PORTABLE PUMPS

IMPROVEMENTS

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Introduction

Flames from the Falklands chased the shadows from many dark corners of ship and equipment design, and focused particular attention on the fire-fighting and damage control systems. In this area weaknesses were revealed in the ships' structure and fittings, in the layout of the High Pressure Sea Water (HPSW) main, and in the fixed and portable pumps. This article reports the steps taken to improve the self-powered and portable pumping equipments which provide the fall-back in the ships defence against fire and flood. In so doing it illustrates the range of problems facing a procurement authority in selecting, specifying, and purchasing equipment for military use. Recent developments in fire-fighting and damage control techniques are discussed elsewhere in this issue[1].

Before the War

Before Operation Corporate, a typical frigate or destroyer was fitted with the following set of damage control/fire-fighting pumps and eductors:

(*a*) *Fixed Equipments*

4 (or 5) Hamworthy Dolphin fire pumps—150 m^3/hr

8 fixed eductors—75 m^3/hr

11 fixed eductors—15 m^3/hr

(*b*) *Portable Equipments*

2 submersible electric salvage pumps (Worthington Simpson or Flygt)—40 m^3/hr

2 non-submersible electric salvage pumps (Worthington Simpson or Selwood Spate)—35 m^3/hr

1 gas turbine driven emergency fire pump (the Rover)—120 m^3/hr

2 air-driven general purpose pumps (Madan Gurkha)—4 m^3/hr

2 portable eductors—15 m^3/hr

As part of the preparation for war, all spare Rover pumps including those in training establishments, were rounded up and despatched to the Task Force for distribution to ships as required. Some vessels found themselves with two Rovers; others had to make do with one.

Two other independent portable pumps also saw service in R.N. ships: the Selwood Spate diesel pump fitted to Type 21 frigates, and the Enfield HO2/Worthington Simpson Type 27/70 portable diesel fire pump fitted in Type 12 frigates and in some other older ships.

Falklands Experience

Exposure to conflict conditions revealed a number of faults with this equipment, several of which had been apparent for some time before. Perhaps the most significant of the lessons learned was the inability of the portable firefighting pumps to compensate to any extent for the loss of the HPSW main. This truth was dramatically illustrated by the sequence of events in H.M.S. *Sheffield* where no fewer than five Rover pumps were available during the course of the fire. The ship's own Rover, deployed on the quarter deck, was disabled by an immediate and irreparable failure of the starting chain drive. A second pump supplied from H.M.S. *Arrow*, was landed on the flight deck, where it was unable to establish a suction. As the pump was too large to pass through the flight deck hatch it had to be manhandled into the ship through the hatch in the ship's office flat—a process involving removal of the accommodation ladder—and back out on to the quarter deck where it eventually did make a useful contribution, albeit some considerable time after its arrival on board. Three other pumps were landed by helicopter on the fo'c's'le. The first to arrive started but again failed to establish a suction. At the time the pump and the suction hoses were blamed, but it later transpired that rags had been stuffed into one of the hoses and were blocking the water path. Of the two other forward pumps, one was found seized on arrival and the second was not used because by the time it was rigged, fire main pressure was available directly from H.M.S. *Arrow* which had come alongside. Failure of Rovers in other ships underlined the need for improvement.

Although the unreliability of the Rover was the most obvious and dramatic of the faults revealed, several other deficiencies were found. The Enfield HO2 was of ageing design and limited capacity. Although nominally portable, its weight (620 lb) and its size (51 in × 37 in × 29 in) reduced its value as a mobile unit close to vanishing point. The second independent pump, the diesel Spate (FIG. 1), was primarily used as a salvage pump, for it has excellent self-priming performance. This unit was also supposed to fulfil a fire-fighting role but unfortunately the output pressure falls rapidly as suction lift increases to such an extent that at a typical 3 m. lift the pump is unable to support both a jet and the waterwall required by the fire-fighting team. This deficiency was officially reported in 1979 and work to find a replacement was well in hand before the conflict broke. An emergency buy of the replacement pumps was considered, but the delivery timescale (3 months) was too long to be of value. As will be seen later, this replacement pump—the Hathaway HMD7—was to fill a useful gap in the post-Falklands equipment fit.

Among the electric portable pumps two areas for improvement were noted. The 40 tonne Worthington Simpson submersible, a pump which should have been replaced by the Flygt Bibo in the mid 1970s, was found to be still in service in many ships. The Flygt Bibo itself, although reliable and easy to use, was substantially outperformed by the larger submersibles carried by the salvage tugs.

