

**BRITISH FLUID POWER
ASSOCIATION
QUALIFICATIONS**

**MOBILE HYDRAULICS
PROGRAMME (MH3)**

**CETOP (PASSPORT) OCCUPATIONAL
LEVEL 3**

FOREWORD

Developed on behalf of the British Fluid Power Association by members of the BFPA Education and Training Committee, representatives from BFPA member companies, the Construction Industry Training Board (CITB), end users and machine manufacturers, this programme represents one of a range of new competence based qualifications launched by BFPA.

It is intended for those personnel involved in the maintenance and management of hydraulic systems used in mobile applications and who require knowledge and competence based skills to support work based activities such 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".

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The working group members were as follows:

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INTRODUCTION

Throughout the programme, emphasis is 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:

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 by means of a written examination of 2½ hours duration. These 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 the competence based programme is 1 - 2 years (this will depend upon previous experience and the learning mode devised by the approved centre) 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 Mobile Hydraulics 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.

PRACTICAL TASK ASSESSMENT (MH3)**Assessment Requirements**

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

Assessed Ability

MH3.1 Interpret hydraulic circuit diagrams applicable to a selected machine and prepare a schematic representation of the system.

Evidence Required

- MH3.1.1 Machine function and operating principles identified.
- MH3.1.2 Components correctly identified.
- MH3.1.3 Function and operation of individual sub-circuits correctly identified.
- MH3.1.4 Machine control inputs and outputs identified.

Assessed Ability

MH3.2 Assemble a hydraulic system from given information and establish suitable maintenance procedures.

Evidence Required

- MH3.2.1 Components selected and conformance checked against system specification.
- MH3.2.2 Installation plan prepared.
- MH3.2.3 System assembled in a safe and efficient manner.
- MH3.2.4 Commissioning procedures followed in accordance with technical specification.
- MH3.2.5 Start up procedures correctly specified and followed.
- MH3.2.6 System operated according to specification.
- MH3.2.7 Establish predictive maintenance procedures to be followed, including:
 - (i) component performance testing
 - (ii) fluid sampling and assessment of contamination level against target level.

Assessed Ability

MH3.3 Carry out effective fault diagnosis.

Evidence Required

- MH3.3.1 Nature of fault correctly identified.
- MH3.3.2 Fault, cause, remedy checklist prepared.
- MH3.3.3 Diagnostics used to locate fault.
- MH3.3.4 Safe working practices followed at all times.
- MH3.3.5 Faulty components replaced.
- MH3.3.6 Cause and effect of faults assessed.
- MH3.3.7 System re-commissioned in accordance with set procedures.
- MH3.3.8 System operated according to machine specification.

Assessed Ability

MH3.4 Designated or faulty component replacement carried out in accordance with given information.

Evidence Required

- MH3.4.1 Component checked against technical specification.
- MH3.4.2 Action plan procedures prepared.
- MH3.4.3 Safe working practices determined and adhered to at all times.
- MH3.4.4 Cleanliness control procedures followed at all times.
- MH3.4.5 Component removed following recommended procedures and correct tools used at all times.
- MH3.4.6 Replacement component installed effectively in accordance with procedures and respective technical data sheets.
- MH3.4.7 Commissioning procedures followed and adjustments carried out using correct instrumentation where necessary.
- MH3.4.8 Start up procedures correctly specified and followed.
- MH3.4.9 System operated according to specification.
- MH3.4.10 Work place re-established to required levels of tidiness and cleanliness.

