The TSCF/InterTanko Manual for Best Practice in the Inspection and Maintenance of Tankers

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Abstract

The fragmentation of the shipping industry, and in particular the tanker business, over the last 30 years has led to an increase in the number of companies now operating tankers, many of whom are relatively inexperienced in the special requirements for the maintenance of elderly ships. There is a mistaken belief in some of these companies that it is acceptable practice to rely solely on classification society and third party inspections to identify potential structural problems. Some recent high profile incidents suggest that there is a need for more guidance in the area of Owners'structural inspections. Many regulations and publications on the survey and operation of tankers require that the owner, or his manager, applies "effective maintenance" or "normal maintenance" to the ship's structure. The certificates issued by some Classification Societies state that the ship is classed "subject to normal maintenance". However, when asking different tanker owners what they understood by "normal maintenance" all had their own ideas and it was apparent that there is no internationally accepted concept of "normal maintenance", even allowing for the fact that tankers of different ages and designs will require different approaches to maintenance. The Tanker Structures Co-operative Forum (TSCF) has cooperated with InterTanko to produce a book with the broadest possible input from industry, which can be used by any owner or manager of any tanker afloat as a guide to effective maintenance of the structure. In developing the manual, there were many suggestions for simple measures that could be taken at the design stage to facilitate inspection and possibly reduce the requirement for maintenance. The paper will introduce the manual in general, but focus on those issues of particular relevance to builders and designers.

1 INTRODUCTION

Surprisingly, there is no universally accepted manual of good practice for the inspection and maintenance of tanker structures. Other parts of the tanker industry have produced a safety guide, (ISGOTT), a ship-to-ship transfer guide, a bridge procedure guide and many other publications which have become yardsticks of best practice in their particular field. Although the TSCF has produced many guidance manuals on the inspection and repair of single and double hull structures, these have never before been assembled in a format that answers the question "how do I inspect and maintain a tanker structure?"

High profile tanker casualties have also caused charterers, P & I clubs and hull insurers to take a greater interest in the condition of the tankers in which they have a financial interest. Different charterers and different P & I clubs have taken different, and sometimes conflicting, approaches to the protection of their interests, to the frustration of the owner. There is therefore an urgent need for an industry consensus on what constitutes acceptable maintenance, into which all stakeholders in the industry can buy.

The Tanker Structures Cooperative Forum (TSCF) has therefore collaborated with InterTanko to produce recommendations that are backed by the industry's principal owners, charterers and classification societies.

2 OVERVIEW OF THE MANUAL

2.1 Input to the Manual

The guidance covers only maintenance of the hull structure (including coatings), main pipelines and rudder, emphasizing that this is a responsibility of the owner. There are requirements in the rules of all the classification societies for various routine inspections, and the ISM code and MARPOL (CAS surveys) also influence the timing and extent of inspections. Nevertheless, the prime responsibility for timely inspection and repair of the hull structure remains with the owner, or the management company if he has appointed one. This responsibility can only be properly discharged by the establishment of a programme based, however loosely, on a risk assessment. The Manual refers to this programme as the Inspection and Maintenance Plan (IMP). Factors that need to be considered in the IMP include:

- Results of any analysis done during the design process
- Areas where failure could have a serious consequence
- Ship's age
- Experience

The last item, "experience", is probably the most important. It covers not just past experience with similar ships when setting up the IMP, but also means that experience with the results of the maintenance plan should be fed back to modify the frequency and intensity of inspections. For example, a fracture might be found at the 10-year survey in an area that was not even analysed at the plan approval stage. The IMP should be modified to require immediate inspection of similar details and follow up monitoring of whatever repair is applied. For this reason the IMP has to be a "living" document, reactive to new information.

2.2 Typical Defects

Chapter 3 of the Manual contains an overview of typical defects found in Tanker structures. This is effectively a resumé of information and advice published in previous TSCF manuals. Nevertheless, it is a useful reminder of the hazards we are trying to avoid in our designs (corrosion, fatigue fractures, pitting, buckling etc).

2.3 Inspection Programmes

Chapter 5 is really the "meat" of the Manual. It describes three inspections, of varying intensity, that owners need to carry out:

- General Condition Surveys
- Detailed Condition Surveys
- Repair Specification Surveys

The purpose of the General Condition Surveys is to check the overall condition of a space and report any unusual or unexpected observation. They are usually carried out by the ship's staff, but the other two should be carried out by trained inspectors.