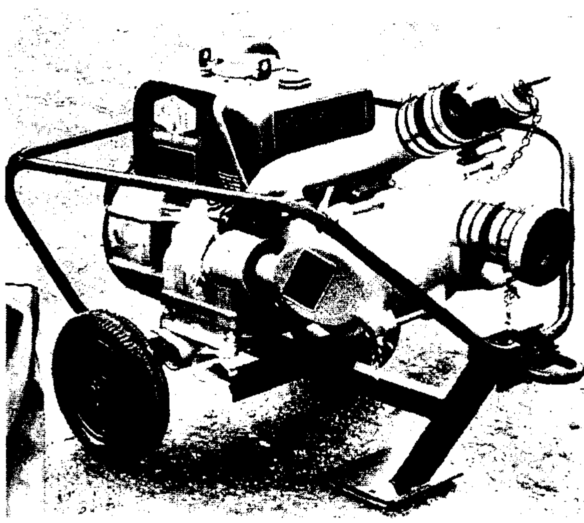

FIG. 1—THE DIESEL SPATE PUMP

Taking Stock

Immediately after the war, work was started to analyse these weaknesses and put them right. Although responsibility for equipment design and procurement lay with the equipment sponsor section of the Sea Systems Controllerate, the task of defining policy and setting equipment design targets was undertaken by the Damage Control Working Party (DCWP). Its membership represents C.-in-C. Fleet, Captain N.B.C.D., F.O.S.T., the Director of Naval Warfare, and the Sea Systems Controllerate.

Setting a policy for improving the portable pumps was not easy as the choice was wide, many factors were involved, and opinions differed on what was needed. Whilst the formal committee meetings provided a useful focal point and court of arbitration, the task of proposing a pump development strategy was largely accomplished out of committee by discussion between the various parties involved. From these discussions a number of conclusions emerged:

(*a*) Ships were over-dependent on the HPSW main and on the electrical power supplies to it.

(*b*) The lack of an independent fire pump in the forward section of the ship seriously hampered fire-fighting efforts.

(*c*) The Merchant Marine had better salvage pumps.

(*d*) A number of problems raised previously remained to be solved.

To rectify these weaknesses the DCWP made the following initial recommendations:

(*a*) Each frigate and above should be provided with two self-powered pumps, of Rover capacity, accessible from the weather-decks forward and aft.

(*b*) Each DC Section Base should be provided with a larger submersible pump.

(*c*) Existing programmes to replace the 40 tonne Worthington Simpson and the diesel Spate pumps should be completed as soon as possible.

The translation of these objectives into reality is discussed below.

100 Tonne/hour Fire Pump

When it works the Rover is an impressive pump and many ships, both naval and mercantile, have had good reason to be grateful for its presence. Unfortunately the pump has an appalling reliability record, stemming primarily from its sensitivity to corrosion if left exposed to sea water. Just how bad things were was brought home most forcibly by a recent visit to the Pump Repair Centre at Blackbrook Farm, Portsmouth. At the time of the visit three pumps were awaiting repair. Despite their appalling condition the sum of readings on the 'hours run' meters was less than 37. The Rover's suitability for shipboard use is also severely limited by the hot exhaust from the gas turbine engine. Action was clearly needed to replace the Rover or to improve it.

A Replacement for the 'Rover'

In the search for an alternative, three prime movers were considered: other gas turbines, petrol engines, and diesel engines. Although no suitable gas turbine pump units were discovered, other small gas turbine engines were available but not in a marinized form. Given sufficient time and money a reliable portable marine gas turbine fire pump could be developed, probably utilizing the low weight and excellent corrosion resistance properties of titanium at the pump end. Within the weight limit provided by the Rover considerably greater output is feasible. Although an attractive concept, the effort and cost involved in marinizing the engine, plus the continuing problem of the gas turbine exhaust were sufficient to rule this option out.

Portable petrol-driven pumps of the right capacity were commercially available, for such units are used by the land-based fire services. The use of gasoline in warships is strictly limited and there was an understandable reluctance from Fleet Engineering Staff to countenance its use when fighting fires. Mobile diesel driven pumps are also widely used commercially, particularly by the construction industry. These pumps are simple, reliable, and competitively priced but they are also heavy, large, vulnerable to shock, and quite unsuitable for moving around a ship. However, one available diesel pump of the right size and capacity was found—the Angus LD 1600 (FIG. 2)—based on the diesel engine in the Volkswagen Golf car. As pressure from the Fleet for a second independent fire pump was considerable, an Angus LD 1600 was bought without modification and supplied direct to H.M.S. *Brilliant* for trial.

