PRE-COAT FILTERS

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ABSTRACT

The pre-coat filter has features which could make it an attractive alternative to the more familiar cartridge element filter for cleaning of middle distillate fuel, whether F.76 or MGO for the Royal Navy. A commercial unit has been procured and assessed ashore at the Gosport oil fuel depot and afloat on board the R.F.A. *Black Rover.*

Introduction

A major consequence of using aero derived gas turbines in ships, is that the quality of the fuel reaching the gas turbine must be closely controlled. Emphasis is placed on protecting the engine from sodium (salt), which erodes hot end components and results in expensive repair and overhaul costs. The quality of the fuel is closely controlled by using a coalescer (filter water separator), which removes water containing the sodium. A pre-filter protects the coalescer. However it is important that clean fuel is supplied to ships, to prevent undesirable high usage rates of pre-filter elements.

In view of the above, a Diesel Filtration Test Kit (DFTK) (FIG. 1) was introduced to enable ship's staff to easily check the standard of fuel being supplied from either a R.F.A. at sea or an Oil Fuel Depot (OFD). The principle of the DFTK is that it measures the differential pressure across a standard filter after a known amount of fuel has been passed through it. The minimum acceptable filterability standard in the R.N. F-76 (dieso) specification, is that at least 250 mls must have passed when the differential pressure has risen to 1 bar.

ES216 is constantly in contact with filter manufactures, with a view to future design improvements and cost reduction. As part of this process, the 'Pre-Coat Filter' system already used extensively for aviation Kerosene on airfields, was investigated. High flow rates at OFDs and onboard R.F.A.s, means that if cartridge elements are used, they must be large. Large elements mean that they are heavy to handle and expensive to purchase. The pre-coat system would alleviate these large, heavy and costly elements. During preliminary talks with the manufacturer, concerns were raised that the viscosity of middle distillate fuels such as F76 could cause a problem in forming a filter cake. Small scale trials were carried out which suggested that with the possible future saving on through life cost, it was worth proceeding. It was decided to obtain a 200m^3/hour commercial unit, to be assessed both ashore and at sea.

FIG. 1—DIESEL FILTRATION TEST KIT

What is a Pre-coat Filter?

The pre-coat filter uses a filter medium which is carried by the fuel to form a cake on filter candles (FIG. 2). Various types of medium are available and after manufacturer's trials, the recommended medium to meet the Royal Navy requirements was a diatomaceous earth.

Diatomaceous earths are composed of the skeletons of microscopic plants, diatoms, deposited on the bottom of oceans and lakes up to 15 million years ago. Diatoms come in many shapes and sizes and because they are inert and, insoluble, they are ideal for use as a pre-coat system. The pre-coat is defined as the formation of a layer (or cake) of filter aid on a septum. The pores of the pre-coat are very small and numerous when compared to the pores in the supporting septum, giving rise to a filtering layer of high permeability.

Trial Unit for the Royal Navy

It was decided that the best way forward was to invest in a pre-coat system contained in a 20ft International Standard Organisation (ISO) container, which made it mobile for transportation to OFDs and simpler to instal there and on board a R.F.A. for the eventual sea trials.

Although the pre-coat system had been successfully used in aviation systems ashore and at Gosport, it had never been tested at sea. It was felt that ship motion and vibration in heavy seas could cause the filter cake to fall off the candles. In view of this it was decided to trial the unit on a R.F.A. and *Black Rover* was chosen.

The filtration system installed in the ISO container comprised (FIG. 3) of:

- Gemini pre-coat filter vessel.
- Dosing tank.
- Bagwash tank.
- Bag filter vessel fabricated in carbon steel.

The instrumentation included:

- Gauges for on-line and differential pressures.
- Flow meter.
- Sight glasses, both upstream and downstream of the filter.
- Data recorder.

System Operation

With the system on-line and full of fuel, 20 kg of filter aid is dosed into the inlet line, from the dosing tank, via the dosing pump. The flow of fuel deposits the medium onto the candles, forming the filter cake. Filtration of the fuel proceeds until the differential pressure across the Gemini filter reaches 35 psi, at which point audio/visual alarms are activated. If no further action is taken and the differential pressure reaches 40 psi, the main feed pump will be tripped. With the system off line, the 'dirty' filter cake is back washed off the candles into the backwash tank, a new filter cake is then dosed onto the candles allowing fuel filtration to continue. Meanwhile all contaminated products in the backwash tank can be recovered by circulating through the re-injection pump and the bag filter.