Guidance is given on the frequency with which the tanks and spaces on a tanker should be inspected, ranging, for example, from twice a year for ballast tanks, to once every five years for bunker and cargo tanks.

Methods of inspection are also covered. Despite the requirement for Permanent Means of Access (PMA) for inspection, most owners have their own ideas of how they want to inspect the structure, which are not always fulfilled by the PMA requirements. Access for inspection is therefore still a design issue. Builders need to liaise with owners on their specific requirements, whether these be provision for suspended platforms, rafting, or simply wider stringers or longitudinals with guard rails.

This chapter also gives detailed guidance on what to look for in the various different tanks of a tanker. For example, the guidance for a cargo tank is:

- Corrosion and fractures in the vapour space at the top of the tank (due to sun on deck, corrosive I.G. and cargo vapours).
- Necking of deck longitudinals at weld to deck plating.
- Pitting of the upper surfaces of horizontal structure and of bottom plating.
- Microbial induced corrosion of the bottom plating
- Fractures in web frames in way of longitudinal penetrations
- Check for fractures at bulkhead stringer/longitudinal connections
- Weld at the sloping hopper connections at mid tank length.
- Erosion under suctions
- Condition of pipework valves and fittings
- Bottom and Side Shell for contact damage
- Condition of access structure (ladders and platforms etc.)

The chapter concludes with a section on acceptance criteria, specifically for pitting corrosion.

2.4 Repairs

Chapter 6 deals with repairs and, again, is a resumé of recommendations contained in previous TSCF publications. However, the question of the benefits of repairs carried out afloat and on voyage versus deferral until a visit to a shipyard is dealt with, since techniques for afloat repairs are advancing all the time. Detailed guidance (based on Classification Society guidance to surveyors) on specific repairs such as insert plates (also relevant to closing plates during the construction process) is also included.

2.5 Coatings

Coatings have been given a chapter of their own, in view of their increased importance in ship longevity today. Tanker owners are apprehensive about the life of coatings in the double hull ballast tanks, since blasting and re-coating of these areas would be a costly and hazardous operation, potentially determining the economic life of the ship.

Chapter 7 is a useful “primer” for anyone wanting a quick guide to marine coatings, covering organic and inorganic coatings, what they are, where they can be used and why they fail. All this is relevant to the design process.

There is also advice on the inspection and maintenance of coatings, much of it driven by the IACS definitions of “Areas under consideration” and “Good”, “Fair” and “Poor” conditions.

3 DESIGNING FOR EASE OF INSPECTION AND MAINTENANCE

3.1 Use of Higher Tensile Steel

It will come as no surprise for shipbuilders to hear that owners are, at best, cautious over the use of higher tensile steel. There is obviously a place for it in the top and bottom flanges of the main hull girder but extensive use in transverse structure can lead to greater maintenance.

The thinner plating allowed by the use of higher tensile steel results in greater flexing under both static and dynamic loading conditions. This is suspected to be a cause of coating cracking and detachment from the flexing steel, especially on internal bulkheads. The extent of this problem as well as the compatibility of paint coatings / attachment / adhesion characteristics to the flexing of the steel is an area where a substantial amount of study is still required. The exact deflection and fatigue characteristics of the paint film attached to a moving steel surface are not yet quantifiable and it is advisable to aim to limit defections of coated steel where a premature failure could have serious consequences.

Arguments about the corrosion and fatigue properties of higher tensile steel are already well rehearsed and provide further grounds for owners’ reluctance to accept its widespread use.

3.2 Cargo Tank Corrosion Problems

Historically, tankers have experienced the most corrosion on the underside of deckheads and on the tank bottom in cargo tanks. Originally this was found on single hull vessels but is also being experienced on double hull vessels. In the double hull the general warming of the tank and hence the possibility of more corrosion especially on the deckhead has been attributed to the insulation effect of the double hull. Sulphur carry-over from the I.G. system is another potential source of corrosion to cargo tank structure. Sulphur dioxide reacts with water in the scrubber to form sulphuric acid, extremely corrosive to unprotected steel. Recently the damaging effect of CO_2 corrosion from IG systems, in particular those based on combustion exhaust gases, has been identified as a cause of concern.