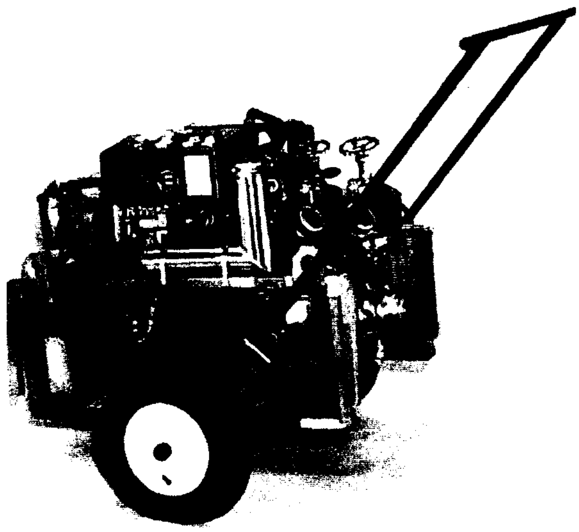

FIG. 2—ANGUS LD1600 FIRE PUMP AS SUPPLIED TO H.M.S. 'BRILLIANT'
The wheels and handle are removable

This trial provided an excellent example of the benefits and pitfalls of using commercial equipment on warships without modification. The pump was cheap, relatively quickly available, and attractively presented. It also performed its basic functions well. On the negative side, however, the electrical systems proved totally unsuitable for the marine environment, the carrying frame was inadequate for moving the unit between decks, and the pump lacked a number of essential features, such as twin fuel tanks and the facility for remote starting. Although further work was needed, the trial did prove that the diesel engine pump had the necessary potential.

In order to minimize the costs, and hopefully save time, the decision was made to make an initial buy of 10 mobile diesel pumps without any funded development, by fixed price competitive tender. The essential prerequisite for this exercise was a comprehensive and unambiguous specification. Much to our surprise this specification[2] took three months to finalize. It also proved most instructive as it revealed considerable differences in emphasis between the different ship projects as to what was required. In particular, conflict arose between the Batch III Type 22 project which required a fixed unit located on 4 deck with full remote start facilities, and the earlier Type 42s and 22s which could not provide a fixed operating position for the pump and had a clear requirement for a fully portable unit. As the diesel pump would inevitably be considerably heavier than the Rover (plus about 100 kg.), the following policy was agreed:

(*a*) In new ships and those where fixed operating positions could be provided the diesel pump would be installed.

(*b*) In locations where the pump had to be moved from stowage to operating position the Rover would be retained.

This added the task of improving the Rover to that of selecting, purchasing and testing a 100 tonne/hour diesel pump.

A second issue to emerge from the specification writing concerned the diesel engine itself. Diesel engines are complex and require substantial logistic support. For this reason a standard range of engines has been tested and approved by a joint Service Committee[3]. As one engine in this range—the Perkins 4·108—appeared suitable, the pump specification required its use. In retrospect this was a mistake.

Invitations to tender were issued on 1 August 1983 with a six-week timescale. One firm declined to offer any unit; the second, the supplier of the Angus LD 1600, offered only their Volkswagen-based commercial unit; and the third, Godiva, who had used the Perkins engine, were unable to meet, or even come close to, the target weight. Consultation with the firms involved suggested that improved designs would be possible with alternative engines. So, on the instruction of the DCWP, the tenders were re-issued in November. At the time of writing replies have been received, and Godiva has been selected to supply the first ten units. The design, which is based on the new Ford diesel engine, is just being finalized, and delivery by the end of 1984 is forecast.

Improving the 'Rover'

Work on improving the Rover should have been started many years ago. So many S2022s had been raised without result that both the Fleet and the Ship Department had become inured to the pumps appalling reliability record. When the problem was eventually faced two parallel courses emerged. In the short term many of the chronic sores could be removed by a package of minor modifications readily fitted by ships staff; in the longer term, changes to body materials could be considered. The approved list of modifications is shown in TABLE I and, after completing the detailed design, three modification kits were purchased for trial at N.A.M.D. Haslar and in ships. As no adverse comments were received, a contract for the full set of modification kits has been placed.

