THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
601 Pavonia Avenue, Suite 400, Jersey City, New Jersey 07306 USA
Paper presented at the Marine Structural Inspection, Maintenance, and Monitoring Symposium
Sheraton National Hotel, Arlington, Virginia, March 18-19, 1991

Inspection and Structural Maintenance of Chevron's Tanker Fleet

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ABSTRACT

The condition of the structural steel, particularly in the ballast tanks, is generally the most important parameter governing the economic life of a tanker. A tanker owner has considerable leeway in planning and carry out his program to maintain this structure. He must, of course, meet the minimum requirements of a classification society in order to keep the ship's certificates in force. However, the classification society only sets standards for the condition of the ship and does not dictate how the ship should be maintained.

If an owner plans to safely operate a ship for 20 years or longer and at the same time minimize maintenance costs over the life of the ship, he must establish a comprehensive maintenance program. Chevron has developed such a program which consists of inspection and gaugings beyond what is required by the classification societies, a computer system to assist in handling and interpreting the resulting data, and a maintenance program aimed at obtaining high quality repairs at a competitive price. This program has enabled us to economically achieve a high level of maintenance in our tanker fleet.

INTRODUCTION

The popular press often refers to a tanker's life as being somewhere between 15 years and 20 years--the implication being that a tanker older than this is about to fall apart and is a danger to the environment. If this were the case and it was impossible to properly maintain tanker hulls for more than 20 years, it would apply equally well to other steel structures serving in a marine environment and the 52-year old Golden Gate Bridge should have been replaced years ago. The actual safe, economic life of a tanker is determined primarily by the maintenance of the ballast tanks. A properly maintained tanker, with particular emphasis on the ballast tanks, can be operated safely and economically well beyond 20 years.

Virtually every ship is classed by a classification society which signifies that the ship was designed and built and is being maintained to certain minimum standards of the classification society. However, this does not imply that the ship can be economically operated for any minimum number of years or that it is being maintained in the most economical manner possible.

This paper focuses on the

maintenance of the structural elements of tankers. It briefly reviews the role of the classification societies, which set the minimum standards of a maintenance program; and then describes in some detail Chevron's more extensive tanker hull maintenance program. This program includes frequent and extensive inspection and gaugings, a data-base system to facilitate the data handling and analyses, and a maintenance program designed to accomplish high-quality repairs on a timely and economic basis.

ROLE OF THE CLASSIFICATION SOCIETIES

The rules of the classification societies leave an owner a wide degree of latitude in maintaining a ship (Ref 1). The reason for this can be found in the basic nature of these societies. The first of these societies was established in the 18th century by insurance underwriters. They were founded to provide an independent agency which would certify that a ship was in adequate condition to be an acceptable insurance risk. Over the years, the number of societies has proliferated. The principle ones are ABS (The American Bureau of Shipping), Lloyd's Registry and Det Norske Veritas.

To carry out their function, the classification societies develop rules (Ref 2) for the design, construction, and maintenance of ships and certify that the ships which they "class" meet these rules. Specifically, once engaged by an owner to classify a prospective ship, the classification society reviews the shipyard's design to assure that it conforms to its rules. Next, its surveyors inspect the ship as it is being constructed, and, provided the construction also conforms to its rules, the classification society issues certificates to the ship at the time it is delivered to the owner. These certificates are needed for the owner to obtain insurance coverage for the ship and its cargo. Over the life of the ship, the classification society's surveyors will periodically inspect it. If the condition of the ship continues to satisfy the rules, the society renews the ship's certificates. If the condition of the ship has deteriorated beyond the minimum acceptable level, the surveyor will advise the owner as to what repairs are required and will inspect the repairs once they are completed.

It should be kept in mind that the classification society requirements are minimum requirements for building and maintaining a ship. The rules are established by technical committees which are composed primarily of representatives of the ship owners, equipment manufacturers, shipyards, as well as regulatory agencies. For example, the U.S. Coast Guard is a member of the ABS Technical Committee. As a result, the rules represent a compromise on the part of the various parties involved. The rules do not address the expected life of a ship or dictate an optimum maintenance philosophy but, rather, specify minimum conditions which must be met if the ship is to retain its certificates.

INSPECTION--THE KEY TO PROPER MAINTENANCE

Once a ship is delivered, the inspection program begins and continues for the life of the ship (Ref 3). The typical classification society's hull inspection and maintenance criteria can be summarized as follows:

1. Surveys of the structure are completed in five year cycles called special surveys. Each successive special survey period has progressively more rigorous inspection criteria included in the requirements (Figs 1 & 2).

