SEA-WATER VALVES IN THE ROYAL AUSTRALIAN NAVY

BY

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Introduction

The introduction of copper-nickel-iron piping for sea water systems in naval vessels brought problems which had not existed with the older galvanized steel systems. Firstly, where water speeds approached 10 ft/sec failures of CNI piping due to impingement pitting often occurred downstream of flanges and fittings and at bends, and secondly, severe erosion of globe valve seats and lids became prevalent.

Considerable attention has been given to both these problems in the R.A.N. in recent years, with the result that impingement failures of piping have been virtually eliminated by attention to design, workmanship and the judicious use of flow-controllers (Ref. 1), while the globe valve problems have been overcome by the adoption of a range of valves of a new design.

A further valve problem of long standing was that of the erosion of the sealing faces of gate or double-faced sluice valves in sea water systems, which has been solved by the use of butterfly valves for full-flow applications.

The following is a general account of the sea-water valve problems, the work undertaken to overcome them and some details of the design and characteristics of the valves finally adopted in the R.A.N. Full details and description of valves and other components of sea water systems are contained in A.B.R.5100, R.A.N. Pipework Manual Vol. 2 — 'Sea Water Services'.

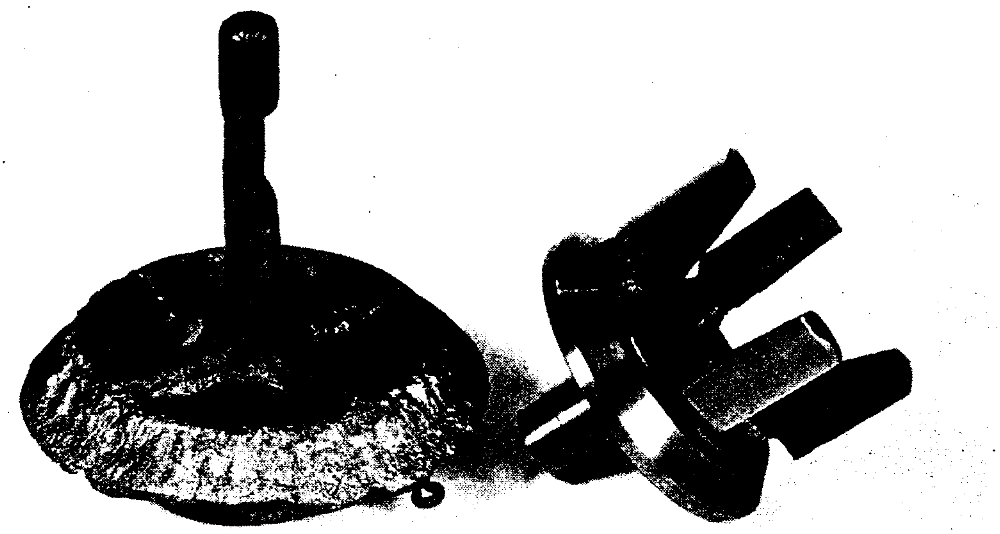

FIG. 1—CORRODED ADMIRALTY TYPE 3 IN. DIAMETER VALVE DISC IN GUNMETAL TOGETHER WITH AN R.A.N. TYPE 2 IN. VALVE DISC IN MONEL

History of Failures

The valves originally used in the CNI systems were basically similar in design to the valves used in galvanized steel systems. Material changes, such as the use of gunmetal in lieu of cast iron for body castings, were made to reduce galvanic corrosion with the copper alloy piping, but otherwise valves were substantially unchanged.

The extent of the valve problem first became apparent during refits of *Darings* and Type 12 vessels, when large numbers of standard Admiralty pattern valves were forwarded to the workshop for repair or replacement. The high failure rate caused an acute shortage of standard pattern valves and many were replaced with commercial types. The life of repaired or replaced valves was extremely short and ships staff became reluctant to use limited refit money in this manner. Many valves were therefore left in an unserviceable condition with 'essential' valves being maintained by the ships staff.