In early double hull vessels there were some rather spectacular cases of corrosion on the deckheads which have not been fully resolved. However, a salient factor was that there was no paint coating on the steel at all. Even the shot blast primer had not been applied. Whilst shot blast primer is not designed to be a proper corrosion protection system, it is generally regarded as providing a holding coat until the first cargo is loaded. Thereafter an oil film attaches to the steel and provides a coating to combat corrosion. It is therefore recommended that cargo tanks should have at the very least a full coating of shot blast primer at the building stage.

The prudent owner is advised to provide protection against pitting corrosion on the cargo tank bottoms, as described in Chapter 3.1.1 (b), by measures such as coatings to the tank bottom and deck head. However, coating of the tank bottoms has proved a problem in shipyards where the fabrication process means that this coating is damaged during erection and its initial integrity reduced. Constant touch up in a shipyard is never very effective as it is often carried out at the last minute in atmospheric conditions which are not conducive to good adhesion and curing.

It is good practice to provide an additional corrosion margin to the plating on the deck head and tank top above that provided by Class rules. Additional factors to consider are the facts that the designer calculates the Rule scantlings after which the thickness figure is rounded down to the nearest 0.5mm. This coupled with use of the maximum tolerance of the rolling margin which is typically about 0.3mm, can result in a loss of 0.5mm in thickness compared with the Rule figure.

Coating of the horizontal stringers on the transverse bulkheads will be a very effective means of avoiding renewals in later life of the vessel. Efficient drainage of these areas is paramount to reduce sediment build up and hence corrosion. However, experience has shown that additional corrosion margins or coating can be very cost effective. It should also be recognized that it is the corners of the stringers against the longitudinal bulkhead which have the highest fatigue loading and also have no openings for drainage in order to improve fatigue durability.

3.3 Inspection of cargo tanks

The IMO Regulations for Permanent Means of Access (PMA), in general provide a very effective means for inspection in a dry tank. However, there are still areas of the tanks that cannot be reached for close up inspection and require the use of rafting. The deck head cannot be viewed completely from the PMA routes. For cargo tanks fitted with swash bulkheads, openings need to be provided in the upper regions of these bulkheads for passage of the raft along the tank.

Two access routes to each cargo tank are required. The typical arrangement is for the aft access to lead down through the stringers on the aft bulkhead whilst the forward bulkhead is provided with a set of vertical ladders on the plane side. There is a great benefit in providing sloping ladders on the forward bulkhead as this permits a larger area to be inspected as well as providing a safer means of access.

Recent structural failures on VLCC's have led to the fitting of horizontal brackets on the aft side of the transverse bulkhead at its attachment to the wing longitudinal bulkhead to provide fatigue loading durability from deflection of the side structure. Access to these brackets will only be possible by rafting or extension of the bulkhead access routes and it is important to consider this at the design stage.

Whilst the bottom of the cargo tank is now very open in the double hull tanker, there is often considerable sludge build up against the transverse brackets and webs on the inner bulkheads. The provision of large drainage holes is paramount, taking account of the fatigue performance of the bracket; the outer part of the bracket is subject to very high loads and is often inserted with HT steel. The upper toe of these transverse brackets also is highly loaded and a permanent means for inspection is advised via a vertical ladder.

Drainage of cargo tanks in the after bays is often provided by means of a sump set into the inner bottom. This sump must have large corrosion margins built in with a good coating. Welds need additional attention as well as local structural detailing.

3.4 Inspection and Maintenance in Ballast Tanks

3.4.1Ventilation

On double hull tankers the side shell area is accessible from the side stringers. With the PMA rules requiring an inspection level every 5m it is sensible to provide full stringers at this spacing.

The double bottom area presents hazards to the inspector in terms of provision of a safe atmosphere. The multitude of cells impedes the flow of air such that gas pockets can remain undetected prior to entry. It is common practice to only sample the atmosphere at the top and bottom of the tank from the access hatch. It should also be borne in mind that sediment accumulates in ballast tanks, often from mud ingested in shallow berths in rivers which contain many noxious substances which can be another potential source of gas in the ballast tanks.

To provide a safer environment the bays or cells of the tanks should be opened up as much as possible to improve flow of air coupled with a means of providing an efficient distribution of air in the tank. Opening up of the vertical floors and girders in each bay also aids access in these spaces for inspection. The horizontal stringers should be treated in a similar way with openings in each bay for ventilation as well as drainage - typically openings 600 x 800mm in each bay on an Aframax tanker. These openings have to be fitted with grid bars welded sufficiently close to prevent an inspector's leg from falling through.

