NFPC National Fluid Power Centre
for Fluid Power Motion Control

CENTRE OF VOCATIONAL EXCELLENCE

National Training Programme for Apprentices and Undergraduates Hydraulics and Control Summer School 2009

Proposed Dates
Course 1 (6-17 July 2009)
Course 2 (20-31 July 2009)

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UKAS QUALITY MANAGEMENT 015

Issue date March 2009

Apprentice and Undergraduate Training Programme in Fluid Power

Duration – 2 weeks (8 days)
Start time – 13:00 on the Monday
End time – 14:30 on the Friday

Summary

This training programme is designed to compliment and support those apprentices and advanced apprentices who are on route to a National Vocational Qualification in engineering. The programme is also ideal for undergraduates on work based secondments.

The programme has been developed to provide all candidates with the opportunity to gain an excellent foundation of knowledge in hydraulics and achieve a **CETOP** (**C**omité **E**uropéen des **T**ransmissions **O**léohydrauliques et **P**neumatiques) **Level 1 Hydraulics (H1)** competence based qualification. For the candidates, this will lead to improved levels of communication, confidence, skills and overall contribution to the company for which they are employed, that company being involved in fluid power systems and motion control engineering.

Course Content

The content of the course will cover all the requirements of the **CETOP Level 1 Hydraulics (H1)** competence based qualification and lots more. The content is designed around a hydraulic system and each component part will be investigated. The course will place emphasis on the function, operation and introduce the application of these components. Reference will be made to both static and mobile equipment/applications. It will start at a fundamental level covering theory and formulae, with the learning experience being supported and reinforced by practical hands on tasks, allowing the candidates to take advantage of the excellent facilities at the NFPC and the extensive real world experience of its staff.

A participative approach will taken during the delivery of the course and approximately 50% of the course will be practical training. Throughout the delivery of this course **health and safety, risk assessment and safe working practices will be carried through at every stage**.

Each candidate will be given a comprehensive set of course notes and candidates will produce a portfolio during the course, which will consist of; daily exercise sheets, group practical tasks/investigations, individual practical tasks and feedback from the course tutor. This will provide evidence of the knowledge and practical skills gained by the candidate and will clearly indentify where learning objectives have been achieved.

Assessment

Candidates will be given the opportunity to achieve a **CETOP Level 1 Hydraulics (H1)** competence based qualification. This will consist of the candidates being individually assessed performing practical tasks and completing two short one hour examinations. The examinations will take place on each Friday starting a 13:30 and finishing at 14:30.

On a daily basis candidates will complete exercise sheets, which will be marked by the tutor allowing feedback to be given to the candidates regarding their progress.

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Additional Information

The programme will be delivered at the National Fluid Power Centre based in Worksop, Nottinghamshire. The National Fluid Power Centre is the first and only institution to offer the **CETOP Level 1 Hydraulics (H1)** competence based qualification in the UK. This qualification developed initially by the BFPA, has been adopted and implemented by CETOP as a European educational standard. The delivery of this programme will be similar to that of a summer school at a time in the calendar year when Colleges of FE are moving in to their non-teaching period, therefore attending this programme would not interfere with the normal college timetable.

This course would obviously be residential to those who wish to stay locally during the Monday to Friday sessions. Worksop is well equipped with reasonably priced suitable accommodation and the NFPC would provide advice to all those wishing to stay locally.

Price

This programme will be offered at a specially reduced rate of £1050.00 per person excluding vat. and is open to apprentices and advanced apprentices in employment and undergraduates.

The candidate or their employer would be responsible for all associated tuition and support costs.

Course Objectives

On completion of this two week programme candidates will:

- Know the fundamental principles that underpin the operation of all hydraulic systems.
- Identify and explain the function and operation of the major component parts.
- Recognise hydraulic symbols drawn to ISO1219/1.
- Know the importance of contamination control.
- Know the terminology associated with fluid power system.
- Know the importance of following safe working practices at all times.
- Know the importance of following correct procedures when involved in the maintenance of fluid power system.
- Perform a series practical tasks (see last page).