2. NDT (non destructive testing), i.e., ultrasonic gauging, is required of various structural members at each special survey to check the hull girder strength. With each succeeding special survey, the number of circumferential bands gauged increases to encompass specific areas such as ballast tanks.

3. Close up inspections of selected tanks are increasingly required as the ship ages.

4. Classification societies set maximum wastage limits for various parts of the hull structure and require that these limits be met at the time of the inspection for the certificates to be renewed.

Most ship owners carry out the inspection and gauging required by the classification society during the vessel's shipyard overhaul.

CHEVRON'S HULL INSPECTION PROGRAM

Chevron's goal is to ensure that it knows the condition of the hull structure at all times (Ref 1). To accomplish this, we expand upon the classification society requirements as follows:

1. Visual inspection is made and where warranted gaugings are taken in areas not required by special survey. This allows identification of corrosion wherever it may occur and the recognition of developing trends.

2. Between required inspections, tanks are cleaned and inspected on ballast voyages. All structural members are inspected for corrosion, stress cracks, buckling and necking. Rubber rafts are used in tanks partially filled with water so that a close up inspection can be made of the under deck area. If an abnormality is found, the inspection activity is increased on sister ships to determine if a similar situation exists.

3. Gaugings for special surveys are taken well before shipyard periods to facilitate planning for overhauls

4. In house wastage limits have been established which are more conservative than those of the classification societies to ensure that the wastage between survey periods does not significantly exceed the classification society's limits.

5. The same gauging contractors are used repetitively to ensure they are familiar with the ships and Chevron's requirements and standards.

Tank bottom pitting is another type of corrosion found in tankers. It is particularly a problem on older non-segregated ballast tankers. On the Chevron tankers of this vintage the bottoms of the swing tanks, which are used alternately for cargo and ballast, were coated at the time of construction. In these tanks a pinhole size coating failure exposes the underlying metal. The metal acts as an anode and slowly wastes. The result is an inverted conical pit. While these pits do not typically threaten the ship's structural strength, they do pose a threat of causing oil pollution. Therefore, we expend considerable effort to find these pits and repair them before they hole through the platting.

As part of the preparation for a shipyard overhaul, all tanks must be cleaned and the residue removed. In addition we hand mop the coated tank bottoms and inspect for pits. Each pit found is measured and marked with spray paint. A diamond is painted around the deeper pits. During the overhaul the shallower pits are repaired by filling with an epoxy pit filler. The deep pits are repaired by welding and recoated.

DATA HANDLING AND ANALYSIS

The procedures for collecting, handling and interpreting, gauging and inspection data have remained little changed over the years. An ultrasonic gauging team of two to four men would board the vessel, take gaugings in the tanks, record them in a notebook, and then at the end of the day, transpose them to a draft report. It generally takes two to three weeks to complete such a survey.
After leaving the ship, the team would return to their office and again transpose the data, combine it with drawings and photographs that had been taken and prepare a final report which would be sent to Chevron. One of our naval architects would sort through the data and compare the gauging readings with the original thicknesses and wastage allowances. He or she would then decide what steel should be replaced and what should be coated, and manually prepare the periodic overhaul specifications and drawings.

Over the years, a library consisting of inspection reports and repair records for each vessel in the fleet has been accumulated. This library provides voluminous amounts of information which could be used to evaluate trends in corrosion development. However, the time required to sort through the data and analyze it is a deterrent to using it for this purpose.

Several years ago, Chevron decided to develop a computer system which would simplify the recording and handling of the gauging and inspection data. Together with Ocean Systems, a software development company located in Houston, Texas, we developed a PC-based computer system called CATSIR (Computer Aided Tanker Structure Inspection and Repair) which combines a data base program and AUTOCAD, a computerized drafting program. Inspection information and gauging data are entered into the CATSIR database by the gauging team personnel while they are on the ship. The hull structure drawings, together with the steel grade and original thickness for each element of the structure, are stored in the AUTOCAD program.

The naval architect who is interpreting the gauging data and deciding on the maintenance required can display the structural drawing for any part of the ship's tank structure on the computer screen (Fig 3). Annotated comments with the display contain the general inspection information. The gauging data itself is annotated at the appropriate location on the drawing (Fig 4).

If the naval architect decides coating needs to be replaced in a certain area, he can outline the area with a cursor and the program will calculate the number of square meters of coating required. Alternatively if he decides that part of the structure should be renewed, the computer will calculate the number of pounds of steel required (Fig 5). The data base is then updated to include the required repairs.

