Corrosion Investigation
M.F.V.'Excel'

Consultancy Services Report No. CR12

March 1990

SEA FISH INDUSTRY AUTHORITY

Seafish Technology

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M.F.V. "EXCEL"

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1. INTRODUCTION

In December, 1989 the Marine Survey, Plymouth requested assistance to investigate and identify the cause of corrosion associated with keel bolts and planking nails of the M.F.V. "EXCEL".

The corrosion was noticed during a refit of the vessel which included the installation of a new engine under the Authority's grant and loan scheme.

The M.F.V. "EXCEL" DH16, is a crabber of wooden construction (Iroko planking on oak frames) with a registered length of 50 feet built at Appledore in 1971 for Paignton owners K. Browse and G. Bartlett.

2. INVESTIGATION

The investigation was carried out in two stages, the first stage with the vessel out of the water and stage two with the vessel in the water at her normal moorings on the River Dart and with the machinery and electrical system installed.

2.1 Stage 1

Accompanied by R. Watts, Marine Surveyor, Plymouth, a visit was made to the vessel slipped at Brixham on Wednesday 12th December, 1989.

2.1.1. Keel Bolts

From examination of the galvanised steel keel bolts previously removed from the vessel, it was evident that a small proportion of the bolts which still had patches of the zinc coating intact had suffered only slight rusting and pitting. Of the remainder it was noted that the bolts were severely rusted and heavily pitted.

Inspection of the keel bolt holes were limited to the stern area, as the remainder of the bolts had been replaced before the time of the visit. However, the remaining clear bolt holes were inspected from both inside and outside of the vessel. The internal inspection identified a high moisture content in and around the bolt holes, examination of the holes outside the vessel showed signs of zinc deposits and again a high moisture content.

2.1.2. Planking Nails

A visual inspection of a sample of planking nails removed from the garboard to bilge area prior to the investigation showed all of the samples to be in an advanced state of rusting, also zinc deposits and moisture was present in the nail holes.

A subsequent sample of three nails each in different stages of corrosion from slight to advanced were provided by the Seafish surveyor.

From analysis of the nails under laboratory conditions, a distinct corrosion pattern was observed whereby;-

(i) nail one to which corrosion was limited to a slight narrowing on the flats 40mm from the head;

(ii) nail two which was in an advanced state of corrosion again in the 40mm section from the nail head, with only slight uniform corrosion along the remaining section;

(iii) nail three, of which only 30mm from the head remained, had been subjected to excessive corrosion with ninety per cent metal loss when compared with nail one.

In all cases the corrosion was most severe in the 40mm section from the nail head which is coincident with the thickness of the planking, the section of nail two which is in the oak frames was corroded but the corrosion is considered commensurate with the age of the vessel.

It was also observed that the galvanised coating on nails two and three had been eroded, but in the case of nail one patches of the zinc coating were evident and protecting the steel.

2.1.3. <u>Sacrificial Anodes</u>

The sacrificial anodes, while serving no useful purpose in the protection of the keel bolts and planking nails, were examined and found to be adequate for providing the necessary protection for the vessels underwater fittings. The internal circuit connections from the anode to the protected fitting, while difficult to trace through the absence of a colour coding system, were satisfactory.

2.1.4 Electrical System

The batteries had been removed from the vessel for the refit period, also the new engine and electrical generators were not installed, therefore comments of the electrical system at this stage are confined to the cabling and distribution boxes as installed at the time of the visit.

Visual inspection of the cabling identified shortcomings in the system as listed below:-

(i) There were a number of redundant cables within the system which had been cut short at bulkheads and deckheads. The presence of these cables not only causes confusion when identifying cable runs, but more important is an additional source of combustiable material in the event of fire.

(ii) The cabling in the engine room is primarily of the P.V.C. sheathed type; although the cable fulfils regulatory requirements, it is not flame retardent and offers no resistance to heat and oil contamination. Butyl insulated with a polychloroprene sheath cable is desirable for machinery spaces.

2.2 Stage Two

The second stage investigation was carried out on the 25th January, 1990; the skipper of the vessel, Mr. John Andrews, was in attendance.

2.2.1. Electrical System

The primary task of the stage two investigation was to test the electrical system for the presence of leakage currents which may have contributed to the corrosion of the keel bolts and planking nails.

The measurement technique adopted for the leakage tests was, in simplistic terms, by utilisation of a device designed to measure the effectiveness of sacrificial anodes fitted to the hull of the vessel below the waterline.

The equipment consists of a voltmeter with a positive and negative lead. The negative lead is connected to the vessel's internal fittings which are in contact with the external underwater fittings i.e. propeller shaft and seawater intakes. The positive lead is connected to a silver/silver chloride reference cell.