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 (MH3)**CONTENTS**

- MH3.5.1 Fundamental and Scientific Principles
- MH3.5.2 Application of the Fundamental Principles
- MH3.5.3 Hydraulic Fluids
- MH3.5.4 Valve Mounting Styles/Configurations
- MH3.5.5 Control Valves
- MH3.5.6 Mobile Multi-function Valves
- MH3.5.7 Hydrostatic Steering Systems
- MH3.5.8 Pumps and Associated Control Systems
- MH3.5.9 Hydraulic Actuators (Motors and Cylinders)
- MH3.5.10 Closed Hydrostatic Transmissions
- MH3.5.11 Reservoirs, Conditioning and Auxiliary Components
- MH3.5.12 Pipes and Hoses - Installation and Commissioning Procedures
- MH3.5.13 Contamination Control
- MH3.5.14 Machine Circuitry and Control Features (Recognition and use of symbols)
- MH3.5.15 Installation and Commissioning Procedures
- MH3.5.16 Maintenance, Monitoring and Fault Finding Procedures

KNOWLEDGE BASED UNIT – WRITTEN EXAMINATION SPECIFICATION

- The examination paper will contain 8 questions integrating the above 16 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

MOBILE HYDRAULICS PROGRAMME - (Knowledge Based Unit)

Fundamental and Scientific Principles

- MH3.5.1 Describe the fundamental principles of power transmission by hydraulics and associated scientific principles underlying its use.
- (a) List the basic building blocks and describe their function with reference to: prime movers, pumps, reservoirs, fluids, control valves, filters, coolers, pipe work 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, 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: heat sinks within a system (reservoirs, pipe work and coolers) and effects of ambient conditions and working cycle.
 - (i) State and use the relationship between: pressure, force and area for cylinders and pressure, torque and displacement per revolution for pumps and motors.
 - (j) State and use the relationship between: flow, area and velocity for cylinders, and 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.

Application and Fundamental Principles

MH3.5.2 Describe the application of the fundamental principles with regard to the:

- (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

MH3.5.3 Describe the application and selection of fluids for use in mobile hydraulic systems relating to:

- (a) Functions
 - power transmission
 - lubrication
 - cooling
- (b) Characteristics and properties (behaviour and effect on system performance):
 - viscosity
 - viscosity index
 - lubrication
 - thermal stability (oxidation)
 - pour point
 - demulsibility
 - shear stability
 - compressibility
 - material compatibility
 - foaming and aeration resistance
 - filterability
 - fire-resistance

- (c) Types of fluids used in mobile machinery:
 - hydraulic fluid
 - engine oil
 - transmission fluid
 - universal oil
 - biodegradable fluid
 - fire-resistant fluid

- (d) ISO/SAE viscosity grades.

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

- (f) 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) see section MH3.5.13

Valve Mounting Styles/Configurations

MH3.5.4 Describe valve mounting styles, standardised interfaces, sizes, flow rates, port layouts and sealing arrangements, relating to:

- pipe mounting/line mounting
- sub-plate mounting
- manifold mounting
- stack, mounting
- flange mounted valves
- screw in cartridge
- slip in cartridge
- ISO interface valves

Control Valves

MH3.5.5 Describe the function, operation and application of control valves and interpret their graphical symbols.

- (a) Flow control devices (fixed and adjustable):
 - non-compensated flow control devices (orifices and throttle valves)
 - pressure and temperature compensated flow control valves
 - hydrostats
 - priority valves
 - spool flow dividers
 - rotary flow dividers
 - differential lock units

- (b) Pressure control devices:
 - pressure limiting
 - single stage, relief valves
 - two stage, pilot operated relief valves
 - unloading valves
 - control features
 - vent
 - remote control (manual/proportional)
 - load sensing
 - pressure reducing
 - single stage and two stage pressure reducing valves
 - two way and three way configuration

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

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

(Where appropriate, control features to include simple on-off and proportional control)

Mobile Multi-function Valves

MH3.5.6 Describe the function, operation, application and control features of mobile multi-function control valves and interpret their graphical symbols.