CATSIR has the following advantages:

1. It improves the productivity of the gauging team by eliminating the draft report and simplifying the final report. The final report consists of a floppy disk containing the gauging information and the comments regarding the vessel inspection.

2. It improves repair planning productivity by eliminating manual writing of the steel repair specification and by automatically calculating steel quantities and coating areas. It also eliminates manual drafting of repair drawings and provides the capability to quickly update repair specifications and drawings in the field.

3. It enhances the efficiency and quality of the inspection and repair. The inspection team and the repair team can both communicate with

the home office naval architect, transmitting copies of the information contained on the floppy disks via satellite communications. Naval architects in the home office can then participate in decisions to modify the inspection program or to change the repair specification.

4. CATSIR provides a "one-stop" data bank for all of the tanker structural maintenance data. The analyses of trends is facilitated by sorting data in the data base to collect and display gauging data, which has been obtained over a number of years, from the same location.

CARRYING OUT THE REPAIRS

The final element in the maintenance program is the repair activity itself. Chevron's primary objective is to protect the crew, the ship, the cargo, and the environment at all times. Our goal is to have zero injuries and zero spills of oil into the ocean. Within this constraint, we make our maintenance decisions on the basis of minimizing the net present cost of the total maintenance expenditures over the expected remaining life of the ship. This often means that our maintenance expenditures are out of step with those of the rest of the industry. For example, in the early to mid-1980s when the shipping industry was going through a severe recession, most ship owners restricted their maintenance expenditures to the absolute minimum. Throughout that time period, we continued to base our maintenance decisions on minimizing the total net present cost of anticipated future expenditures. This meant that we were spending several hundred thousand dollars per ship for coating and steel work when others were spending merely tens of thousands of dollars or even less per ship for these repairs. Now that the shipping industry is profitable again, most owners would like to continue to run their existing ships until they are 20-30 years old (Ref 4). However, because they deferred maintenance in the early to mid 80s, many are now having to spend five to ten million dollars per ship on steel and coating work to extend the lives of their ships. On the other hand, Chevron's expenditures on steel and coating repairs for life extension of similar ships are a million dollars or less per ship.

The best inspection program and preparation for an overhaul will be negated if the they are not followed by quality repairs. Historically Chevron along with most of the industry has operated on a competitive bid approach in which the overhaul is awarded to the shipyard submitting the lowest bid adjusted for positioning costs. The bids were generally based upon a partial description of the work required. The overhaul was then carried out on a quasi-adversarial basis in which we attempted to minimize the costs to complete the work and the shipyard attempted to maximize its profit.

To improve the quality of the repair work upon its vessels, Chevron has entered into partnering relationships with three shipyards: Jurong Shipyard in Singapore; Lisnave Shipyard in Lisbon, Portugal; and West State Incorporated in Portland, Oregon. Each shipyard and Chevron are committed to producing the highest quality work at competitive costs through effective use of planning and new technology.

Since better than 50% of the overhauls are conducted by Jurong, Chevron has stationed several of its personnel in the Jurong Shipyard. The shipyards, in return, have dedicated specific individuals to the overhaul of the Chevron ships.

Each of the shipyards has the CATSIR program so that information regarding the steel and coating work is submitted via computer disk. The shipyards can use the CATSIR program to produce drawings for the repair shops indicating where steel is to be renewed and coating replaced. This allows the yard to plan the work before the ship arrives so as to minimize interference between crafts.

To further improve the quality of the overhaul and the productivity of all involved, Chevron and the three shipyards are jointly developing a PC based specification generation program called SPEC GEN. Each job normally conducted by the shipyard during an overhaul is described in the programs database. The data base is subdivided by class of ship so that nameplate data and drawing references can be included. Agreed-to pricing information is included so that the shipyard's commercial section can use the program to develop the final invoice. The commercial section of a shipyard has access to only its pricing data and the production shops only have access to the technical data thus preserving confidentiality of the commercial data.

CONCLUSION

In conclusion, it can be said that while the classification society rules and requirements may be adequate to ensure that a ship is a reasonable insurance risk, they cannot be used as a guide for a maintenance program which will ensure a ship can be operated for an extended number of years at a reasonable cost. This objective can only be met by: 1) carrying out a program of frequent, thorough inspection and handling inspection and gauging data in a manner that facilitates good decisions; and 2) conducting a maintenance and repair program which is not side tracked by fluctuations in the charter market, but, rather, is aimed toward minimizing the net present value of maintenance costs over the life of the ship. Finally, a cooperative program with the repair yard which is aimed at producing high quality repairs is essential to obtaining the desired results.

