MORE CORROSION

BY

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The recent Corrosion and Metal Finishing Exhibition at Olympia reminded the Editor that it was about time that yet another article on this important subject was written for the *Journal*. Following the Lord Mayor's Show technique, I have been asked to do just this.

In spite of all the articles, A.F.O.s and monographs issued or available to the Fleet, corrosion still accounts for 80 per cent of the maintenance load in ships. These are not the Author's figures ; they were arrived at as a result of a break-down of repairs on a new class of vessel. It could be that this state of affairs has arisen because of previous information being too difficult to assimilate. It is the intention in this article to explain in simple terms some of the main causes of this high maintenance load and what is being done at Headquarters to alleviate some of the problems encountered.

There are three types of corrosion which cause nearly all the failures. These are:

(*i*) Impingement
(*ii*) Electro-chemical
(*iii*) Chemical.

A description of these and the positions where they are generally met, follows.

Impingement

Impingement is the accelerated corrosion arising from the continual removal by turbulent water of the protective corrosion product film. It can be recognized by the appearance of pits of varying depth, usually in areas where acceleration of the normal water flow can be deduced. These pits are normally of horseshoe shape and pointed as though the horse is walking upstream.

The water speed through pipelines is designed at 5·5 ft/sec for older ships and 10 ft/sec for modern ships. The pipe materials supplied will resist water speeds within the range of 14—16 ft/sec. It will be appreciated, therefore that provided full streamlined conditions are met, no impingement attack should ensue. Unfortunately the margin of safety is small and the slightest protuberance at the skin of the pipe can break up these conditions and cause local eddying and hence very high local water speeds. It has been observed that a protuberance of as little as 1/32nd of an inch in a four-inch bore pipe has been sufficient to cause impingement.

This attack can be found in the wake of badly mated flanges, changes of pipe direction or water flow, or badly fitted jointing material. Wherever impingement attack is recognized the cause of the turbulence is not far away, usually within two diameters upstream. Impingement attack is the most prevalent form of corrosion and the easiest to prevent. Imagine that you have a rubber hose 1/32-inch less in diameter than the bore of the pipe. Stretch the imagination to the extent that you have to push this rubber tube through the pipe system. Wherever it is impeded, there will you get impingement. If all mating surfaces are faired off to give an easy passage to the tube, impingement attack will have been prevented in a lot of positions where it was previously experienced. You will argue—how do I push a rubber tube through a standard Admiralty valve? The answer is simple—you cannot. However, S.D. valves, in fact all valves in sea water systems, are of gunmetal which has a much greater resistance to impingement than has the pipe material (20+ f/s as against 14— f/s) so there is a greater margin against failure. In addition, straight-through valves are gradually being fitted in lieu of the S.D. type. These valves will preserve the streamlined conditions when in the open position.

A lot of trouble with valves arises from the use of them for throttling. It is easy to say that this should not be done and that valves should be either fully open or shut. It is appreciated that frequently a fully opened valve means over-cooling or over-supply but it must be emphasized that throttling by valve should be the last resort and only used when the pump cannot be regulated by other means. If throttling has to be arranged, it is better to be on the down-stream side of the heat exchanger or fitting that is being regulated.

Particular care is now being taken to straighten water lines and H.M.S. *Devonshire* is the first ship in which improvement of the geometry has been attempted. Even so, it is anticipated that about 4 per cent of the flanges will require some attention. At present it is calculated that 10 per cent of joints are badly enough aligned to cause impingement. We cannot hope to design and instal a system entirely free from local turbulence but, with use, these positions will make themselves known and can be attended to once and, it is hoped, for all time.

One final remark about impingement. The hull of a ship moves through the water at about 50 f/s. If the corrosion engineer had been invented when ships were first contemplated in steel he would have said that it could not be done. The ship would have had to be made of titanium, if that too had been invented. The fact that ships do live at these speeds shows that correct streamlining does pay, and if constructors can do it, so can engineers.

Electro-Chemical

It is not intended to describe once again the corrosion cell. Suffice it to say that if two dissimilar metals are joined together in sea water or even a marine atmosphere, corrosion of the less noble material will ensue. Generally speaking, if galvanic corrosion is experienced, it is a fault of the designer. Even today one hears of too many instances of aluminium alloy in contact with copper alloy.

The galvanic series is as follows :—

Magnesium and its alloys
Aluminium
Zinc
Cadmium
Aluminium Alloys
Chromium
Steel
Cast iron
Stainless steel*
Lead-tin solder
Lead
Tin
Nickel*

Neutral Point in the Series

Brasses
Copper
Bronzes
Nickel silver
Nickel copper (monel, etc.)
Nickel*
Stainless steel*
Silver
Graphite

Metals which fall above and below the neutral point should not be joined.