- (a) Mobile spool direction control valves:
 - layout/construction (mono-block/sandwich)
 - spool configurations (single and multiple) services
 - flow paths - parallel, series and tandem arrangements including carry-over and alternative inlet sections
 - open centre, closed centre, single acting, double-acting motor half motor, regeneration and float arrangements

- (b) Inlet sections:
 - pressure control/unloading facilities/priority
 - load sensing connections
 - pilot fluid supply

- (c) Controls:
 - manual - spring cantered, mechanical hydraulic and electrical detent
 - solenoid and solenoid pilot
 - proportional control (with and without spool position monitoring)
 - remote control [Joystick], (hydraulic and pneumatic)
 - remote control - electrical [Joystick]

- (d) Special features (including inlet, outlet and service ports):
 - flow sharing (pre and post compensation)
 - load sensing, pressure limiting and vent control
 - load holding
 - anti-cavitation
 - pressure limiting

- (e) Valve characteristics:
 - valve sizes, flow rates and associated pressure drops
 - operating performance (under conditions of closed, partially open and fully open)

Hydrostatic Steering Systems

MH3.5.7 Describe the function, operation and application of hydrostatic steering systems and associated control features:

- (a) Rotary servo steering units:
 - open centre
 - closed centre
 - reaction and non reaction types
 - load sensing systems
 - steer units for electric motor applications
 - steer units with 'power beyond' facilities
 - flow amplifiers
 - dual displacement steer units
- (b) Priority valves:
 - non dynamic types
 - dynamic types
- (c) Steering systems, modes:
 - single ram-single rod, single ram double rod, double rams single rods
 - methods of switching between steering modes
- (d) Emergency steering systems (manual and powered)

Pumps and Associated Control Systems

MH3.5.8 Describe the function and operation of hydraulic open loop 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) Know the power - torque relationship between the prime mover and pump with reference to engine speed.
- (c) Control features:
 - fixed pumps with integral pressure and flow control
 - fixed pumps with unloaded valve systems
 - mechanical/hydraulic servo displacement
 - electro-hydraulic proportional displacement
 - pressure compensation/limiting
 - load sensing (constant flow/variable speed)
 - torque summation control, including prime mover characteristics
- (d) Link to prime mover:

- power take off arrangements
- splitter gearbox
- step up and step down gearbox arrangements
- belt drives and clutch arrangements

Hydraulic Actuators (Motors and Cylinders)

MH3.5.9 Describe the function, operation and application of hydraulic actuators, including control features:

- (a) Motors:
- gear
 - gyrator/orbit
 - vane
 - radial piston } Including variable and dual
 - axial piston, (swash plate) } displacement control features
 - bent axis } and associated torque speed
 - cam/roller types } 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:
- telescopic
 - single acting
 - double acting
 - sealing
 - cushioning
 - mounting arrangements
 - position monitoring
- (e) Semi-rotary actuators:
- rack and pinion type
 - vane type

Closed Hydrostatic Transmissions

MH3.5.10 Describe the function, operation and application of hydraulic components associated with closed loop hydrostatic transmission systems:

- (a) Basic configuration:
- close coupled (motor and pump back to back units)
 - split units (separate motor and pump) single and double
 - multiple pump/motor layouts
 - series and parallel operation
- (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
 - automotive 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
 - differential lock valves
 - parking brake systems
- (e) Special control features:
- inch control
 - creep speed
 - brake defeat function
 - hydrostatic braking

Reservoirs, Conditioning and Auxiliary Components

MH3.5.11 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 minimise aeration)
 - filling connections
 - sampling points
 - level/temperature indication
 - air and oil filtration
 - pressurised reservoirs
 - use of bladder and diaphragms 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

MH3.5.12 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

MH3.5.13 Describe Contamination Control Methods associated with:

- ingress of contamination and the nature of the contaminant
- preventative measures to reduce ingress 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

Machine Circuitry and Control Features (Recognition and use of symbols)

MH3.5.14 Describe and interpret hydraulic circuits and associated methods of control, including failsafe methods:

- (a) Recognise and use current graphical hydraulic and electrical symbols relating to mobile hydraulic systems

Suggested Systems:

- Excavators
- Wheeled loader
- Backhoe loaders
- Forklifts
- Man lifts/access platforms
- Sweeper
- Telescopic handlers
- Mobile cranes
- Agricultural tractors
- Agricultural harvesters/viners

Installation and Commissioning Procedures

MH3.5.15 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

MH3.5.16 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
 - 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 MH3.5.12(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 work place “fit for purpose”
- completion of all necessary reports/documentation