Isolation of part of a system for repairs was usually impossible due to leaking valves and invariably the pump concerned had to be stopped and the piping blanked off before work could proceed. Failures were not confined to a particular type of valve as both screw-down and full-flow designs were unsatisfactory.

Causes of Failure

The principal cause of failure in globe (screw-down) type was corrosion of the seats and discs together with mechanical damage to guides or legs of the discs. Drip-tight operation was possible if the valves were kept closed, but after some throttling use, continuous leakage occurred. Many valve bodies including the standard Admiralty design, could not be refaced very often before replacement became necessary. The design also prevented the valves from being bored to take a screwed insert and large numbers were therefore scrapped at each refit. (see FIGS. 1 and 2).

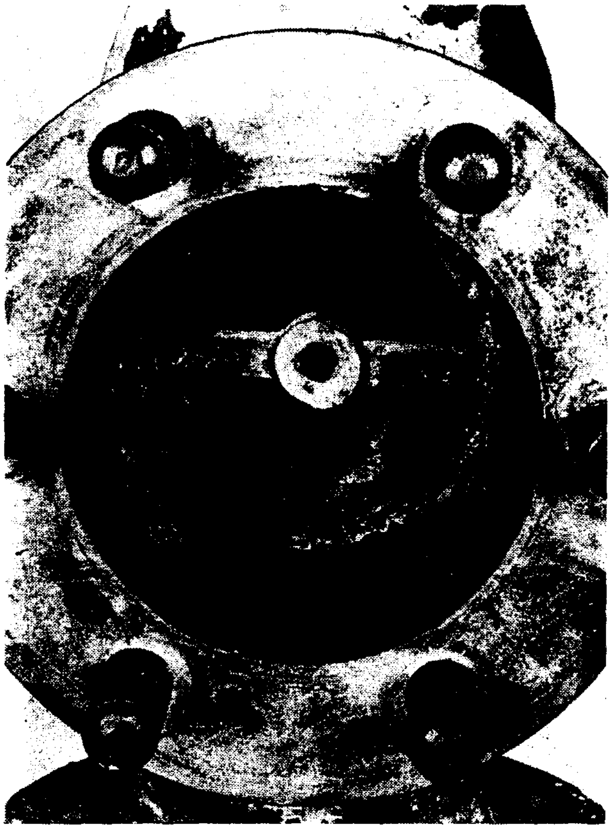

FIG. 2—THE CORRODED SEAT OF A 3 IN. ADMIRALTY TYPE VALVE

Seizing and fracture of spindles, due to painting of exposed screw threads and other moving parts, marine fouling and corrosion of internal threads or overtightening of glands to prevent leakage was common. In commercial valves, dezincification of brass spindles, erosion of bodies and breakage of handwheels contributed to the list of defects (see FIG. 3).

The failure of gate or double-faced sluice valves was not basically due to corrosion, but to a design deficiency. In fresh-water and oil systems these valves gave satisfactory service, but when used with sea water, debris collected in the recess for the gate and prevented complete sealing. Erosion of the sealing faces due to constant leakage soon rendered the valves unserviceable. Seizing of working parts due to painting and fouling was also common to these valves.

