FLUID POWER

FLUID POWER EQUIPMENT

TUTORIAL – HYDRAULIC FLUIDS

This work covers part of outcome 2 of the Edexcel standard module:

UNIT 21746P APPLIED PNEUMATICS AND HYDRAULICS

The material needed for outcome 2 is very extensive so the tutorial is presented as a series.

OUTCOME 2 Investigate the construction and operation of pneumatic and hydraulic components, equipment and plant.	• Identify and describe the features of pneumatic and hydraulic equipment. • Analyse the performance characteristics of pneumatic and hydraulic equipment.

The series of tutorials provides an extensive overview of fluid power for students at all levels seeking a good knowledge of fluid power equipment.

On completion of this tutorial you should be able to do the following.

- Explain the ideal properties of a hydraulic fluid.
- Describe and explain the purpose of the different additives put into fluids.
- Explain the identification codes for fluids.
- Explain the different types of fluids and their applications.
- Use compatibility tables for fluids and system materials.
- Explain how to get maximum life from the fluid.
- Explain how to sample and test fluids for quality.

1. INTRODUCTION

The efficient running of hydraulic machines depends upon using the correct fluid and keeping the fluid in good condition. Always use the fluid recommended by the manufacturer of the hardware.

Filters and good system design are also essential if the fluid is not to deteriorate. The power pack (pump and reservoir unit) plays a vital role in maintaining the quality of the fluid.

2. PROPERTIES

The following are properties required of hydraulic fluids.

1 COMPRESSIBILITY

Liquids are very difficult to squeeze into a smaller volume. This is why hydraulics are ideal for precise motion control. If air is mixed with the fluid it becomes slightly compressible and loses this property. Tests to measure compressibility consist of squeezing the fluid into a very rigid vessel by a screwed plunger and measuring the pressure resulting.

2 VISCOSITY

The viscosity of a fluid determines how easily it flows. Fluids with a low viscosity such as water flow easily but fluids with a high viscosity such as thick oil, flows with some difficulty and this results in a loss of pressure in the pipes and fittings. Fluids with low viscosity do not lubricate very well so the right balance between pressure loss and lubricity is required. Viscosity is measured with viscometers of various types. The preferred units are centi-Stokes but many other units exist such as Redwood Seconds and they may be converted from one to the other with tables.

3. VISCOSITY INDEX

The viscosity of a fluid usually decreases as it gets hotter. This means that a fluid may lose its lubricity as it warms up or flows with difficulty when cold. Oil with a low viscosity index will change very little but one with a high index will change a lot. This property may be improved with chemical additives.

4 AIR ABSORPTION AND RELEASE

Liquids will absorb gas under pressure and release it when the pressure is released. This may be seen with fizzy drinks. A good hydraulic fluid will not absorb air easily and will release it quickly without causing froth and foam. Chemicals may be added to improve these properties. Froth and foam on the surface of the reservoir are really many bubbles with a large surface area. This enables oxygen to be absorbed into the fluid causing oxidation. Chemicals to prevent the formation of foam are also used.

6 OXIDATION

Oxidation is chemical combination of elements in the fluid with oxygen. This causes the oil to thicken and produce varnishes which stain the components surface. The life of the oil is much reduced. Chemicals may be added to reduce the oxidation rate but the fluid should be kept away from air as much as possible. Foam and cascading in the reservoir are the main reason for fluid and air mixing.

7. CORROSION

Hydraulic fluids can cause corrosion of metals. This is avoided by using compatible materials and by adding chemicals to the oil.

8. WEAR

Chemicals may be added which cause the fluid to deposit a surface film at places where surfaces are pressed together such as on the flanks of gears in gear pumps and motors. This prevents wear taking place.

9. POUR POINT

The pour point is the lowest temperature at which the fluid will flow from a beaker when tipped up. It is possible to add chemicals to reduce this temperature for working in cold climates.

10. FLASH POINT

The flash point of a fluid is the temperature of the fluid at which vapour given off will ignite on contact with a naked flame. The apparatus to measure this is called a Pensky-Martens apparatus.

3. TYPES OF FLUIDS

The original hydraulic fluid was water which was alright with cast iron components but it would freeze in cold weather and it evaporated in hot conditions. Water is still used for some applications, especially when emulsified with oil. The most common fluids are made by refining mineral oil. Special fluids such as fire resistant fluids are made from a variety of materials.