References:

1. R. A. Ternus, Royal Aeronautical Society's Safety at Sea and in the Air - Taking Stock Together Symposium, "Inspection and Maintenance of the Chevron Tanker Fleet," November 1990.

2. "Rules for Building and Classing Steel Vessels," American Bureau of Shipping, 1990.

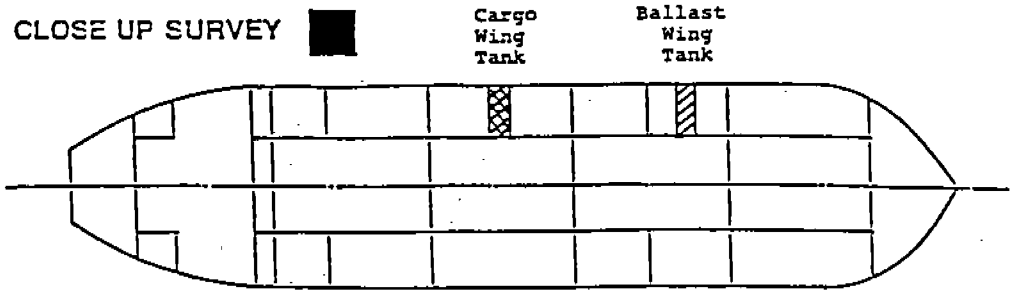
3. "Guidance Manual for the Inspection and Condition Assessment of Tanker Structures," International Chamber of Shipping and Oil Companies International Marine Forum, 1986.

4. "Oil Tanker Design and Pollution Prevention," International Chamber of Shipping - Oil Companies International Marine Forum - International Association of Independent Tanker Owners, May 1990.

SPECIAL SURVEY No. 1 AGE ≤ 5 yrs.

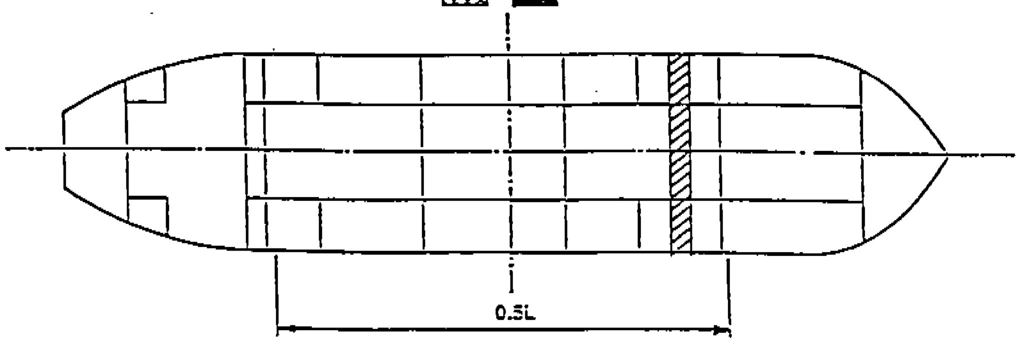
OVERALL SURVEY: ALL TANKS & SPACES

CLOSE UP SURVEY



- One complete transverse web frame ring
- One deck transverse
- Bottom structure

THICKNESS MEASUREMENTS

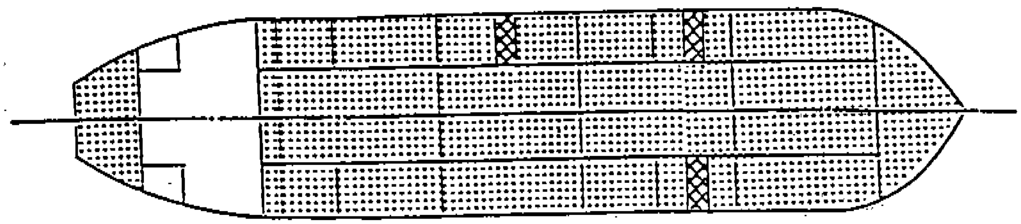


- Each deck plate
- Sufficient measurements of structural members subject to close up survey for general assessment of corrosion pattern
- Suspect areas

SPECIAL SURVEY No. 3 10 < AGE ≤ 15 yrs.