To meet the growing demand for replacement valves a pro-

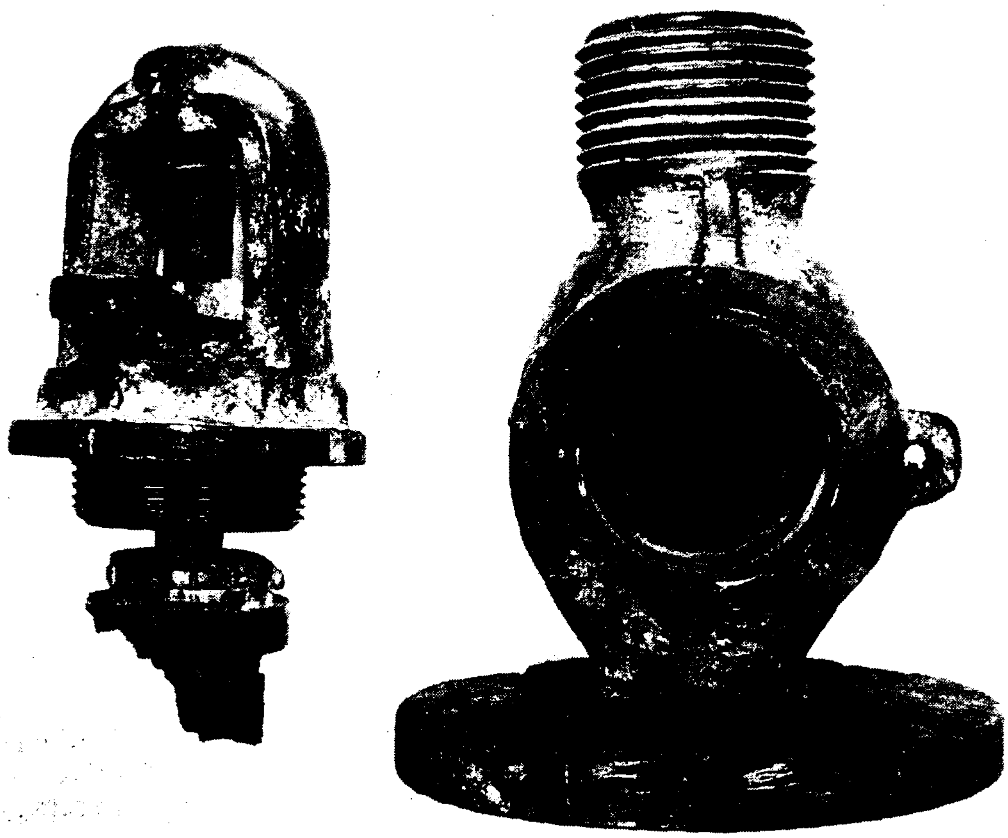

FIG. 3—TYPICAL 1 IN. VALVE WITH CORRODED SEAT AND DISC AND BROKEN SPINDLE

gramme was commenced to compare commercial valves with the Admiralty type and to assess their suitability for naval services. The performance expected from a valve was not specified in naval instructions so before testing commenced the requirements were broadly stated as follows:

'A valve must give reliable, drip-tight operation without maintenance for a minimum of two years when operated in a system designed for a water speed of 10 ft/sec and a minimum pressure of 80 p.s.i. The valve should not cause damaging downstream turbulence when operated over its full working range'.

The programme consisted of laboratory tests on a sea water pump rig, shipboard trials and general assessment of design, materials and weight. Throttling type valves were tested on a sea-water rig at an inlet pressure of 80 p.s.i. with the valve half closed, for a period of six weeks. The downstream turbulence from each valve, over its full throttling range, was examined by the use of clear plastic tubing and rotation of the discharge was indicted by a small rotating vane assembly located in the clear tubing. Full-flow valves were tested in service for twelve months or until failure was apparent.

Results of Assessment Trials

The types of valves tested together with the defects found were as follows:—

(*a*) *Vee and Flat-Seated Globe Valves*

All makes tested failed to meet the specified service life and all became difficult to operate due to internal fouling of exposed threads or external painting of threads. Corrosion of seats and lids was the main cause of failure and the maximum service life obtained was under twelve months. The use of unsuitable materials such as 18/2 stainless steel, gunmetal or aluminium bronze for seats and discs, brass for spindles and split pins was typical of all types. Leakage of glands was general as spindles corroded or became worn in the packing area. Attempts to have valves manufactured in higher duty materials were unsuccessful as manufacturers would not upset production runs for the small numbers required by the R.A.N.

(*b*) *Full-Flow Valves*

Types considered as possible replacements for gate valves included diaphragm and cylindrical rubber-lined types, spherical and lubricated plug cocks and butterfly valves.