Emergency evacuation of an injured person from a ballast tank is an important consideration especially in view of the poor air flow found on many designs. One typical arrangement is to provide a vertical lift at about mid tank length with the opening on each stringer fitted with guardrails and kick bars around its edge. A bolted plate suitably marked is provided on the upper deck with provision for a powered davit.

Air distribution in the tank can be improved by using the IG fan to blow fresh air into the ballast lines. The connection of the IG fan to the ballast line can be carried out by a portable spool piece in the pump room. Another alternative is to provide a fan on deck passing air down a purge pipe leading from the upper deck down round the bilge and to the centerline with many outlets in the lower leg to provide air distribution longitudinally. Generally the most thorough ventilation of a tank is achieved with a deep aft or fwd end ventilation inlet and the farthest away deck opening for the exit ventilation. Having more than one deck opening for ventilation outlets will likely result in "short circuiting" of the ventilation. Computer models of these arrangements, such as "VENT2D" (freely available), can be made to optimize the air distribution. The various papers associated with VENT2D discuss this and show the results of various experiments and calculations.

3.4.2 Access

A practical measure to aid the inspection team in the ballast tanks is the provision of frame number markings close to the access routes.

The PMA rules require a means of inspection of the underside of the upper hopper knuckle and this is often provided by means of an extended side shell longitudinal about 2-3m below the lowest stringer. For larger vessels this does not provide hands-on inspection of the knuckle weld and an additional transverse walkway is required on the web frame which is led from the longitudinal access route. An effective alternative means of access is an elevated walkway passing through the web in the bilge area. Whilst this will provide closer inspection it does provide additional problems in corrosion and possible vibration. However, it does provide a very quick and simple access route in the tanks which will also aid the removal of injured people from the double bottom area.

3.4.3 Drainage

The use of T bars for the longitudinal stiffeners in the band covering the load and ballast waterlines is now common on larger tankers for fatigue performance but the fitting of adequate drain holes on these members is paramount. Fore and aft drainage is obstructed by the web frames and it is tempting to put drain holes in the webs of the longitudinals just forward of the web frame. But fitting of drain holes in the web of the longitudinals must be kept well clear of the web connection.

Designers often overlook efficient drainage of the whole of the bottom of the ballast tanks, which can impair inspection. The emphasis is put on the bay adjacent to the strum that can lead to blockage further forward and to the sides. Common practice is to fit the ballast strums close to the centerline. However, there is a case for fitting several strums to improve the drainage distribution.

3.4.4 Preparation for Coating

Experience with corrosion in ballast tanks has been concerned with coating defects, often originating from poor preparation. The most common defect has been in the erection butt touch up areas where shipyards often prepare the surface after erection welds have been completed by using disc power tools which remove the surface profile which is essential for good coating adhesion. The prevention of blasting in the dock is usually cited as the reason for this. It can only be overcome by portable vacuum blast units or a coating that is surface tolerant.

Edges of stiffeners also experience premature breakdown. Whilst the use of stripe coats is often effective these can be applied too thickly with questionable benefit. There is no substitute for rounding of edges in the shipyard prior to coating. The three pass grind standard is now common practice in shipyards but the specification of this standard needs careful planning; often a sample is the only means of defining this degree of rounding. Three pass grinding is a very labour intensive operation and shipyards may quote a large extra cost for this.

A further coating breakdown problem concerns over-thickness of paint such that it cracks from structural deflection leading to early corrosion. Specifications need to describe tolerances in both under and over-thickness and appropriate monitoring measures implemented. Again, certain paints are more tolerant in flexibility from excessive thickness.

Experience so far indicates that the use of pure epoxy paints with abrasion protection properties due to aluminium flakes in the sub-structure provide the greatest durability. The abrasion protection is important in the shipyard environment. Inevitably these paints are very much more expensive than the conventional modified epoxies which are commonly used.

