

HYDRAULIC FLUIDS IN ARRESTING GEAR

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Water has been used as a hydraulic fluid in ships systems for many years. Where freezing of the fluid does not have to be considered, as in catapults and large gun-mountings, protection against corrosion and a certain degree of lubrication is achieved by the addition of a soluble oil. The soluble oil used before the war was a proprietary product called Argolene but is now obtained from several firms to a specification and is called ZX3.

To prevent water freezing in hydraulic systems glycerine is added either in the proportion of 50 per cent or 60 per cent depending on the degree of protection required. It is found that a fluid containing glycerine tends to develop acidity. To prevent this it was laid down, in 1923, that clear lime water should be used instead of distilled water for preparing such a fluid. When a non-freezing water-based fluid was first required for arresting gear it was prepared in this way.

This fluid sufficed until 1948, when complaints of sludge formation and corrosion were received. The problem was investigated by the Admiralty Chemical Department, now the Central Dockyard Laboratory, Portsmouth. It was considered that the use of lime water might well lead to the precipitation of calcium carbonate and that some better means of controlling acidity and corrosion should be employed. It was decided to try a fluid composed of equal quantities of glycerine and water with 1 per cent of caustic soda, to neutralize acidity, 0.1 per cent of sodium nitrite as a corrosion inhibitor, and 1 per cent of ZX3. This fluid was not a success as the caustic soda hardened the leather washers in the system. It was also found that the oil used in dressing the leather was a source of acidity and caused corrosion and the formation of sludge.

To overcome these troubles the leather washers were replaced by Neoprene seals in 1953. The fluid was also modified to equal proportions of water and glycerine with 2 per cent of ZX3. No corrosion inhibitors were used but orders were given that the acidity was to be tested regularly by the Ships' Officers and that any acidity was to be neutralized by small additions of caustic soda. However, in December, 1955, it was found that in one carrier there was marked corrosion of the spline valve of one arresting gear unit and sludge formation had occurred in the system. This trouble followed a period of intensive flying operations when the unit in question had received a number of heavy and fast aircraft in a short period. The temperature of the fluid in the unit had reached at least 180 degrees F. Another carrier reported that large additions of caustic soda were required to control acidity.

Following consultations between the Director of Naval Construction, the Engineer-in-Chief and the Director of Naval Ordnance Departments and the Admiralty Oil Laboratory, who had taken over the Admiralty Chemical Department's work on hydraulic fluids, it was decided that a comprehensive investigation should be undertaken at the Admiralty Oil Laboratory.

The source of the acids formed in this type of hydraulic fluid is the glycerine. The acids are produced when the fluid is subjected to heat and pressure. The compressed air that is used to maintain the pressure in the system is taken into solution to a certain extent and promotes the formation of acids. To simulate these conditions in the laboratory samples of the fluids under test

were placed in stainless steel containers called 'bombs'. The bombs were then charged to a pressure of 500 lb/sq in with oxygen and immersed in a boiling water bath. To take account of the materials used in the system, mild steel and copper test pieces were fastened together and placed in the bombs. Failure of the fluid was judged to occur when there was any definite sign of corrosion of the test pieces. Normally the bombs were inspected every two days. If there was no corrosion the bombs were recharged with oxygen and the test continued.

With the exception of a proprietary water-based hydraulic fluid, all the fluids tested in this way have been glycerine-water or glycol-water mixtures containing various inhibitors intended to prevent corrosion. The soluble oil ZX3 showed a marked tendency to float to the top of the fluids during the tests and was therefore not considered to be of value in such fluids. Glycol fluids were tried as they are widely used in aircraft and in motor vehicle radiators. A fluid of the glycol type is used in arresting gear by the United States Navy. Glycerine-water fluids have been prepared which are at least as good as the glycol-based fluids and have given considerably better results in the laboratory tests than the fluid recently in use in arresting gear. The proprietary fluid used by the United States Navy in steam catapult systems was found to be unsatisfactory under the test conditions employed.

The most promising fluid tested is of the following composition :—

- 60 gallons of glycerine of dynamite quality
- 40 gallons of distilled water
- 2 lb of sodium nitrite
- 8 lb of disodium hydrogen phosphate

and it has been decided to adopt it in arresting gear.

Dynamite quality glycerine was chosen from the five grades in the British Standards Institute Specification. The third grade had previously been used in arresting gear fluids but it was decided to use the second, the 'dynamite' quality grade, because of its greater purity. The first grade of chemically pure glycerine was not adopted because of its cost and limited availability. There is evidence that the performance of the fluid is affected by the quality of the glycerine and investigations are continuing to establish the factors responsible for this.

The sodium nitrite and disodium hydrogen phosphate used in this fluid, act as corrosion inhibitors and, in addition, the phosphate helps to neutralize the acids which may be formed.

It is necessary to check the condition of the fluid in service by noting the drop in alkalinity and any development of acidity. It was not possible to develop a suitable chemical indicator that would show when the fluid had deteriorated beyond an acceptable limit, so it was decided to use an instrument which measures the *Ph* value. The *Ph* value is a measurement of acidity or alkalinity. The instrument selected is the Pye portable *Ph* meter.

When the fluid is freshly prepared it has a *Ph* value of about 7.9 to 8.2 but is liable to drop fairly rapidly at first to about 6.5 but then should fall very slowly. Active corrosion sets in at a *Ph* value of about 5.5. It has therefore been decided to add more phosphate when the *Ph* value falls to 6.0 in order to prevent a further decline.

While there is no doubt that the new fluid will be a considerable improvement upon that used previously, it is not certain that the corrosion problem has been completely solved. The temperature to which the fluid will rise in the Mark 13 arresting gear, when the next generation of heavy fast aircraft are operated

intensively, may still cause trouble. To meet this the following steps are being taken :—

- (a) Further work is being undertaken on hydraulic fluids
 - (b) Fluid coolers will also be fitted to the arresting gear in the later modernized carriers. They may also be fitted as an Alteration and Addition to all carriers fitted with Mark 13 arresting gear
 - (c) The arresting gear hydraulic system is being separated from the miscellaneous hydraulic system and is being provided with its own pump and accumulator. There are three reasons for this. The first is that the miscellaneous hydraulic system in all carriers in service is badly corroded and full of deposits which contaminate the arresting gear after it has been cleaned and refitted. The second is that if the fluid in the arresting gear can not be prevented from becoming acid it is undesirable that this should contaminate the miscellaneous hydraulic system. Thirdly, it will enable a different fluid to be used in the arresting gear from the other system. In this connection it should be noted that the operation of the arresting gear during pull out is not affected by viscosity. The viscosity does, however, affect the time of re-setting.
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