Besides reacting with each other, metal alloys also have the irritating habit of forming a corrosion cell when they are mixes of mutually aggressive metals. For instance, brasses which are alloys of copper and zinc behave badly in sea water. The zinc is selectively destroyed galvanically and a honeycomb of copper is left. This is known as dezincification.

Stainless steels which are alloys of iron, chromium and nickel also behave in a peculiar manner. If they are freely suspended so that oxygen can be received by the whole surface, they are passive and appear below the neutral line. If however, the surfaces are denied oxygen, e.g. at joints, glands, etc., then it becomes active and above the neutral line. It can thus readily be seen that a stainless steel valve spindle is doomed to failure and will always pit under the gland packing. The fact that they are still in use is a measure of our inability to find a better substitute.

Although the pundits may not agree, it is the Author's experience that alloys containing significant proportions of nickel behave in this active/passive manner.

The one place in ships where electro-chemical attack is most probable is in the water boxes of condensers. Here we have brass tube-plates, cupro nickel ferrules and gunmetal water boxes. Oddly enough, until comparatively recently, we have had no trouble here except that the tube-plate would show incipient dezincification at the edges near the more noble gunmetal doors. Of course, mild steel corrosion pieces were fitted at the inlet end although it was seldom that these were active. They have even been found painted with Detel paint. When trouble did arise, it was in the outlet water space. There are of course several possible reasons for this, but we chose to think that this was yet another example of the inability of brass to withstand present conditions, and aluminium bronze was promptly recommended. In existing conditions arrangements were made for zinc alloy anodes to be fitted. These anodes will waste to nothing and are unlike the old zinc plates provided which rapidly polarized. The inlet water spaces have no corrosion pieces in latest designs. For some time we required the inlet boxes to be sprayed with mild steel. The logic was sound in that the wastage of the iron provided iron oxide to the water stream to enable the oxide film in the tubes to be rapidly built up. When this had been achieved, no more iron oxide would be required. It is believed however that, because the spray was deposited on a surface too aggressively noble, in fact it was stripped from the doors and ended up in a pile at the bottom of the box. Metal spraying has now been discontinued.

Chemical

Chemical attack is the least likely to be met, at least in marine engineering services. It is generally confined to the effects of pollution which by the deposition of sulphides disrupts the protective oxide film on metals and so causes pitting. Shellfish and seaweed, growing and decaying in systems, are common sources of this attack but recently a more insidious and catastrophic form has been met. This comes from poluted water, particularly in fitting-out basins bordering industrial rivers such as Tyne and Clyde. If water from these rivers is allowed in the salt water systems in the early days of a ship's life it will eventually destroy the system and in a very short time will cause aluminium brass condenser tubes to perforate. Luckily the worst effects can be avoided if the systems are emptied as soon after basin trials as possible and flushed with shore water. Of course, if the ship is going to sea in a day or so, the system will be flushed anyway. It might be useful to remember however that the Clyde is badly polluted down as far as the Tail of the Bank so that just anchoring there for some days is not good enough.

This form of attack is also met in engine and boiler-room bilges. It is a measure of our failure to attack this problem successfully in that ships plating fails from the inside. This problem is now being tackled with increasing vigour. New ships have shot-blasted and zinc-sprayed steel plate finally coated with chlorinated rubber paint. Clean ship conditions during building ensure that the bilge is not a receptacle for the detritus of construction. However, it will be impossible to prevent some contamination of bilges during steaming and to clean these we are having some success with detergent washing which enables the resulting mixture to be pumped overboard without offending pollution requirements.

With old ships the problem is monumental. The cleaning of these bilges is quite beyond the capacity of ships staffs unless everything else is subordinated to this job. Detergent washing, as mentioned above, will clear all but the gross deposits ; these will probably have to be removed by hand scraping. It is possible also to degrease after cleaning using a mild solution of degreasing agent. It is possible also that solventless epoxy paints may be applied to a surface not chemically clean. All these things are the subject of trials and, it is hoped, will enable a drill to be formulated in the not too distant future.

Reporting

The reporting of corrosion defects by ships staffs leaves a lot to be desired. There is a strong suspicion that a lot of these defects are not reported at all, being regarded as inevitable. It is accepted that the present method using S.2022, is not ideal for corrosion problems for the simple psychological reason that if one is given a form to fill up, one merely fills up the form. This is no good for corrosion problems which frequently require some knowledge of conditions to give a clue to the failure. For example, a mercurous grease used as a lubricant or in contact with some alloys can have catastrophic effects. Such things can be put into the S.2022 but it is found that an official form usually calls forth official language from the compiler. The Author, in the course of his duty, reads scores of these reports and seldom are any of them of any value except as a plain statement that this or that article has failed. Luckily, most of them are about simple failures, the reasons being readily apparent, but for the minority of reports long correspondence has to be held with the ships concerned.

It is hoped that, if the reader has got as far as this, most of his corrosion defects will have been recognized and the S.2022 will be used merely to report what has been done.