Incorporation of these changes will certainly increase the life of these pumps but they will remain vulnerable to abuse. Ship's staff can help themselves in this by recognizing the sensitivity of the unit and by giving it

TABLE I—*Modification package for 'Rover' fire pumps*

Problem	*Solution*
Priming valve seizes.	New priming valve manufactured in stainless steel with PTFE bearing surfaces.
Fuel tank quick-release couplings corrode; potential leak and fire hazard.	Quick-release couplings manufactured in nickel aluminium bronze (were cadmium plated steel).
Water-cooled exhaust valve and pump drain tap seizes.	Both now Worcester ball valves, manufactured in nickel aluminium bronze.
Inner element of oil cooler corrodes.	Element now of stainless steel.
Gearbox seizes due to ingress of salt water through air pump air filter.	Filter now resited at top of pump.
Hand start chain snaps.	Uprated chain.
Vacuum gauge no longer available from source.	New type gauge incorporated.
Misuse in service.	Operating and maintenance instructions shown on pump under instrument panel cover.
Gauge cases corrode.	Protective varnish to be specified.

the attention it unfortunately requires. The key to success lies in a simple message—if the pump is used with sea water it must be flushed thoroughly with fresh water before it is stowed. Clearly this is an unwelcome chore but the long satisfactory service given by the Rovers held at the Training Establishments, and in particular at the 'Phoenix' NBCD School where the unit is regularly used, confirms that salt water is the pump's most serious enemy. In chosing an aluminium body for an important and expensive marine pump the search for portability was taken one step too far.

In parallel with the work on the modification kit, the pump manufacturers, Hunting Hivolt Ltd., investigated the cost and weight penalties of changing the body material. The results provide an interesting example of a decision involving a balance between conflicting objectives (see TABLE II).

TABLE II—*Alternative materials for 'Rover' fire pump bodies*

Material	*Cost*	*Weight*	*Comments*
Aluminium	(existing)	88 lb	Corrodes badly
Gun metal	£3 830	144 lb	Good corrosion resistance, severe weight penalty
Aluminium bronze	£3 830	117 lb	Good corrosion resistance, difficult to cast, weight penalty
Titanium	£14 570	61 lb	Good corrosion resistance, light, very costly

The decision on whether and how to proceed was further complicated when it was discovered that the Repair Centre at Portsmouth was not re-anodizing the pump bodies. Anodizing—the process whereby a coherent layer of oxide is created as a barrier to further corrosion—is undertaken on new pumps and may increase life usefully if repeated during repair. Mention of anodizing also drew attention to the possible value of other coating techniques. Investigation of these topics is just beginning as work on the other activities nears completion.

Improvements to the Rover and the provision of the 100 m^3/hour diesel will greatly strengthen the warship's ability to fight its own fires, but the newer ships with two installed diesels will loose their readily portable pump. Fortunately, work on the successor to the diesel Spate pump has produced a solution to this problem and it is to the story of this smaller unit, the Hathaway HMD7, that we now turn.

The Hathaway HMD7

The reason for starting work on an improved portable diesel pump has already been stated—the inability of the diesel-driven Spate pump to support the two hoses required by a fire-fighting team. The full requirement as stated by the DCWP in 1979 was:

(*a*) An output of 33 m^3/hr at 2·4 bar pressure, i.e. sufficient to supply a jet (24 m^3/hr) and the waterwall (9 m^3/hr).
(*b*) Ability to pass through a 24 inch hatch.
(*c*) Readily portable by two men.
(*d*) Good self-priming characteristics.
(*e*) It should use the Petters AC1 diesel, which had already been type-tested by the Ministry of Defence.

Enquiries were sent to a number of firms, two of whom were given contracts to supply pumps for testing at the NBCD school and at NAMD Haslar. The first unit, supplied by the Modern Engineering Co. Ltd., was adapted from an existing commercial pump. The second, from Hamworthy Engineering Ltd., was specially designed to meet the specification. Halfway through the test programme an unsolicited approach was received from a further contender, L. Hathaway Ltd. of Gobowen, who had heard of the competition through a third party. They offered to supply one of their commercial pumps free of charge and, as the unit appeared to meet the specification, the test programme was duly expanded.