OVERALL SURVEY: ALL TANKS & SPACES (Major Items)

CLOSE UP SURVEY

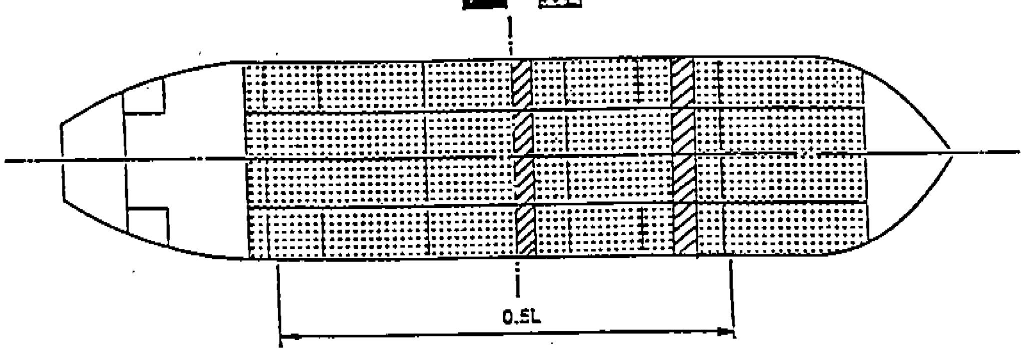


All complete transverse web frame rings (all ballast tanks and one cargo wing tank).

Bottom structure in all cargo and ballast tanks

Transverse and longitudinal bulkhead girder system in all cargo and ballast tanks