The diaphragm and rubber-lined valves were very disappointing, as their performance was well below that claimed for them. Laboratory tests showed that these valves pulsated internally when fully opened and gave violently disturbed discharges when slightly throttled. Diaphragm valves with a flattened cross-section vortexed audibly with a water speed of 10 ft/sec. Their unsatisfactory characteristics were confirmed during service trials when downstream piping failed due to impingement attack.

Ball valves (spherical) were almost perfect for turbulence and pressure drop characteristics, but became extremely difficult to operate after being closed for several months.

Plug cocks gave considerable downstream turbulence and required long awkward handles to operate them. They were heavier than gate valves and had to be constantly lubricated to keep them free.

Butterfly valves of several designs were tested and the concentric-disc type with rubber lining proved to be most efficient and was adopted as the standard R.A.N. valve for full flow applications.

FIG. 4—A 5 IN. DIAMETER BUTTERFLY VALVE OF THE TYPE ADOPTED IN THE R.A.N.

The particular valve chosen had a solid integrated concentric disc and spindle and a split body. This design avoids the risk present in butterfly valves, with separate spindles and discs secured by screws or pins, of the spindle being ejected if the securing screws are sheared due to debris trapped across the seat. The valves gave negligible turbulence or pressure drop and weighed approximately one-eighth the weight of gate valves. Drip tight, maintenance free service over a period of five years has been obtained (see FIG. 4).

Butterfly valves of the offset-disc type were unsatisfactory due to the turbulence created by the eccentric disc and stepped bore, which is a feature of this design.

Experimental Work

The tests conducted confirmed that all known screw-down valves failed to reach the standard required by the R.A.N. However, an examination of the various defects suggested that it was feasible to design a valve which would be superior to those tested. The principal cause of failure was the use of corrosion prone materials for seats and discs and tests were commenced to find a satisfactory material for this purpose. Materials tested included gunmetals, aluminium bronze, superston, monel and 316 stainless steel.

Impingement tests in a modified Brownsden and Bannister apparatus indicated that monel and 316 stainless steel had superior impingement resistance to the other alloys tested and subsequent tests on the pump rig and actual service trials confirmed that a corrosion resistance equal to or better than monel was required. Experience during testing also indicated that better casting properties, superior strength and impingement resistance were obtainable from gunmetals when a low percentage (1·8 per cent — 2·2 per cent) nickel was added. The alloy finally chosen for body castings was B.S.1400 LG4 + 2·0 per cent Ni and this became the standard alloy for sea-water fittings.

An examination of valves with excessive down-stream turbulence indicated that improvements were possible to the internal design especially with regard to the elimination of rotational motion. Several designs were tried and the turbulence patterns observed with clear tubing.

In general, all features such as the number of parts, shape, water tightness, ease of maintenance, interchangeability and rationalization of parts, materials, and resistance to mechanical and corrosion damage, were examined for im-

