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Human Elements in Bulk Carrier Inspections and Repair

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Abstract

Over the past ten years, more than 700 officers and crew have been lost in bulk carrier casualties. Due to their design and operation, bulk carriers are subjected to accelerated corrosion, cracking, and other structural damage. Increasing the frequency of regulatory and/or class inspections alone will not ensure adequate safety. The responsibility for safe operation of the ship lies with the owner, not the flag state, port state or classification society.

Most marine accidents can be traced to human elements. To improve inspection effectiveness, management, operating personnel, and shore-side facility personnel must place greater focus on human interaction in the safety system. This focus should be placed on inspection procedures, personnel training, deficiency identification, loading practices, and repair processes. Owners must be convinced that the best investments in safety are often not technically complex or high cost endeavors. This paper discusses how managing and operating personnel can enhance safety by addressing the human elements involved in bulk carrier inspection and repair. It presents an example of non-technical guidance that can be an effective tool for crewmembers and shore side personnel to identify structural deficiencies.

Introduction

For the past several years, the rate of bulk carrier losses has drawn international attention to the design and operation of these ships. Bulkers transport dangerous and corrosive cargoes and visit terminals that often employ cargo-handling procedures that are harmful to ship structures. Several initiatives are in progress to mitigate these and other problems with these ships. These efforts are primarily focused on design characteristics and required inspections. Efforts to improve the safety of bulk carriers, however, must go beyond focusing on design considerations and inspections. To be effective, safety efforts must consider the interaction of the safety system participants by addressing the role of human elements in shipboard and shoreside operations. This paper discusses of current inspection processes and outlines measures to improve the safety of bulk carriers by maintaining their structural integrity. An example of non-technical guidance, which may be an effective and inexpensive step in enhancing the safety system, is also presented.

Background

Over the past ten years, bulk carrier accidents have been responsible for a great number of deaths. Many of these fatalities are believed to be caused by structural failure, with ships of 15 years of age and older representing the largest number of these casualties. Bulk carriers are subjected to accelerated corrosion, cracking, and other structural damage due to their design and operations. These ships operate in a harsh environment, evident during loading and unloading operations. In loading operations, high density cargoes, such as iron ore, are dropped into the hold from significant heights. Heavy grabs, hydraulic hammers, and bulldozers often impact the inner bottom, transverse bulkheads, side shell and frames while unloading. The unloading process is more destructive in bulk carriers than in any other type of ship. Corrosive or high temperature cargoes degrade the structure and maintenance of the cargo holds is limited. Due to the nature of the cargo and handling operations, keeping a coating system intact within the hold is almost impossible. Cleaning of holds is infrequent and usually done only when a cargo will be potentially reactive with residue from a previous load. Cleaning with water is discouraged due to characteristics of many cargoes (concerns with reactivity and moisture content) and the inability to maintain an intact coating system. All of these factors result in accelerated structural damage and corrosion and are significant contributors to structural failure.

Many of these failures are catastrophic, resulting in the total loss of the ship. This sequence of failure typically starts with a hull breach on the single skin area of the side shell, which results in flooding of a cargo hold. A second hold is possibly flooded either by free communication through a wasted bulkhead (especially along the intersection with the inner bottom) or by failure of the transverse bulkhead due to the dynamic loads imposed by the flood water. The International Maritime Organization (IMO) has estimated that 60%[1] of the current bulk carriers are not designed to meet one-compartment damage requirements and the flooding of a second cargo hold will likely cause rapid sinking of most bulk carriers. This can be exacerbated when the ship carries cargo in an alternate hold loading pattern that significantly increases the structure's initial stress condition.

Current efforts to address this problem at the IMO are focused on accelerating required regulatory and class surveys and enhancing the survivability of bulk carriers through increased structural and stability requirements. The principal survey requirements are detailed in the Enhanced Survey Program (ESP). Class efforts, primarily through the International Association of Classification Societies (IACS), are intent on enhancing the existing ESP with additional surveys as the vessel ages and developing new design requirements. This approach, however, does not consider the human element issues inherent in operating and maintaining these ships. Nor does it place adequate focus on the owner's responsibility to operate and maintain a safe ship.

Management

Current human element research attributes approximately 80% of all casualties to human elements, Coast Guard (1). Of these, many of these casualties are believed to be caused by a lack of effective company procedures and policy. This indicates that it is more cost-effective to focus on human elements before considering technological approaches. Due to the nature of their operations, bulk carriers, more than any other type of ship, require a high degree of owner involvement in managing vessel condition. In engineering parlance, bulk carrier operations may be viewed as an "open system." In this context, many variables act as inputs. Many, but not all, of these can be controlled by humans (e.g., sea conditions and weather. These variables are influenced by the participants in the system including the ship owner, cargo owner, cargo handlers, port operators, flag administrations, designers, class societies, etc. Of these, the ship owner has the highest degree of control. It is imperative then, for the owner to exercise this control to make positive changes within the system. Without action and support from the owner, changes by the other participants will be of marginal consequence.