None of the pumps proved ideal. The Modern pump was rejected for inadequate suction lift; the Hamworthy unit had excellent performance but was heavy and not well packaged; and the Hathaway HMD3 pump, although much lighter (69 kg as opposed to 97 kg) and having a number of attractive design features, had an output characteristic which favoured high pressure at the expense of flow. After considerable discussion it was decided that the Hathaway HMD3 should be adopted for further development.

Over the next few months Hathaway's design engineers, in co-operation with M.O.D. staff, made a range of detailed improvements to the original design. Shock mounts were provided, the impeller clearance was increased to give improved solid handling and greater flow, and the carrying frame was modified to bring the wheels inside the tubing, to provide attachment points for slinging, and to improve 'wheelbarrow' peformance. Finally the hose connections were changed to match existing naval fittings.

In August 1982 three of the modified units, now redesignated the HMD7, were purchased for final trials. As differences of opinion remained on certain features—the finish to be applied to the frame, and starting rope versus starting handle—the opportunity was taken to supply both variants and seek ship's staff reaction. H.M.S. *Alacrity* and H.M.S. *Brazen* were each supplied with one pump and the third unit was sent to R.A.E. West Drayton for shock testing.

Reaction to the pump in H.M.S. *Alacrity* was very favourable as the unit was an obvious improvement on the ship's diesel Spate. H.M.S. *Brazen* also found the pump well engineered and easy to use, but criticized the output as still too low to support a strong waterwall. They also complained that the black rubber feet marked their passageway tiles! Both ships stated a preference for crank starting. The shock-tested pump fared less well, as in the final test the mounts bottomed and one of the engine feet cracked off. The air filter casing was also badly dented by collision with the frame (FIG. 3). Nevertheless the pump started and ran successfully afterwards with no loss in performance.

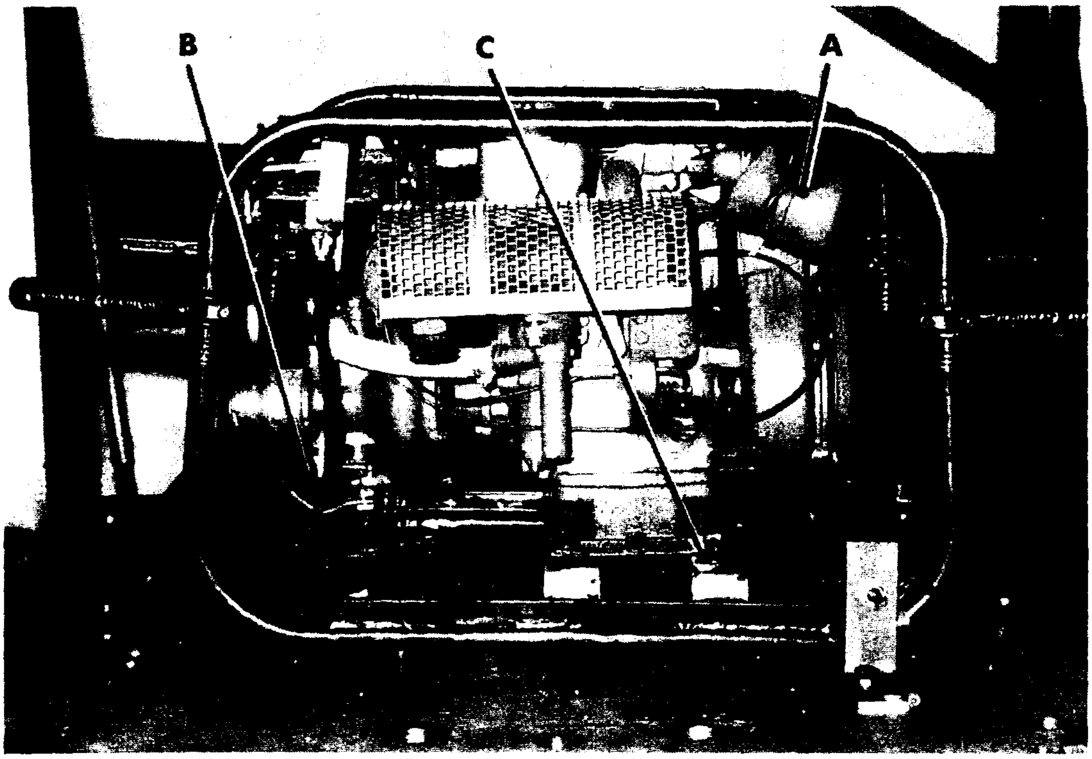

FIG. 3—HMD7 AFTER SHOCK TEST
A: dented air filter
B: extended 'J' strap
C: cracked engine mount

Having completed a full evaluation programme and agreed a final design (including increased shock clearance and white rubber feet!) action was in hand to declare Modification State Zero and order the pumps, when Hathaways advised that an uprated version of the diesel engine was now available. This new unit, the AD1, provided a one h.p. advantage over its predecessor with only a one-inch increase in height. After discussions with Hathaways the new engine was adopted, as the benefit of increased output was judged to offset the small development risk and slight programme delay. The Mod State Zero pump is shown in FIG. 4 and the pump's output curve in FIG. 5.