THE PROGRAMME

INTRODUCTION TO HYDRAULICS

- What is hydraulics? – examples of applications covering mobile and static systems
- Why do we employ hydraulics? – advantages and disadvantage over other forms of power transmission.
- Hydraulics – force multiplication associated with Pascal's Law.
- Hydraulics- a means of transmitting power
- Hydraulic Oil- its functionality within the system.
- The basic building blocks that form the hydraulic system.- names, terminology and general functionality and flow path layout.
- The 7 fundamental principles
- Review of units used

THE PRIME MOVER

- Types in common – electric motors and IC engines
- Prime mover performance with reference to speed, torque and input power
- Prime mover connection to pump unit with reference to couplings and bell housings
- Associated ISO 1219 symbols

HYDRAULIC PUMPS and Energy Storage

- Function and principles of operation of a pump – fixed and variable displacement (introduction to pressure compensation)
- Types of pumps in common use, gear, vane and piston
- Pump size relating to displacement. (meaning of displacement and associated units)
- Difference between positive and non-positive displacement pumps
- Relationship between shaft speed, displacement and flow rate in litres per minute.
- Hydraulic Power Calculation
- Rating of pumps
- Physical attributes that affect the performance of the pump with reference to: leakage and internal wear. How pumps perform under load conditions.
- Causes of pump failure with reference to cavitation, aeration and contamination.
- Importance of positive suction conditions and the effect of a negative suction.
- Importance of following manufacturers recommendations when installing and commissioning a pump.
- Accumulators. What are they? How do they perform and how do they work in conjunction with the pump? How do they operate? How to check the pre-charge pressure?
- Function of a flow meter and pressure gauges
- Associates ISO 1219 symbols

HYDRAULIC RESERVOIR

- Function of the reservoir
- Reservoir capacity with reference to cubic capacity/physical size and the number of litres contained (relationship between m^3 and litres)
- Typical layout in relationship to internal baffles and flow paths also input and output connections and services with reference to filling, test points isolation and contamination control.
- Overview of control and protective devices incorporated.
- Associated ISO 1219 symbol

HYDRAULIC ACTUATORS with reference to cylinders and motors.

- Cylinder function
- Cylinder performance - relationship between, force, pressure and area.
- Cylinder performance - relationship between cylinder speed, flow rate supplied and cylinder size/dimensions.
- Regenerative operation- relationship between power and performance.
- Classification (single and double acting)
- External construction with reference to screwed or tie rod options and mounting arrangements.
- Internal construction with reference to piston seals, rod seals and cushioning.
- Common cylinder problems resulting in reduced performance.
- Storage and handling (accidental damage)
- Associated ISO 1219 symbols.

- Motor function
- Motor performance – relationship between motor size, flow rate, internal leakage and motor speed.
- Motor performance – relationship between pressure drop, motor size, internal resistance and torque transmitted.
- Motor performance (fixed displacement Vs variable displacement)
- Basic displacement control principles and effects upon torque and speed.
- Classification / types in common use- overview of construction.
- Operation of a piston and orbital motor
- Installation- need to follow manufacturers recommendations.
- Importance of correctly sized drain lines and routing.
- Causes of motor failure (operational, mechanical and contamination related)
- Associated ISO 1219 symbols

- DIRECTION CONTROL
- Valve function- (stop/start, forward/reverse, hold position/one way and speed control)
- Simple check valve. function, operation and application.
- Spool valves- function and operation.
- Spool valves- configurations/port layouts/identification.
- Valve classifications with reference to 2/2, 3/2, 4/2, 4/3 direct and two stage valves.
- Available operating options with reference to mechanical, oil and air pilot, solenoid and solenoid /oil pilot.
- How does an “on-off “ operation differ from a proportionally controlled operation?
- Overview of spool valve performance and the factors that affect performance.
- Overview of mounting and sealing arrangements (pipe, sub plate, manifold and stack)
- Installation procedures to follow including manufacturers recommendations.
- Associated ISO 1219 symbols

PRESSURE CONTROL

- Relief Valves (N/C Valve)
- Function within a system and various places they can be installed.
- Basic configurations available and mounting arrangements.
- Valve operation and performance- comparing direct operated valves to that of the two stage pilot operated design with and without vent control.
- Effects upon system performance when adjustments are made to valve settings.
- Procedures to follow when setting a relief valve
- Typical multi-pressure circuitry employing direct and two stage relief valves.
- Associated ISO 1219 symbols