THICKNESS MEASUREMENTS

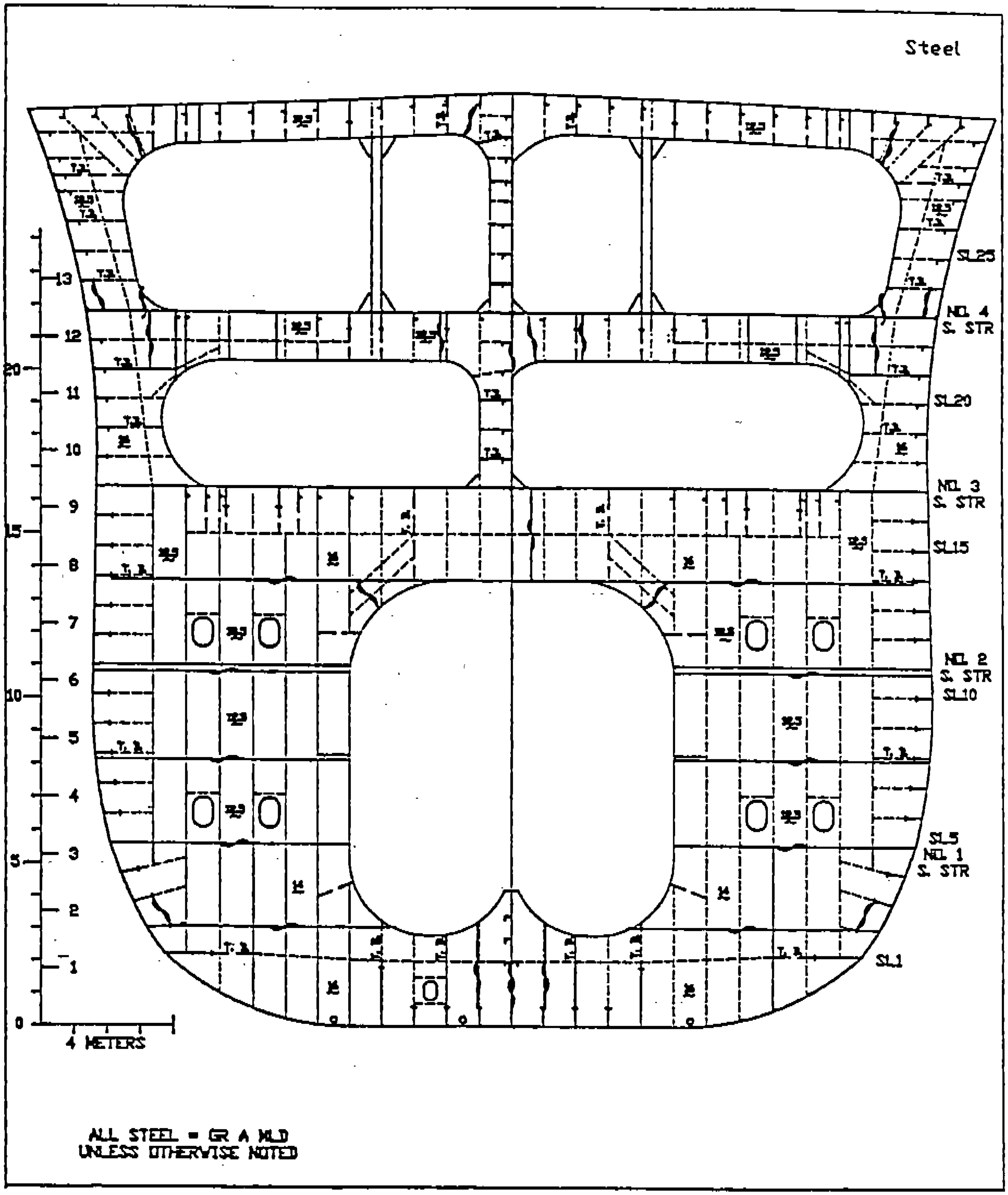


Each deck plate

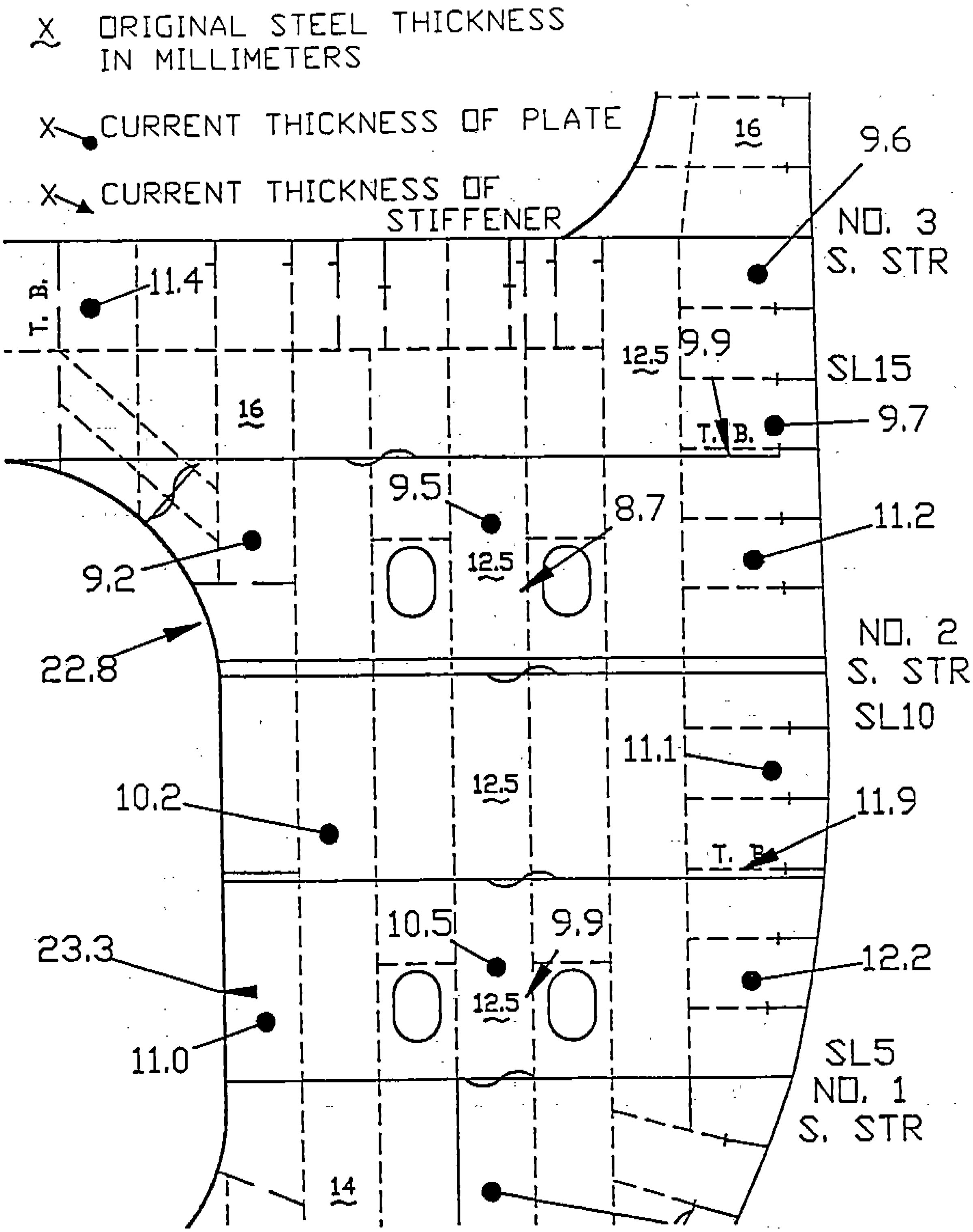
One transverse belt

Suspect areas

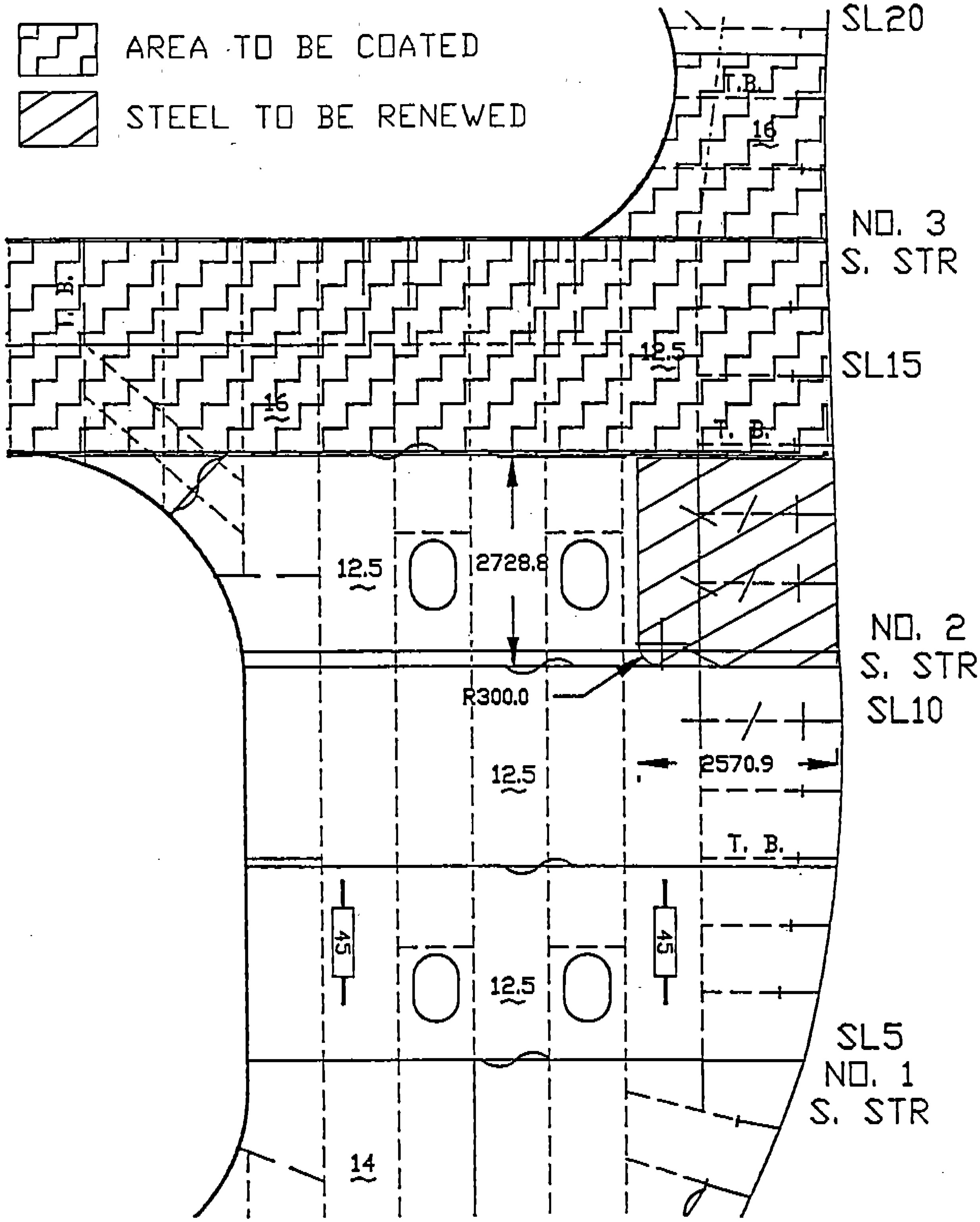
Selected wind and water strakes outside 0.5 L Amidships



CATSIR DRAWING OF
FORE PEAK TRANSVERSE



CATSIR DRAWING OF FORE PEAK TRANSVERSE - LOWER STARBOARD SIDE



CATSIR DRAWING OF
FORE PEAK TRANSVERSE -
LOWER STARBOARD SIDE

R.A. Ternus

I'd like to make some additional comments concerning double hull tankers. We pay considerable attention to the design of these ships to make sure they are inspectable and maintainable. We have been operating our five double hull U.S. flagged tankers for 15 years, currently have contracts for two 130,000 ton double hull crude carriers and are about to sign contracts for two more. We're spending a considerable amount of time working with the shipyard designing the ballast tanks of these new tankers so that they're accessible and can be purged. For example, instead of a two meter double bottom, we've specified a 3.1 meter double bottom; we are applying a two coat epoxy coating system. The top coat in the double bottom area is a bleached coal-tar epoxy, so that coating breakdowns will be readily evident. This is going to be very critical.

