP (Passport) Occupational Level 3

INTRODUCTION

This is a LEVEL 3 Hydraulics Programme, forming the start of a series of competence-based qualifications designed around CETOP occupational levels.

It combines the necessary knowledge and competence-based skills for those people on route to this high level of qualification, involving the maintenance and management of both Industrial and Mobile hydraulic systems.

CETOP OCCUPATIONAL LEVEL 3

LEVEL (3) This person will be involved in a broad and often complex range of activities, often requiring independent decisions to be made on technical matters concerning specifications, resources, or processes. Planning of work will be a responsibility, as will the finding and rectification of faults. Responsibility for the quality of work undertaken and the required outcomes are also included.

Throughout the programme, emphasis is placed upon the development of knowledge relating to" F U N C T I O N "," 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:

- 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 emphasized 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 by means of a written examination of 2½ hours duration. These will be prepared and offered at approved centres or at an engaged external examination centre. The pass mark for the written examination will be 70%.

The expected completion time for a competency-b a s e d programme is one to three years depending on work experience within hydraulics and will require a high level of personal commitment to study and research the subjects within the syllabus.

Practical task assessments to verify competency against the agreed performance criteria will be carried out at the approved centre during the education programme period. It could be arranged on one-to-one base or in groups, candidate/ candidates to tutor.

All candidates taking a level 3 qualification should have a minimum of 2 years work-based experience involving hydraulics verified by their employer.
Alternative:
Where candidates do not have 2 years work-based experience, they can undertake the qualification but will not receive the award until they have completed two years of verified employment involving hydraulics.

Successful completion of both the knowledge based and competency-based units will result in the a w a r d of a CETOP Level 3 Industrial Hydraulics Qualification Certificate. Candidates successfully completing only one unit will receive a CETOP Unit Certificate.

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
IH 3.1. Machine function and operating principles identified.
IH 3.1.2 Components correctly identified.
IH 3.1.3 Function and operation of individual sub-circuits correctly identified.
IH 3.1.4 Machine control inputs and outputs identified.

Assessed Ability
IH 3.2 Assemble Electro-Hydraulic system involving on-off control and proportional control from given information.

Evidence Required
IH 3.2.1 Components selected, and conformance checked against system specification.
IH 3.2.2 Installation/Action plan prepared.
IH 3.2.3 System assembled in a safe and efficient manner.
IH 3.2.4 Setting up/commissioning procedures followed in accordance with technical specification.
IH 3.2.5 Startup procedures correctly specified and followed.
IH 3.2.6 System operated according to specification.
IH 3.2.7 Establish proactive maintenance procedures to be followed, including:

a) component performance testing

b) fluid sampling and assessment of contamination level against target level

c) electrical input and output signals involving on/off and proportional control systems

Assessed Ability
IH 3.3 Carry out effective fault diagnosis and rectification.

Evidence Required
IH 3.3.1 Nature of fault correctly identified.
IH 3.3.2 Fault, cause, remedy checklist prepared.
IH 3.3.3 Diagnostics used to locate fault ensuring safety at all stages.
IH 3.3.4 Safe working practices followed at all times.
IH 3.3.5 Faulty component replaced, adjusted, or repaired in line with planned procedures.
IH 3.3.6 Cause and effect of faults assessed.
IH 3.3.7 System re-commissioned in accordance with set procedures.
IH 3.3.8 System operated according to machine specification.

Assessed Ability
IH3.4 Establish documented procedures and carry out proactive maintenance and monitoring of Electro-Hydraulic systems.

Evidence Required
IH 3.4.1 System assessed to determine service/ maintenance schedule requirements.
IH 3.4.2 System assessed to determine routine monitoring requirements.
IH 3.4.3 Documented system established including safety requirements/risk assessment.
IH 3.4.4 Performance testing carried out and results recorded.
IH 3.4.5 Electrical input and output signals involving on-off and proportional control systems checked and recorded.
IH 3.4.6 Fluid sampling carried out and contamination levels assessed against target cleanliness and result recorded.
IH 3.4.7 Manufacturers recommendations and specifications checked against results.
IH 3.4. Safe working practices followed at all times.