- Sequence Valves (N/C Valve)
- Function within a system
- How do they differ in performance to that of a relief valves?
- Associated ISO 1219 symbols

- Pressure Reducing Valves (N/O Valve)
- Function within a system
- How do they differ in performance to that of a relief valves?
- Operating principles
- Setting up procedures compared with relief valves.
- Typical circuit applications (clamp and hold conditions)
- Associated ISO 1219 symbols

LOAD HOLDING and MOTION CONTROL (Basic overview)

- Function and operation of a pilot operated check valve.
- Performance and limitations of this type of valve.
- Typical application circuitry.
- Function and operation of the remote pilot counterbalance valve
- Valve performance compared to the PO check valve.
- Typical application circuitry. Associated ISO 1219 symbols

FLOW CONTROL (The application of flow control valves)

- Reasons for controlling to an actuator.
- Effects of controlling flow from a fixed displacement pump, interaction of the relief valve.
- Relationship between pressure drop and flow through a valve.
- Fundamental principles that dominate the flow control process.
- Operation of throttle valves and pressure compensated flow control valves.
- How simple throttle valves perform against pressure compensated valves.
- Heat generation and energy losses associated with flow control operations.
- Common circuit positions where flow control devices can be fitted and their performance.
- Typical application circuitry. Associated ISO 1219 symbols

HYDRAULIC FLUIDS

- Function of the fluid
- Types and application of fluids in common use.
- Important characteristic to consider when selecting a fluid.
- ISO Grades and classification / identification.
- Correct storage, handling, filling and disposal techniques.
- Factors that affect the life expectancy of the fluid.
- Personal hygiene and safety measures to be followed when handling fluids
- Contamination control procedures.
- Terminology
- Effects on system performance associated with viscosity.

CONTAMINATION CONTROL

- What are contaminants and where do they originate from?
- How clean is new oil.
- What effect does contamination have on the performance of a hydraulic system.
- How can we reduce the ingression of contamination- general good practices.
- What is meant by the term flushing and how is it achieved?
- Understanding the different levels of contamination sensitivity .
- ISO Cleanliness codes – systems for measuring and managing contamination.
- Establishing target cleanliness levels (reference BFPA P5 Guideline)
- Function and operation of a filter.
- How does a filter perform? (Depth type only) including by pass facility.
- How efficient are filters and how are they assessed and classified.
- Where is the best position in the circuit for a filter?
- Associated ISO 1219 symbols

HYDRAULIC HOSES, PIPES AND COUPLINGS

- Hose types and classification – (general overview)
- Typical hose construction and termination configuration (couplings)
- What factors are taken in to consideration when choosing a hose?
- How are hoses sized (what are Dash Nos?)
- Pressure drops and hose sizing- recommended flow velocities.
- Recommended installation procedures
- Storage, handling and cleanliness control.
- Steel tubing, wall thickness and recommended performance levels.
- Overview of tube connectors in common use and associated thread recognition.
- Clamping and securing steel pipe work (why do we bother?)
- Quick release couplings (designs in common use)
- Safe working practices when handling pipes and hoses.
- Associated ISO 1219 symbols

LABORATORY EXERCISES

Students will be individually assessed completing the four tasks below. These tasks meet the practical assessment requirements of the **CETOP Level 1 (H1)** qualification.

- Recognise the component parts of a selected machine and their functionality, linked to the system and circuit diagram.
- From a circuit diagram provided and associated system, check operating pressures at strategic points and record.
- Change filter element on a system.
- Check accumulator pre-charge pressure and establish level against specification.

Students will also complete the following practical investigations:

- Pump performance under pressure- the use of flow and pressure test equipment, Q/P relationship.
- Relief valve performance relating to flow and pressure relationship including setting up procedures.
- Relief performance comparison relating to cracking pressures.
- Performance and comparison of a simple throttle valve to that of a pressure compensated flow control valve.
- Pressure reducing valve performance and setting up procedures.
- Performance of a pilot operated check valve and counterbalance valve involving loaded cylinder.
- Motor performance in series and parallel using compensated and non-compensated flow controls.
- Taking an oil sample from a system and preparing for microscopic inspection and reviewing results.
- Circuit construction from circuit diagram involving a range of pressure and flow control valves to achieve a given sequence.
- Investigate pressure intensification associated with meter-out control of a cylinder under varying load conditions.