Trials

Ashore

The system within the container had undergone trials at the OFD Gosport where the results were very encouraging. Fuel out of specification on filterability, was recovered to acceptable standards, using the pre-coat filter. In financial terms this can be a great saver, as fuel having poor filterability must often be downgraded with a consequential large financial loss.

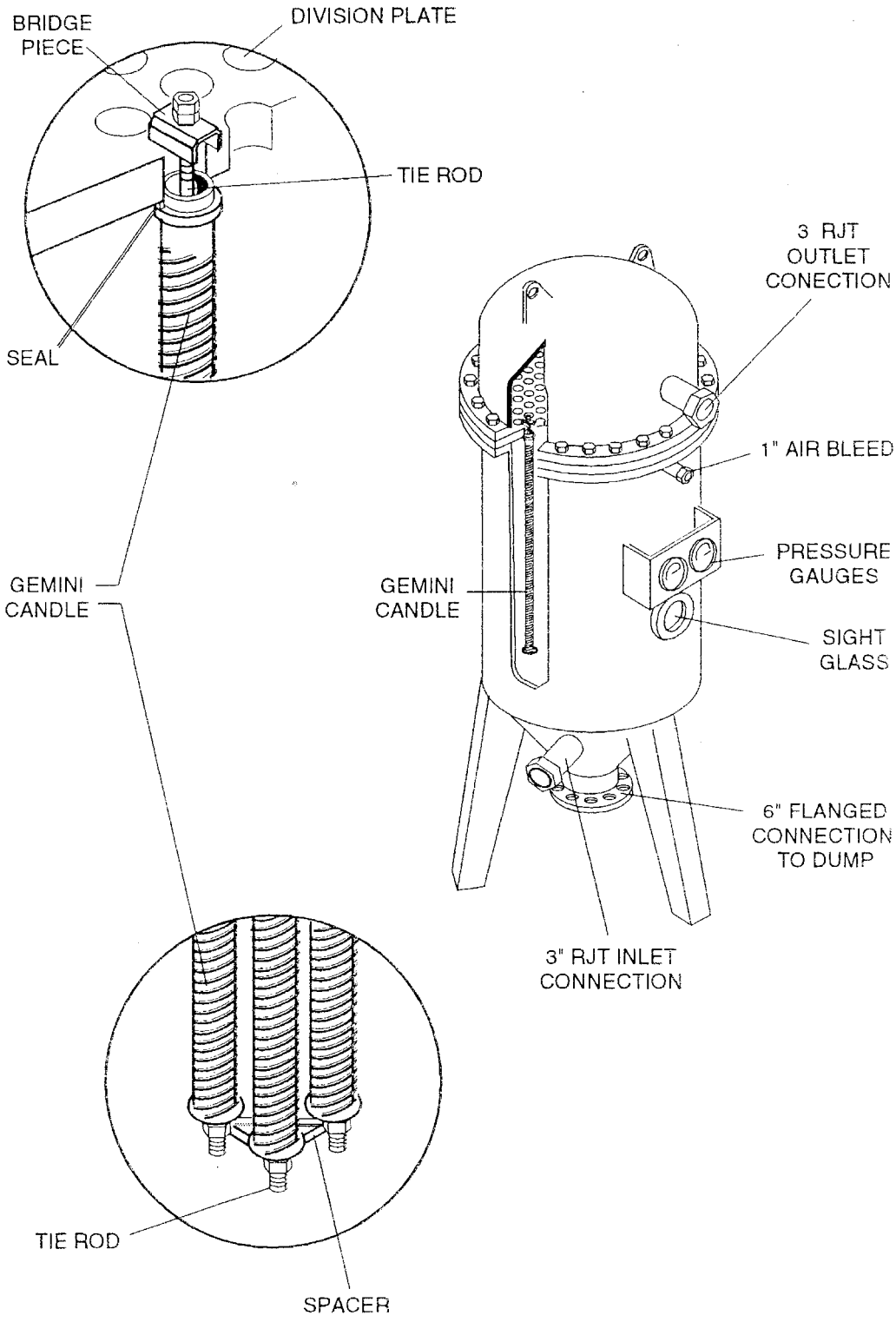

FIG. 2—GEMINI FILTER

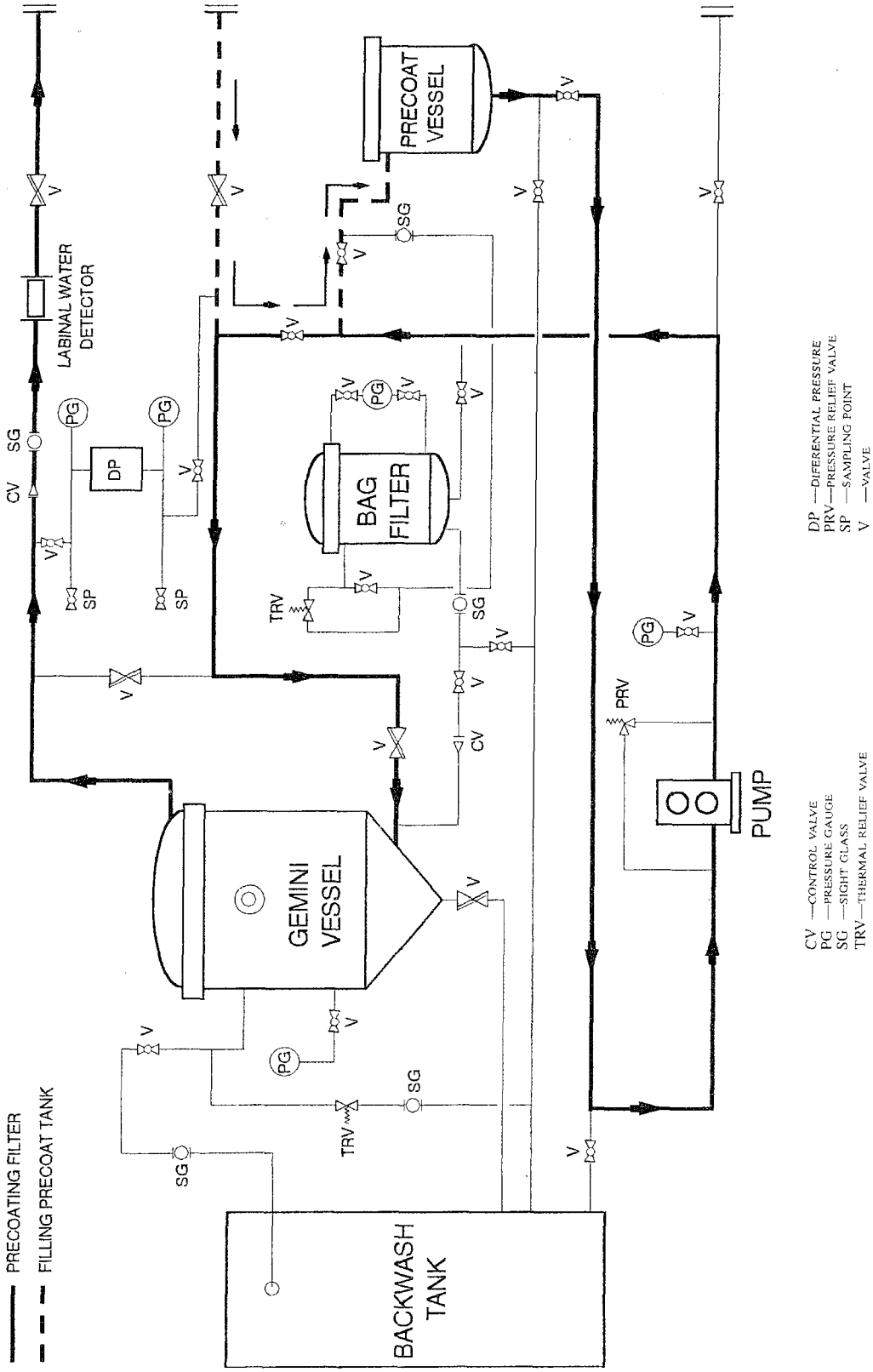

FIG. 3—PRECOATING FILTER VESSEL

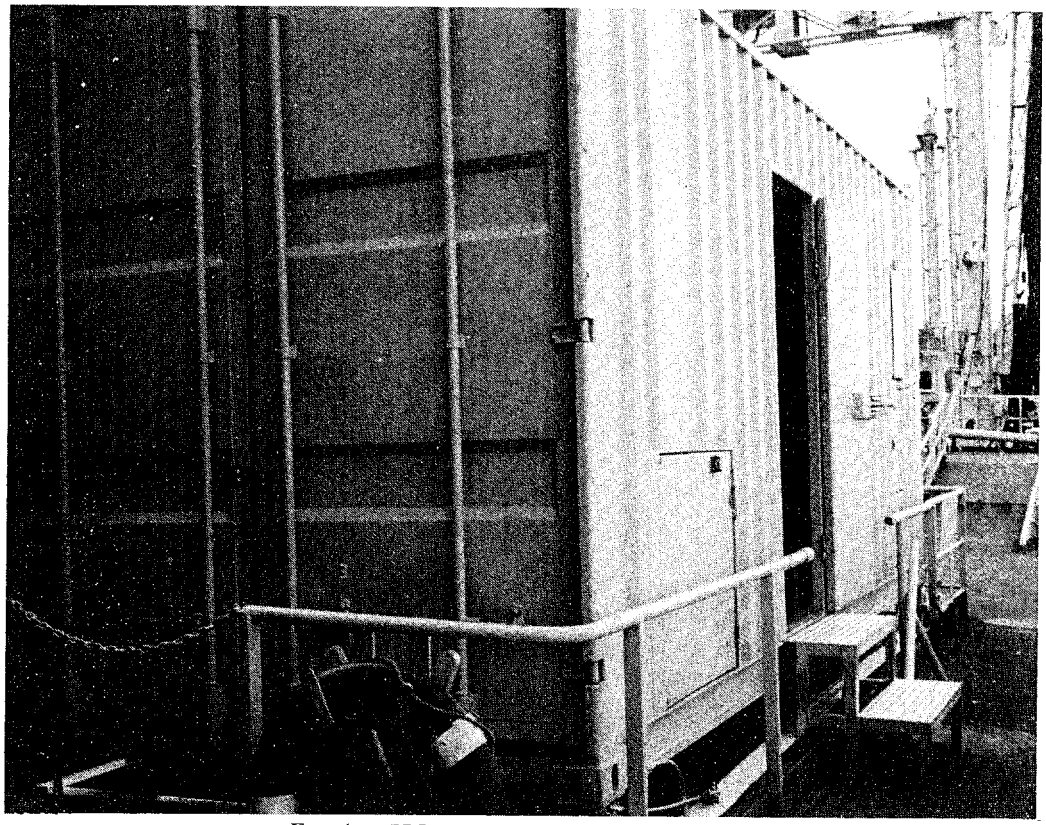

FIG. 4A—ISO CONTAINER LOOKING FORWARD

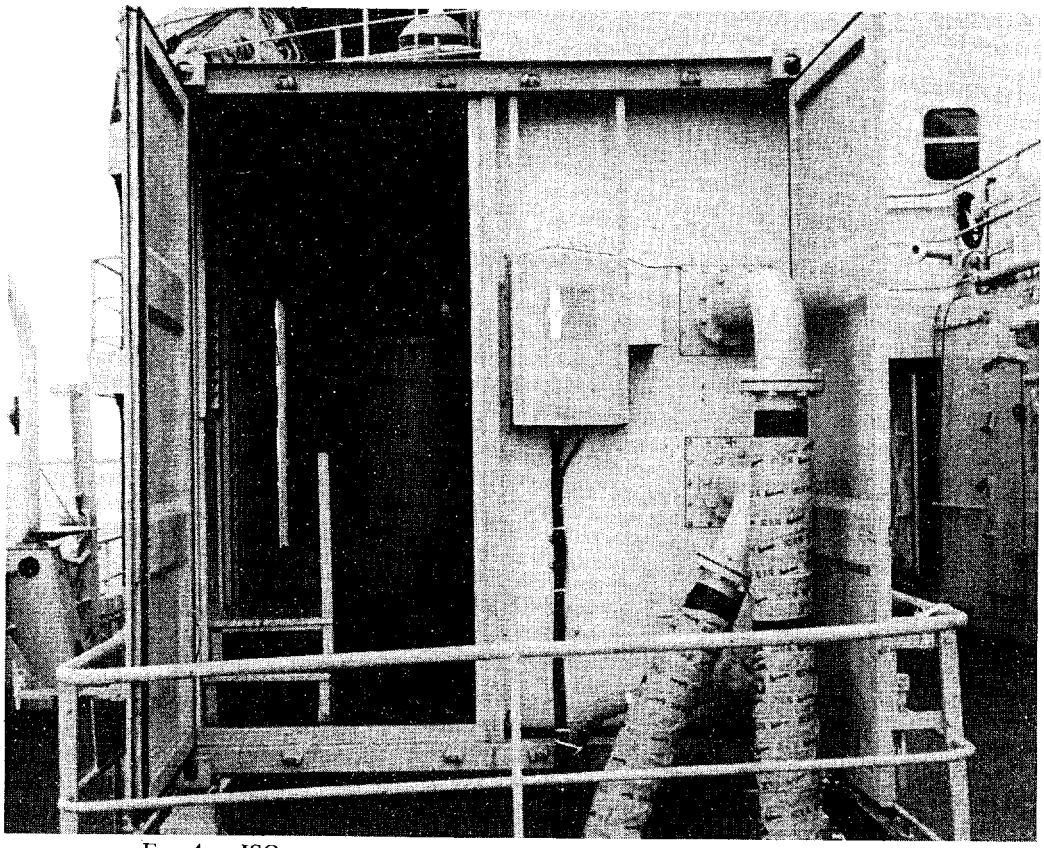

FIG. 4B—ISO CONTAINER LOOKING AFT SHOWING INLET AND OUTLET PIPES

At sea

The ISO container was mounted on a steel framework built over the ship's swimming pool (FIGS. 4A & 4B), as there was no other suitable area available. The filter inlet and outlet connection were connected via flexible hoses to a new manifold inserted in the drop line to No. 3 centre cargo