4 INSPECTION AND MAINTENANCE DOCUMENTATION

The Inspection and Maintenance Plan will almost certainly be a computer-based system, tailored to the owner's specific requirements. Appendix 2 of the manual contains an example of a typical IMP and the information necessary for a complete record of the maintenance of any space. Much of this information is diagrammatic, and shipbuilders can assist by making this available to their customers. The manual recommends that, for each space to be included in the IMP, the ship is provided with:

- Information on the corrosion protection (if any) originally provided
- Recommended frequency of survey
- Location of details that require detailed condition survey
- Means of access to details that require detailed condition survey
- Recommended route through the space for general condition surveys
- Pro-Forma report for general condition surveys

A Data Sheet for each space is a convenient way of recording some of the above information:

No. 5 Wing Ballast Tank, port, Frames 24 to29
General condition survey twice annually

Coating: 2 x 250 microns Jotun Balloxy. No anodes

Access: Permanent ladders in place

Notes: Detailed Condition Survey to cover the following:
Check fractured web fr 26 at side shell long 10.
Coating blistered on longl bhd frs 25 to 28 at longls 3 to 5
Coating lifting under suction
Corrosion starting at all deck longls iwo fillet welds to deck plating

Fig. 1 Typical Data Sheet for a Ballast Tank

The results of FEM analysis should be used by the owner to plan the locations subjected to detailed condition surveys:

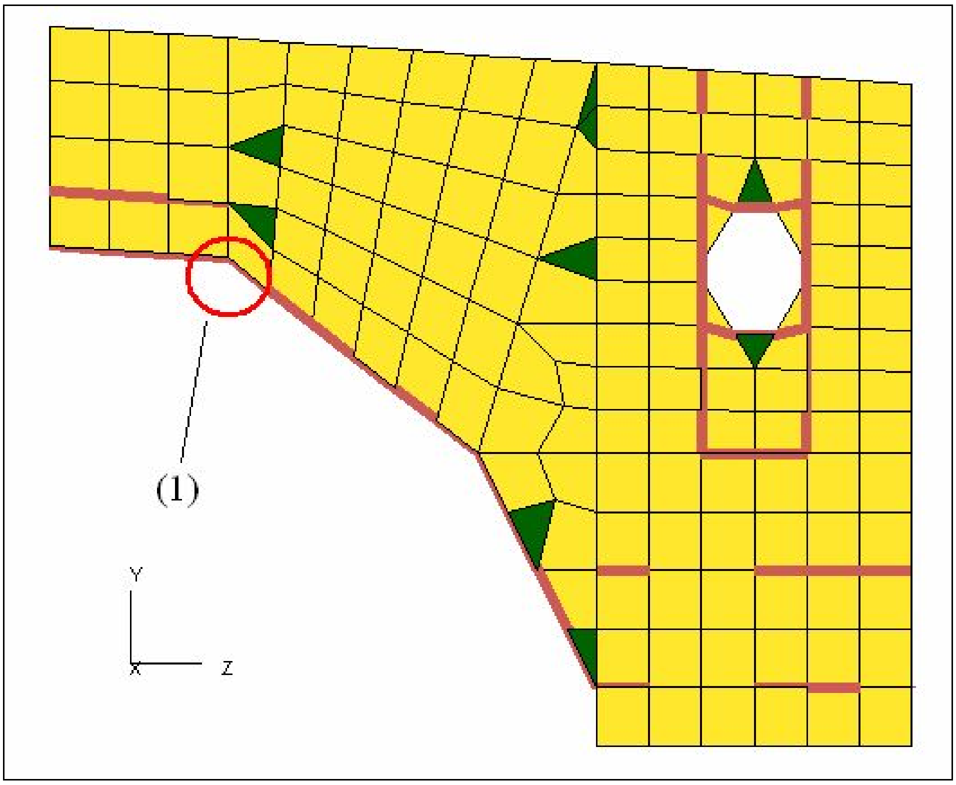

Fig. 2 Typical FEM result used for Detailed Condition Survey

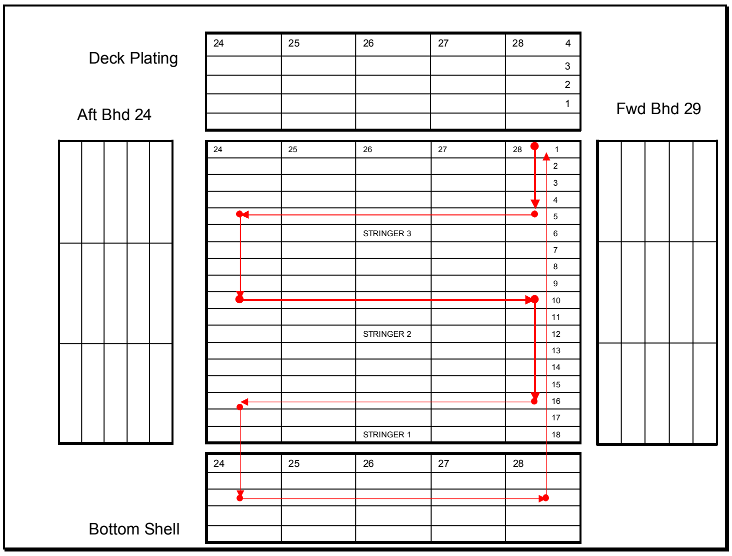

Fig. 3 Typical diagram for route for General Condition Survey

Figure 4 is an example of a typical report for a general condition survey in a ballast tank.