No coating manufacturer has a system, that we've been able to find, that will last 20-25 years. The blasting and recoating of these tanks is extremely expensive. If these ships aren't designed so that someone can easily get in and do the work, it's going to be prohibitively expensive.

This brings me to the concept of short-lived ships. You've heard today about short-lived ships because of their high-tensile steel and minimum scantlings. I see this as a problem created yesterday that is being addressed today. The problem for tomorrow that is not being addressed by most shipyards today is the design of double hull spaces so that they can be maintained.

LCDR Paul Brinkhurst

I think the system you've described looks very interesting. I'd be interested to know though whether Chevron is looking at ways of improving ultrasonic thickness gauging techniques, as the system is only as good as the data you've got in it. Do you have NDE systems in place for area mapping the thickness of the sides of your tankers, for example, or do you still use point sampling techniques?

R.A. Ternus

We use point sampling techniques and follow the procedures outlined in the guidelines published by the Tanker Structure Cooperative Forum. That is, we gauge a number of points in an area and then record the readings and location so that when we go back next time we can take gaugings at the same location.

Walter Maclean

As a professor at the Merchant Marine Academy I read a lot of sea projects from midshipmen that go to sea in a wide variety of ships, including a sizable number of tankers. I must say, in deference to what you've said here, I understand why I'm pleased with those midshipmen that go onboard the Chevron tankers because, quite frankly, they seem to be much better run than others that they go aboard. I'm quite appalled at the state of maintenance on some of these tankers that they send back information on as part of their sea projects. I'm very concerned about them getting bad ideas out of this operational experience which we try to dissuade them from and which presumably they will carry out of the school and into the industry.

The work that you've talked about here seems to me to be most forward looking and quite cost effective I'm sure as well as technically plausible. Are you or do you plan to work with any of the other tanker operators in order to try to bring this level of technology to them? It seems to me that we badly need to bring up the state-of-the-art in an awful lot of these ships that are out there and I think what you are doing is commendable. I'd like your comment. How in the world can we move the state-of-the-art forward with the others as well?

R.A. Ternus

We work primarily through the Tanker Structure Cooperative Forum. We have shared what we do and our experience with the other Forum members and we've been directly involved in preparing the Guidance Manual and the current update. We've also been active in advising the Coast Guard on the problems that we see with the double hull tankers in the hopes that these problems will be addressed in their upcoming rulemaking.

It's unfortunate, but the state laws that hold both the cargo owner and the ship owner liable without limit for oil spills may be what is going to clean up the industry. It's going to be prohibitively expensive to have accidents. I don't think many cargo owners yet realize what their exposure is. This is particularly true for those that are in the trading business who aren't producing the oil, aren't refining it, but just buying a cargo and selling it to somebody else. When a couple of these traders get burned with serious accidents, the sub-standard tanker owners will be forced to improve or go out of business.

Dag Kavlie

I would like to ask you about your experience with respect to structural details of high tensile steel. Have you found it necessary to impose a stricter standard than what the shipyards would do according to the classification societies? That's one question; the second, have you found that according to the different routes that your tankers are sailing that you have a different experience in failures in structural details because fatigue loading obviously is different? Do you have any special practice for some trade routes that you have to watch especially carefully?

R.A. Ternus

In regard to the first part of the question, we limit the use of high-tensile steel; we don't allow the yards to use anything higher than H-32 and even there we limit where it's used - we specify mild steel in certain areas. We also do extensive finite element analysis modeling of the details on our new ships. We decided to design the details for a fatigue life of 40 years, figuring that if we design for 40 years, we should get 20 years allowing for the actual construction practices in the yard.

As to the second part of the question, we have not been able to find any correlation between structural detail fatigue failure and trade patterns on our ships. On the other hand, we have found accelerated ballast tank coating breakdown and corrosion on tankers that are primarily used in short haul trades carrying heated cargoes.

Mo Husain

A couple of short questions. The five double hull tankers you have, are they product carriers or crude oil carriers? Secondly, you ordered two more ships, are they actually ordered or are you exercising an option to build double hull and are they to be crude oil carriers or oil carriers?

R.A. Ternus

We are currently operating two crude oil carriers, two product carriers and one is a swing ship that alternates in trades. We have ordered two 130,000 ton crude carriers and we expect to order two more some time before the end of April.