oil tank. Because the design throughput of the filter (200 m^3/hour) is low compared to normal RAS pumping rates, it could not be used to supply fuel direct to a warship The filter could therefore be supplied with oil from any of the ship's cargo tanks, but could only discharge to No. 3 centre tank, which was used as an issue tank. The aspects of performance of particular interest were:

(*a*) Time between pre-coat changes.
(*b*) Adhesion of pre-coat.
(*c*) Dirt removal performance.

Time between Pre-coat Changes

The manufacturer's instructions direct that the pre-coat is changed when the filter differential pressure reaches 2.4 bar (35 psi). The trial indicated this figure was adequate to give a reasonable life for the cake (typically 4,000 m^3). Of course, the cake life is very dependant on the condition of the fuel to be cleaned. It is to be noted that the fuel on *Black Rover* for this trial was typically 250 ml at 0.8 bar using the DFTK.

Adhesion of Pre-coat

In the early stages of the trial the pre-coat was found to have detached after periods of shut down, in two cases, after periods at sea in good weather. Subsequent pre-coats were applied using only 2/3 of the previous quantity (1 bag instead of 1½ bags) and thereafter there were no significant problems. During trials the ship experienced rough weather (sea state 6-7) with no evidence of cake detachment. It was therefore concluded that the operation of the filter is not adversely affected by moderately heavy weather or ship vibration.

Dirt Removal Performance

Regular samples were taken and in some instances the inlet sample was worse than the DFTK acceptable standard of 250 ml at 1 bar. In all of these instances the outlet sample was of an acceptable quality. The scatter of results of the outlet filterability was low varying between 0.15 and 0.25 bar. It is considered that this is an acceptable dirt removal performance.

Discussion

The unit, as supplied and configured for the Royal Navy, when compared with the cartridge type filter required more man-hours to operate. However much of the extra work load was due to the unit being a trial rig not tailored to the ship and the requirement for continuous trial readings. The work load to run a purpose built system would be little more than that for cartridge filters, but should not be large. With the current design, changing filter bags is difficult and dirty. However, the manufacturer has ideas to overcome this in later units. The unit has a high initial cost compared to cartridge units, but both running and through life costs would be lower. On removal from *Black Rover*, the unit was installed at the OFD Gosport, where more running experience and performance results can be achieved.

Conclusion

Trials have shown that the pre-coat filter to be a serious competitor, with significant advantages over cartridge. In the future, ES216 feel that the pre-coat system should be considered, together with cartridges, for meeting future filtration requirements in both R.F.A.s and OFDs.