<table>
<tr><td colspan="8">4. Ballast tanks</td></tr>
<tr><td colspan="8">General identification data</td></tr>
<tr><td colspan="8">Person responsible B Inspector</td></tr>
<tr><td colspan="5">Date of inspection 4/07/07</td><td colspan="3">Place of inspection At sea</td></tr>
<tr><td colspan="5">Name of ship Tanker A</td><td colspan="3">Location (port/stbd, from frame … to frame …) No.2 port tank 24 - 29</td></tr>
<tr><td colspan="8">Summary of finding and repairs for the different areas and fittings in this space (Note 1)</td></tr>
<tr><td>Items in the area</td><td>Coating/ anode condition</td><td>Fractures</td><td>General corrosion</td><td>Pitting or grooving</td><td>Deformations</td><td>Repairs</td><td>Other</td></tr>
<tr><td>Floor plating</td><td>Good</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Centreline Girder</td><td>Good</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Double bottom girder at x mm from CL</td><td>Good</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Double bottom girder at x mm from CL</td><td>Good</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Double bottom girder at x mm from CL</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Horizontal girder at x mm above BL</td><td>Fair</td><td>No</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Horizontal girder at x mm above BL</td><td>Fair</td><td>No</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Horizontal girder at x mm above BL</td><td>Good</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Vertical web frames</td><td>Good</td><td>Yes</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Bottom plating</td><td>Fair</td><td>No</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Bottom longitudinals</td><td>Fair</td><td>No</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td></td></tr>
</table>

Inner bottom plating	**Good**	**No**	**No**	**No**	**No**	**No**	
Inner bottom longitudinals	**Good**	**No**	**No**	**No**	**No**	**No**	
Side shell	**Fair**	**No**	**Yes**	**No**	**No**	**No**	
Side longitudinals	**Fair**	**No**	**Yes**	**No**	**No**	**No**	
Inner hull longitudinal bulkhead	**Good**	**No**	**No**	**No**	**No**	**No**	
Inner hull longitudinals	**Good**	**No**	**No**	**No**	**No**	**No**	
Hopper plating	**Good**	**No**	**No**	**No**	**No**	**No**	
Hopper longitudinals	**Good**	**No**	**No**	**No**	**No**	**No**	
Deck plating	**Good**	**No**	**No**	**No**	**No**	**No**	
Deck longitudinals	**Good**	**No**	**No**	**No**	**No**	**No**	

(1) Answers for: Summary of findings and repairs

- Coating condition: the answer is to be either “no coating”, or “good”, or “fair”, or “poor”
- Anode condition is to be answered by giving an estimated average loss of weight as a percentage
- The other columns (fractures, general corrosion, pitting/grooving, deformations, repairs) are to be answered “yes” or “no”, depending on whether or not such defect/repair has been found/performed.
- The column “other” is to be used to indicate whether another type of inspection has been carried out, such as thickness measurement, pressure test or working test.

Fig.4 Typical report of General Condition Survey

Few owners have the facilities to produce all this documentation, whereas builders are ideally placed to offer a pro-forma IMP as part of their supply. We would therefore encourage all builders to study the manual, particularly Appendix 2, and offer to produce this documentation, preferably in electronic format.

5 CONCLUSION

This latest publication of the TSCF gives guidance on a methodical approach to maintenance of the structure of tankers. It is the first time the Forum has collaborated with InterTanko on one of its publications, which thus has the backing of the major classification societies, charterers and tanker owners. Although aimed principally at other tanker owners, there are many useful sections on access and design for ease of inspection and maintenance that are relevant to designers and builders.

Much of the documentation required for the Inspection and Maintenance Plan is beyond the capability of the smaller tanker owner to produce, and the industry looks to the shipbuilding industry to support it in its efforts to improve maintenance by providing their customers with all the information necessary to establish a comprehensive and rationally based Plan.