The system operates by lowering the reference cell into the sea water (electrolyte) which creates an electrolytic cell, in which current flows from the sacrificial anode to the reference cell (the cathode). The current flow is indicated on the meter from which the level of cathodic protection can be determined. Should there be additional current paths as a result of electrical leakage they would also be displayed on the meter.

Several readings were taken with the cell at various locations around the vessel and the negative lead connected to all the fixtures and fittings in contact with the sea water. The tests were carried out with the engine stopped and running with full electrical load applied. No evidence of leakage from the electrical system was observed.

3. CONCLUSIONS

3.1 Electrical System

At the time of the second stage investigation the redundant cabling had been removed and all cabling was adequately secured.

THe use of heat oil and flame retardent cables are not a regulatory requirement, but are advisable for machinery spaces.

No evidence of electrical leakage was observed in the investigation and therefore can be discounted as a contributory factor in the corrosion of the keel bolts and planking nails.

3.2 Nail and Keel Bolt Corrosion

The corrosion of metals in contact with wood is a well known phenomena, both oak and to a lesser extent Iroko form acids by the decomposition of sugars and starches in the wood which can cause corrosion to susceptible metals such as steel, zinc, cadmium and manganese, while copper and bronze are less affected. However, the corrosivity of the acids is reduced in proportion to the duration of seasoning of the wood. As all timbers used in boat building are well seasoned, it is considered that acids may have been present in the timbers, but were not a significant factor in the corrosion process.

The most significant factors in the rusting of both the keel bolts and the planking nails are the ingress of sea water and the erosion of the protective zinc coating.

The use of zinc coatings for protection of steel is a well proven technique, however, the useful life of the zinc in protecting the steel is dependant on the thickness and uniformity of the coating and its surroundings. For example a galvanised nail with a 0.3mm coating (as measured on a sample of the replacement planking nails of the "EXCEL") in a dry atmosphere could have an effective life of around twenty years. In the presence of small amounts of sea water containing dissolved oxygen the effective life would be reduced to approximately seven years, at which point the steel would not be protected and the rusting process beings, again the rate of rusting is increased with the presence of moisture.

From examination of the keel bolts and planking nails taken from the "EXCEL", it can be seen that the bolts and nails which are not corroded have patches of zinc remaining which are protecting the steel. Of the corroded samples it is evident that the rusting is heaviest in the area close to the outside of the vessel, clear evidence of the presence of moisture increasing the rate of corrosion.

An accurate prediction of time at which the zinc ceased to protect the metal and the rusting commenced is not possible. However, it is known that the presence of small amounts of sea water in contact with the metal accelerates the erosion of the zinc coating and subsequently the rusting process. It is also a reasonable assumption to expect timbers of the keel and planking to be dry when the vessel was launched, at which point the zinc coating could be expected to protect the steel for around twenty years, which is coincident with the age of the vessel and ratified by the bolts and planking nails which have a proportion of the zinc coating intact. It is, however, considered from the advanced state of rusting of the majority of the nails and bolts, that corrosion began not less than three years ago. If this is so, it must be assumed that the zinc coating did not have a uniform thickness, which suggests that the bolts and nails which are still protected had the thicker coating.

To predict the time at which the ingress of sea water into the timber became a significant factor in the corrosion process is outwith the expertise of the author, but it is considered to have been over several years. It is more important to consider the present situation, the keel does have a high moisture content, the level of moisture in the planking is relatively low, but as previously stated even damp areas will accelerate the erosion of the protective zinc coating.

What can be said is that moisture will always be present and will most probably increase. The effect of increased moisture will extend the corrosion along the length of the nails and bolts, and significantly reduce the protective life of the zinc coating. It is considered that a period of six to seven years is all that can be reasonably expected from the protective zinc coating, at which time the rusting will recommence.

4. Recommendations

There is nothing that can be done to arrest the corrosion problem, short of the impracticable tasks of exuding the moisture from the wood.

Regular painting with the correct base coat and a compatible top coat will help to repel the ingress of water and should be continued. Nevertheless it is recommended that a sample of nails are drawn for inspection at approximately two year intervals.

When the first signs of rusting are evident, the zinc coating will have lost its protective qualities, at this point early consideration will have to be given to replacing the nails and possibly the keel bolts.

Copper nails and bronze bolts while more expensive than the galvanised steel equivalents, do have significantly enhanced resistance to corrosion by sea water and as such should be considered as an alternative to replacement of like with like. However, if financial restraints exclude this alternative, then an increase in nail size and the thickness of the zinc coating will offer extended protection.

It is understood that the owners of the "EXCEL" have a similar but younger vessel. It would be prudent to inspect a sample of the planking nails and keel bolts from this vessel at the time of the next slipping. This would not only be in the interests of safety, but may also provide valuable data with regard to the rate of the corrosion process.