Mineral oils can meet most of the requirements listed above. The only drawback with them is their low flash point of 150° to 250°C. Fire resistant fluids are used where there is fire risk. Water is a suitable F.R. fluid in some cases but has obvious problems. Adding 10% oil to water in emulsified form helps provide the necessary lubrication. A mixture of 40% water in oil with special agents produces a good F.R. fluid. Synthetic F.R. fluids have flash points as high as 600°C. These fluids are very expensive.

The viscosity of a fluid is covered in ISO3448, BS4231. Basically the viscosity stated is the viscosity that occurs at 40^{o}C in cSt units. For example a fluid designated HM32 is a mineral oil as defined overleaf with a viscosity of 32 cSt at 40^{o}C.

The main categories of fluid are as follows:

1 MINERAL OILS DIN 51524/ISO6743/4 BS6413/4

Mineral oils are produced by refining crude oil and adding certain substances to improve their quality.

Type HH is a non inhibited refined mineral oil.
Type HL has anti-rust and anti-corrosion additives.
Type HM has anti-wear additives as well as the above.
Type HV has a viscosity index improver as well as all the above.

2 FIRE RESISTANT FLUIDS

Type HFAE is an oil in water emulsion.
Type HFAB is a water in oil emulsion (40% water emulsion)
Type HFAS is a chemical solution in water.
Type HFC is water-polymer (water - glycol) solution.
Type HFDR is a synthetic fluid made from phosphate ester.
Type HFDS is a synthetic fluid made from chlorinated hydrocarbons.

Water/Oil Emulsions

In this case the oil is the majority substance (about 60% oil). Special additives cause the water to disperse (emulsify) in the oil. When the fluid comes into contact with a hot surface, the water turns to steam and prevents fire. The lubrication properties are good.

Water Glycol

Type HFC has 60% glycol 40% water mixed together. The water forms into a solution instead of mixing. They have the advantage of working at lower temperatures than emulsions and produce a better temperature-viscosity characteristic.

Phosphate Esters

Type HFD-R. These fluids have good fire resistance and do not ignite until heated to 550°C or higher. The lubrication properties are similar to mineral oils. The main problem is that they are chemically active and will strip paint from a surface and attack certain kinds of rubber, so special seals, hoses, accumulator bags, etc. have to be chosen. They melt electrical insulation if they leak onto cables. The cost of these fluids is exceptionally high.

Typical FR fluids commercially available are:
Shell Iris 904 (Water/oil emulsion)
Walkers Aquacent (Water/oil emulsion)
Vaughan-Houghtosafe 620 (Water glycol)
Fina Hydran FR32s and Houghtosafe 1120 (Phosphate Ester)

Environmentally Friendly Fluids

These are made from plant oil. Types are : HTG or Trigliceride, HPG or Polyglycol and synthetic ester.

4. COMPATIBILITY OF FIRE RESISTANT FLUIDS WITH MATERIALS.

When considering Fire Resistant Hydraulic Fluids, either in the design or installation stage it is essential to have in mind their degree of compatibility with materials normally encountered in hydraulic systems. The following table describes in general terms the compatibility of various types of fluids with a variety of materials and is intended as a useful guide. It is advisable, however, to finally check compatibility at least with the material supplier.

C = Compatible NC = Not Compatible LC = Limited Compatibility		Water Glycol Based Fluids	Phosphate Ester Fluids	Water-in-Oil Emulsion
Metals				
	Ferrous	C	C	C
	Copper & Brass	C	C	C
	Bronze	LC[1]	C	C
	Cadmium & Zinc	NC	C	C
	Lead	NC	C	NC
	Aluminium	LC[2]	C	C
	Magnesium	NC	C	NC
	Tin & Nickel	C	C	C
Paints &				
Finishes	Common Industrial			
	Oil Resistant	NC	NC	NC
	Epoxy & Phenolic	C	C	C
	Vitreous Enamel	C	C	C
Plastics				
	Acrylic (Includes Perspex)	C	NC	C
	Styrene	C	NC	C
	Epoxy	C	C	C
	Phenolic	C	C	C
	Silicone	C	C	C
	P.V.C.	C	NC	C
	Nylon	C	C	C
	Polypropylene	C	C	C
	P.T.F.E.	C	C	C
Rubbers (Elastomeric Seal Materials)				
	Natural	C	NC	NC
	Neoprene	C	NC	C
	Nitrile	C	NC	C
	Butyl	C	C	NC
	Ethylene Propylene	C	C	NC
	Polyurethane	NC	LC[3]	NC
	Silicone	C	C	C