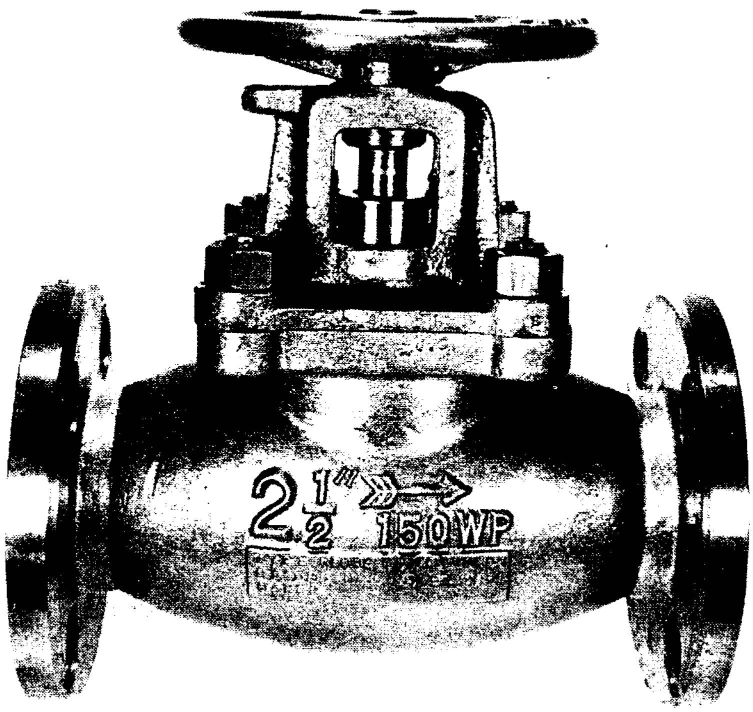

FIG. 5—A $2\frac{1}{2}$ IN. DIAMETER VALVE OF R.A.N. DESIGN

provement with particular emphasis on overcoming the problems encountered in other designs.

Features of the Screw-Down Valve

As a result of the experimental work carried out a new screw-down valve was produced. The main features of the valve are as follows:

(*a*) *The body* is of conventional shape (see FIG. 5), but is modified internally to give improved flow characteristics and to accept an inserted seat. It has machined bores at each end to match the size of piping used.

(*b*) *The bonnet* is of unconventional design and uses one integral casting in lieu of the usual three, i.e., bridge, cover-plate and gland (see FIGS. 6 and 7). The standard packed gland has been replaced by 'O' ring seals (Viton A) which are also used for the bonnet seal and for back seating. The screw threads of the spindle are not exposed to dirt, paint or sea water and the same spindle is used when the valve is remotely operated by rod gearing. In the smaller valves (under $3\frac{1}{2}$ in.) one bonnet assembly is common to two sizes. Sealed lubrication is provided by a grease-filled groove between the 'O' ring seals in the rising nut.

(*c*) *The valve discs* are the four-legged type (see FIG. 1) with a top male guide which is a neat fit in the rising nut. This top design eliminates milling and provides better support for the disc so that mechanical damage is reduced. The disc is lifted by a securing pin which is omitted when non-return action is required. In valves over 2 in. diameter the pin is mounted in a simple synthetic rubber bush (Viton A) to reduce wear.