Note: Preparation for practical task assessment can be a group activity or it could 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 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.

INDUSTRIAL HYDRAULICS PROGRAMME – (Knowledge Based Unit)

In addition to demonstrating an understanding of Industrial Hydraulic Systems and Associated Control, candidates must prove an ability to:

IH3.5.1 Fundamental and Scientific Principles

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:
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: pressure, force, area, displacement, fl ow rate, speed/velocity, torque, and power.

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

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

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

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

k) Know the relationship between:
- 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:
- mechanical systems
- electrical systems
- pneumatic systems

IH3.5.2 Application of the Fundamental Principles

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

IH3.5.3 Hydraulic Fluids

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 (behavior 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 standard
- 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

f) Explain the need for cleanliness control systems to be in place and associated fluid analysis procedures and monitoring (ISO and AS standards)

IH3.5.4 Valve Mounting Styles/Configurations

Describe valve mounting styles, standardized 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

IH3.5.5 Hydraulic System Components

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:
- pressure limiting
    - single stage, relief valves
    - two stage, pilot operated relief valves
    - unloading valves
- control features
    - vent
    - remote control
    - load sensing
    - pressure sensing (application of pressure switches)
- 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

e) control features to include – on-off and proportional control

IH3.5.6 Slip-in Logic Cartridge Valves

Describe the function, operation and application Slip-in (logic) cartridge elements

- construction and manifold assembly
- sizes and associated fl ow rates
- operating principles
- application for pressure, fl ow and direction control including associated control methods

IH3.5.7 Fundamental Electrical Principles

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 term's amplitude, frequency, periodic time and RMS
- defi ne the terms digital and analogue associated with control systems
- describe the fundamental principles of open and closed loop control

IH3.5.8 Proportional Valve Technology

Describe the principles of proportional valve technology

- list the potential benefits compared to application of "on/off" 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 PLC's

IH 3.5.9 Pumps and Associated Control Systems
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:

- Semi-rotary actuators: fixed pumps with relief valve unloading systems and
- ack and pinion type
- vane type 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 (Q/P) characteristics

IH 3.5.10 Hydraulic Actuators (Motors and Cylinders)
Describe the function, operation, and application of hydraulic actuators, including control features:

a) Motors:
- gear
- gerotor/orbit
- vane
- radial piston
  Including variable and dual displacement control features and associated torque speed characteristics. axial piston (swash plate)
  Including variable and dual displacement control features and associated torque speed characteristics
- bent axis
  Including variable and dual displacement control features and associated torque speed characteristics
- 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

IH 3.5.11 Close-Loop Hydrostatic Transmissions 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
- crossline relief valves
- counterbalance valves
- free-wheel by-pass valves

IH 3.5.12 Reservoirs, Conditioning and Auxiliary Components

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
- •pressurized 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

IH 3.5.13 Hydraulic pressure equipment and safety components

Describe the function, operation and application of hydraulic accumulators, associated safety components and associated selection process and sizing relating to application:

a) Accumulator:
- • piston
- • bladder
- • diaphragm

b) Associated Safety component and control features Fluid side: • pressure relief valve
- • safety block
- • pressure switches
- • pressure relief valve
- • temperature fuse
- • burst disc
- • pressure switches
- • pre-charge pressure (p_0) and control
- • working pressure (p1)
- • max. pressure (p2)

Gas-side:
Describe the pressure terms:
c) Have full knowledge about the fundamental rules of European Pressure Equipment Directive: • PED

IH 3.5.14 Machine Circuitry and Control Features (Recognition and use of hydraulic symbols)

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

- • Recognize and use current graphical hydraulic symbols

FLUID POWER ELECTRONICS PROGRAMME - *KNOWLEDGE BASE UNIT, CONTENTS*

IH 3.6.1 Electrical Components

IH 3.6.2 Electronic Sensors for Control and Condition Monitoring in integrated Fluid Power Systems

IH 3.6.3 Electrical/Electronic sensor signals in integrated Fluid Power Systems

IH 3.6.4 Recognize and understand the application of integrated system control methods used in integrated fluid power systems.