C = Compatible NC = Not Compatible LC = Limited Compatibility		Water-Glycol Based Fluids	Phosphate Ester Fluids	Water-in-Oil Emulsion
Viton (Fluorocarbon Based)		C	C	C
Other seal materials				
	Leather	NC	LC	LC
	Cork including Rubber Impregnated	NC	LC	NC
Filter Media				
	Cellulose - Phenolic Resin Treated	C	C	C
	Metallic	-	As metals	-
	Earth Type	NC	NC	NC

5. CARE OF HYDRAULIC FLUIDS

70% of faults in hydraulic systems are due to contamination of the fluid. All possible precautions should be taken to prevent air, water and solid matter entering the fluid. This means that when assembling units, strict cleanliness is needed. Such assembling should take place in a special dust free room with clothing designed to prevent human contamination. Any work carried out should be followed by cleaning procedures such as flushing out particles from pipes. To further protect the system, filtering systems should be used. Filters generally should be capable of removing particles down to 10 microns and in some cases down to 3 microns. (1 micron = .001 mm).

Oil is a very expensive commodity. It is important to choose the right grade for the job and obtain the maximum life possible by caring for it. The condition of the fluid should be regularly checked and records kept for each machine.

SAMPLING

Oil samples are taken in order to check the quality of the oil. The following method should be used:

1 Take one sample from the top of the tank immediately after use.
2 Take another sample from the bottom of the tank after allowing time for it to settle (e.g. Monday morning).
3 Keep the samples in a clean metal or plastic container.
4 Label the samples and record its details such as:
Date, Machine number, oil type, date of last check, date when installed.

The samples should be tested for various properties. Some tests can be conducted simply on the spot. Others are done in the laboratory.

SPOT TESTS

1 Compare the sample with new oil.

Appearance	Smell	Condition	Action
Clear and sparkling	Sweet	Good	None
Dark and cloudy	Rancid	Deteriorated	Change it
Cloudy, no colour	Sweet	Water present	Settle and separate

2. Hot plate test
Drip a drop onto a hot plate. If it sizzles, it contains water.
3. Filter test
Put a drop into the middle of a filter paper. The spot spreads. Any dirt is left at the middle as a dark patch.

PIPE-WORK

Pipe work is covered in the next tutorial but it is worth noting that pipes carrying oil are normally painted brown and if they carry oil at pressure they have bands of salmon pink colour on them.

SELF ASSESSMENT EXERCISE

You will need to have read the tutorials on fluids and reservoirs to answer the following questions.

1. List the additives in oil identified by the code HV.

   a. ______________________________

   b.______________________________

   c.______________________________

2. What happens normally happens to the VISCOSITY of a fluid when it get hotter.

   ____

3. State the names of THREE types of fire resistant fluid

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   ____

   ____

4. What does viscosity measure?

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   ____

5. State 2 seal materials which are compatible with phosphate ester fluids?

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   ____

6. State two hydraulic hose materials which are compatible with phosphate ester fluids?

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   ____

7. What is the meaning of viscosity index?

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8. State two effects a fluid with a poor viscosity index would this have on a machine running hot?

9. List 2 reasons why hydraulic oil may overheat when in use.

10. What is the difference between an oil/water emulsion and a water/oil emulsion?

11. State two disadvantages of water as a hydraulic fluid.

12. State 2 reasons why oil should not be stored in open containers.

13. State the danger associated with oils with a low flash point.

14. State two measures you would use to ensure that a hydraulic machine is not topped up with the wrong type of fluid.

15. State the correct colour coding for a pipe carrying mineral hydraulic oil under pressure.

16. State the reason why hydraulic oil should not be allowed to cascade into the tank on return.

17. State how water may form in a hydraulic tank over a period of time.

18. State the consequence of letting air mix with mineral oil.

19. State 2 consequences of using a tank which is too small for a hydraulic machine.

20. State the purpose of baffles inside hydraulic tanks.