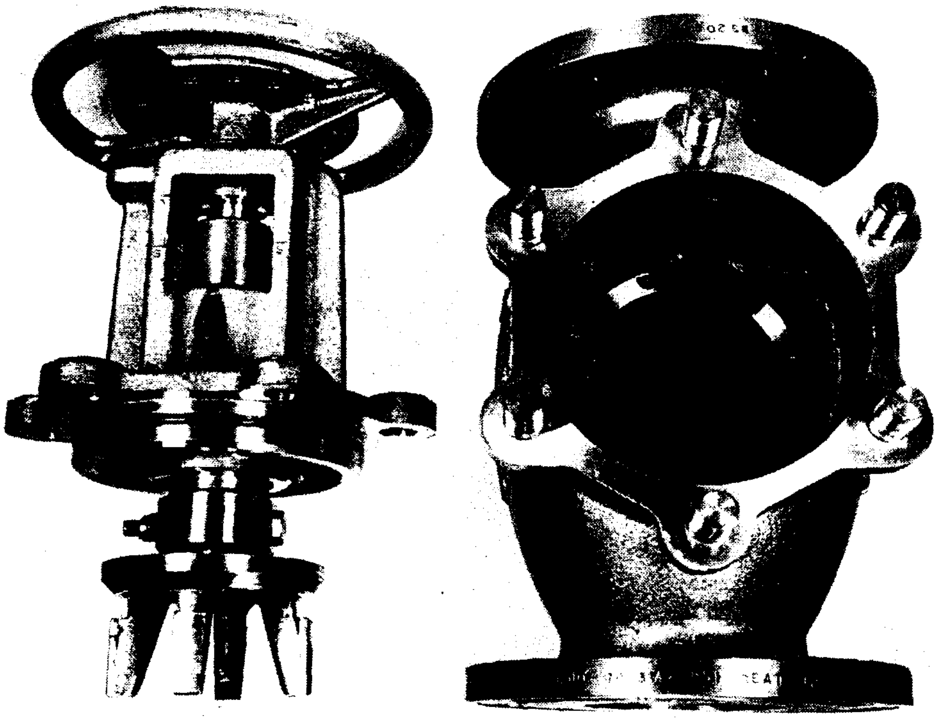

Fig. 6—Internal construction of a 3½ in. R.A.N. valve showing the monel seat and monel-faced valve disc. The valve disc and securing bolt are mounted in synthetic rubber

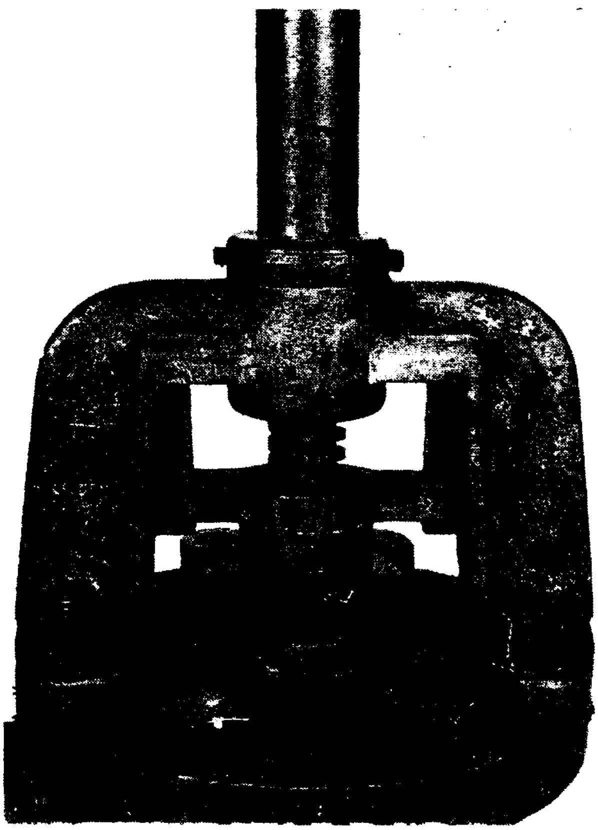

Fig. 7—Bonnet of Admiralty type valve showing bridge cover plate and gland with exposed spindle threads. Compare with single integral casting of R.A.N. valve in Fig. 5

To avoid large areas of monel inside the valve, discs over 3 in. diameter are cast in a weldable bronze and monel faced on the seat and legs by welding.

(*d*) *General Features.* All parts have been made interchangeable by carefully toleranced drawings, and flanges have been accurately drilled to ensure concentricity with the pipe flanges.

The range has been extended to include right-angle and hydrant valves and valve chests, with the standard bonnet assembly common to all types.

Service Experience

With some minor modifications found desirable as a result of service experience, both the R.A.N. screw-down and butterfly valves have proved very satisfactory.

Butterfly valves used initially in D.D.G.s had cast iron bodies and some failures were experienced due to water leakage under the rubber seats. The cause was traced to faulty fittings which displaced the rubber liner, but subsequent modifications to the liner have reduced this risk. All valves used in new construction have gunmetal bodies as an additional safeguard.

The maximum safe water speed for the screw-down valve has been found to be approximately 12 ft/sec as some body erosion commences around 15 ft/sec.

Conclusion

Valve failures will always occur, but it is expected that the changeover to the new valves will help to reduce failures to a minimum.

Reference:

(1) D. E. Fifer and B. W. Turnbull, 'Factors Contributing to the Impingement Corrosion of Copper-Nickel-Iron Sea Water Systems; *Journal of the Royal Naval Scientific Service*, Vol. 22, No. 5 (1967), p. 269.