Although initially intended only for the Type 21s and those later Type 22s with fixed diesel pumps, the versatility of the HMD7 and its low price led the DCWP to recommend its supply to all major warships. Thirty units have been ordered and if repeat shock tests are successful action will be taken to buy the others required. The HMD7 has also been supplied to the Falkland Islands patrol vessel and to the RIVER Class fleet minesweepers (MSFs), where again they have been very well received. Further pumps will also be bought for harbour craft as their existing diesel Spates require replacement.

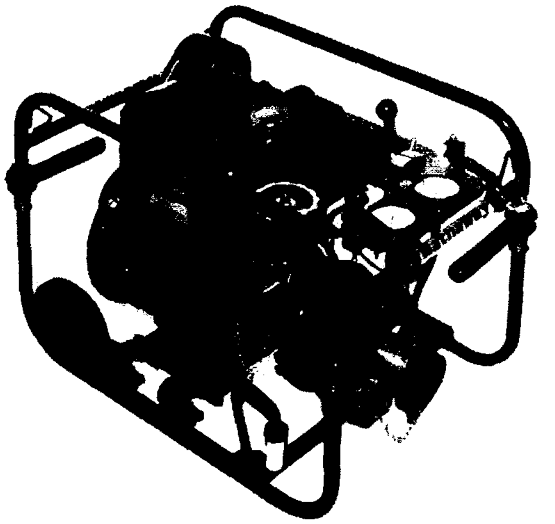

FIG. 4—HMD7 AT MOD. STATE ZERO

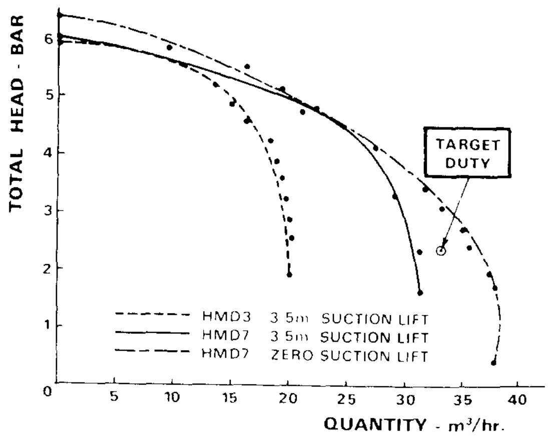

FIG. 5—PERFORMANCE OF HATHAWAY PUMPS
delivery size 2½ inches
suction size 3 inches

A Larger Salvage Pump

Amongst the stories to filter back from the South Atlantic were reports of a very powerful portable salvage pump, lent to warships in difficulty by accompanying merchant vessels. Attempts to identify these pumps positively have met with little success but a market survey did confirm that larger portable electric submersible pumps were available from at least two suppliers. Based on the target set by the DCWP (100 m^3/hr at 2·4 bar), four candidate pumps were identified. The details are shown in TABLE III. As the Weda pumps were both lighter and cheaper, the manufacturer's offer to lend units for test at Haslar was duly accepted.

TABLE III—*Larger Portable Salvage Pump: Comparison of Alternatives*

Manufacturer		*Weda*		*Flygt*	
MODEL	—	L555	L702	B2125	CS3152HT
Rating	kw	7·5	11·8	9·5	15
Starting current	amps RMS	63/65	48/50	37/39	62/64
Continuous rating	amps	12	19	15	25
Star-delta starter	—	NO	YES	YES	YES
Output at 2·4 bar	m^3/hr	59	102	65	108
Head at 100 m^3/hr	bar	1·8	2·5	2	2·6
Dimensions	mm	277×330×762	362×413×914	389×549×798	600×844×1189
Weight	kg	55	95	83	287
Cost (including 20 m cable)	£	1157·3	2097·18	1587·18	2305·8