IH 3.6.5 Awareness of current Safety requirements of an integrated system

IH 3.6.6 Safe working practices for an integrated system

IH 3.6.7 Safety related components

IH 3.6.8 Circuit and Control Features (Recognition and use of component symbols)

ELECTRONICS *PROGRAMME - (Knowledge Based Unit)*

IH 3.6.1 Electrical Components

Describe the function, operation and application of electrical components used in integrated systems:

- Switches/Contacts: Normally Open (NO), Normally Closed (NC), Change Over (CO)
- Protective devices
- Lighting
- Relays
- Solenoids
- Limit switches
- Distance sensors
- Photo-electric sensors
- AC and DC Motors
- Electric Motor control technology

IH 3.6.2 Electronic Sensors for Control and Condition Monitoring in integrated Fluid Power Systems

Identify sensors used in integrated Fluid Power Systems

- Pressure
- Flow
- Temperature
- Level
- Particle
- Humidity
- Viscosity
- Conductivity
- Noise
- Vibration

IH 3.6.3 Electrical/Electronic sensor signals in integrated Fluid Power Systems

Describe the function, operation and application of electrical communication signals used in integrated systems:

- Digital (switching)
- Analog
- Bus
- Bi-directional communication
- Wire-less

IH 3.6.4 Recognize and understand the application of integrated system control methods used in integrated fluid power systems.

- Relay control
- Power Amplifier control
- Analog and digital
- Open loop control
- Closed loop control
- Computer control

IH 3.6.5 Awareness of current Safety requirements of an integrated system

- Overview of relevant regulations

IH 3.6.6 Safe working practices for an integrated system

- utilizes the safe working practices and procedures to be used when working on integrated systems
- Risk Assessments for the system and your workplace
- Comply with all health and safety requirements for the machine and your workplace
- Use the correct personal protection equipment (PPE)

IH 3.6.7 Safety related components

Describe the basic function and application of safety equipment and components used in integrated fluid power systems

- Personal safety
- Machine safety

IH 3.6.8 Circuit and Control Features (Recognition and use of electrical component symbols)

Identify symbols and describe common drawing practices in integrated fluid power systems

INSTALLATION AND COMMISSIONING PROCEDURES

H 3.7.1 Pipes and Hoses – Installation and Commissioning Procedures
H 3.7.2 Contamination Control
H 3.7.3 Installation and Commissioning Procedures
H 3.7.4 Maintenance, Monitoring and Fault- Finding Procedures

IH 3.7.1 Pipes and Hoses – Installation and Commissioning Procedures

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 affect 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
- thermoplastic
- high temperature and protective sleeved (abrasion resistant)
- low temperature

e) Hose/pipe fitting and assembly procedures:
- use of adapters 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
- pipe-work installations
- layout fastenings
- leakage prevention

IH3.7.2 Contamination Control

Describe Contamination Control Methods associated with:

- ingression of contamination and the nature of the contaminant particles, water, gasses) preventative measures to reduce ingression to an acceptable level
- establishing a suitable cleanliness target,
- achieving and maintaining a cleanliness target (ISO and AS standards)
- measuring and monitoring cleanliness levels (particles and level of water ingression/saturation)
- remedial actions
- filter types, rating, location and performance

H 3.7.3 Installation and Commissioning Procedures

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 workplace is re-established" fit for purpose"
- completion of all necessary reports/documentation

H 3.7.4 Maintenance, Monitoring and Fault-Finding Procedures

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
- continuous condition monitoring systems
- analysis of results and actions to be taken
- 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:

- excessive noise
- vibration
- high system/component temperature
- 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 H3.7.1 f)
- contamination level too high

c) Describe procedures to follow when carrying out fault finding, including:

- 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 workplace "fit for purpose" completion of all necessary reports/documentation