FIG. 6—THE WEDA L555 SUBMERSIBLE PUMP

The performance of the Weda pumps was entirely satisfactory but the running current of the L702, at 19 amps, exceeded the maximum available from the ships portable equipment sockets. The smaller Weda, the L555 (FIG. 6), although slightly below the declared performance target was considered acceptable by the DCWP as the high figures for starting current show, this pump lacked a star delta starter. At first glance the starting current taken by the L555 exceeded the fuse rating of the ships' supplies. Considerable time and effort was expended in trying to find a suitably compact and robust soft starter before an observant electrician spotted a basic error—fuses are rated in RMS currents and we had assumed they were peak. A shipboard trial of this pump has just been completed to confirm that direct-on-line starting can be accomplished safely.

Two other minor issues remain to be resolved—the type of cable and the type of finish. Tests showed that the outer sheath of the commercial cable had inadequate tear strength and, as the Ministry-approved alternative cable was of slightly smaller diameter (13·1 mm. versus 15 mm.), a choice had to be made between altering the gland or adding a further layer of sheathing to the cable to make up the difference. Costs and practicalities are being investigated. Choices also remain on the paint scheme and on the incorporation of sacrificial zinc anodes to protect the aluminium body. With the history of the Rover in our minds the temptation to ask for an alternative body material was considerable, but as such a change would have made the pump a 'special' it has been decided to accept the risk of a shorter life rather than the increases in cost, weight and delivery which such a change would involve. A formal invitation to tender has yet to be issued before the contractor is finally selected but purchases of these pumps are expected to start in 1984 when they will be supplied to replace one of the existing Flygts at each Damage Control Section Base.

Reflections

Life in a Foxhill Specialist Section may lack the immediacy of the ship or dockyard environment but the jobs carry a real technical weight which can more than compensate. Working on the portable pumps in the 20 months since the end of Operation Corporate has proved particularly enjoyable as many of the negative factors which are normally present—the long shipbuilding timescales, the lengthy communication chains through project section, shipbuilders, main contractor and sub-contractor, and the inevitable technical and financial restrictions imposed on larger equipment projects—were avoided. The full task of setting policy, writing specifications, organizing tenders, selecting contractors, and controlling the introduction of the hardware into the service has been handled directly by the section. A further point of interest in this work has been the opportunity to experience over a relatively short time period three different approaches to procurement: the HMD7 by a traditional select-develop-order route, the submersible salvage pump by purchase of a proprietary item, and the 100 m^3/hr. diesel by fixed price competitive tender for design and build. Whichever method is chosen the need exists to communicate the Ministry's requirements to the contractors. Recent experience both with the portable pumps and elsewhere had confirmed the value of approaching this task in a disciplined and formal manner by writing a comprehensive Statement of Technical Requirements. The benefits are many, but none is more important than the attention this focuses on defining the precise task the equipment has to do.

Conclusions

The previous allowances of portable fire-fighting and salvage pumps for a typical frigate or destroyer are compared with the present fit in TABLE IV. It is too soon to know whether the decisions of the past two years have been the right ones. Certainly the ships' fire-fighting and damage control systems have been usefully strengthened but has too much been done? Did it take too long? Have better solutions been overlooked or priorities misjudged? It is the difficulty in answering these questions that keeps life interesting.

TABLE IV—*Portable Fire-fighting and Damage Control Equipments—allowance for frigate/destroyer*

	Fire Pumps		*Salvage*			
	Large independent fire pump	*Small independent fire pump*	*Selwood Spate electric*	*Flygt Bibo*	*Weda**	*Portable eductor*
	100 m^3/hr at 7 bar	35 m^3/hr at 2·4 bar	21 m^3/hr	40 m^3/hr	100 m^3/hr	15 m^3/hr
Pre-Falklands	1	—	2	4	—	2
Now	2	1	2	2	2	2

*Note: Subject to tender.

To meet its purpose the Royal Navy asks much of its mechanical equipment: high availability, compact design, resistance to shock, low noise, and low magnetic signature. The list of desiderata can be extended at will but meeting the conflicting requirements has never been easy. As time has passed emphasis has switched from designing equipment in-house, through closely directed and monitored development with a selected contractor, to a position where competitive tendering is encouraged as the norm. These changes have altered but in no way diminished the role of a professional engineer and his supporting technical staff in obtaining for the Royal Navy the equipment it needs at a price it can afford to pay.

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