Addressing human elements in bulk carrier inspections generally includes several levels: management, operating personnel, and shore-side facilities. The first and most important aspect of improving safety starts with the ship management organization itself, Bea (2). This is the goal of various "quality instruments" being implemented such as the International Standards Organization (ISO) 9000 series standards and the International Safety Management (ISM) Code. IMO has mandated the ISM Code which applies to shipping companies and addresses the operational phase of a ship's life-cycle. The code contains broad requirements for a safety management system. It focuses on company management of ship operations because of the enormous influence that a company's safety culture has on the day-to-day decisions made by ship and terminal personnel. Adherence to such a system cannot be fully ensured by external auditing, rather it is management's commitment to safety that will determine its success. To improve effectiveness, greater focus must be placed on people-related elements in cargo operations, inspection procedures, deficiency identification, repair procedures, and training. Once management undertakes the use of a human elements approach to operational safety, it can influence the ships' processes at the operating personnel and shore-side facilities levels.

Cargo Operations

The driving factor of cargo operations is the age-old adage that "time is money." Loading rates continue to increase as terminals attempt to turn ships around more quickly. This push for rapid loading increases the potential of structural damage and overloading. The speed of loading is not necessarily the problem; it is the human interface within the loading procedure. Loading operations contribute to damage and overloading when they are accompanied by poor communications between the ship's crew and terminal staff. As a result, structural damage may occur, causing lower global strength of the hull girder and defects that may eventually become serious. In addition, the quick turnaround time at the facility reduces the time available for vessel surveys before and after cargo operations. There has been some attention to this problem at IMO and by the classification societies, including developing of a guide by IACS on safe procedures for bulk cargo loading and discharging.

1 MSC 66/4: Bulk Carrier Safety - Report of the Intersessional Correspondence Group

There are several key junctures in the process where the human elements may be addressed. Ensuring that the crew and shore side personnel clearly understand the properties of the cargo being loaded is one example. The cargo will dictate the extra precautions, structural capacity, stowage and trimming requirements needed. Using this information, a detailed loading plan may be developed in conjunction with terminal personnel. The plan should include considerations of the loading sequence (to manage hull girder strength capacity and stability), ballast operations (again for strength and stability concerns), any inspections to be completed, and the loading rates and levels. Coordination between the ship and terminal will help prevent miscommunication. Although these steps may seem obvious, they are not always practiced and the result is overloading and subsequent over-stressing of the hull structure. Comprehensive cargo operations guidance developed and supported by the management will provide a framework useful to ship and shore facility personnel to ensure that these considerations are not overlooked.

Planning is only part of the equation to address human elements in cargo operations. Another key to successful operations is effective monitoring of the plan and being aware of the potential for structural damage. Deviations occur due to lack of communication and misunderstanding, as well as equipment availability and improper operation. Adhering to the cargo transfer plan and monitoring cargo operations is essential. Particular emphasis should be placed on the loading/discharge sequence, mechanical devices (heavy grabs, hydraulic jacks, bulldozers, etc.), and the avoidance of overloading. Coupled with these, crews must realize the potential for damage during the loading and unloading process, particularly with regard to the mechanical unloading equipment.

Inspection Processes

It is not surprising that loss statistics indicate that most structural failures occur as the age of the ship increases (noting that maintenance costs increase proportionally with age). Eighty-five percent of losses in which the structural failure is known or possible are attributed to ships over the age of 15 years. Current survey requirements under the ESP[2] and survey level definitions are detailed below.

Table 1 Current Bulk Carrier Survey Requirements

Special Survey (every 5 years)	**Intermediate Survey** (mid-way between Special Surveys)	**Annual Survey**
<u>Close-up survey</u> of all shell plate areas in all holds	<u>overall survey</u> of all holds, <u>close-up</u> as needed	**>10yrs old:** <u>overall survey</u> of representative fwd and aft hold **>15yrs old:** overall survey of all holds, <u>close-up survey</u> of lower area in No. 1 hold

<u>Overall Survey</u>: A survey intended to report on the overall condition of the hull structure and determine the extent of additional close-up surveys.

<u>Close-up Survey</u>: A survey where the details of structural components are within the close visual inspection range of the surveyor, i.e., preferably within reach of hand.

There is a proposal within IACS to toughen these guidelines by requiring a close-up survey of all cargo holds twice every 5 years for ships over 15 years in age. While this positive step may improve the effectiveness of required inspections, other issues should be addressed before (or in conjunction with) such a change.

Is the current survey system conducive to finding defects? This depends on many elements, paramount of which is the corporate stance on inspections:

- do surveyors have enough time,
- is proper equipment provided to access difficult-to-reach locations, and
- has the hold been prepared through the removal of cargo residue?

Without attention to these basic components of an inspection program, current and increased inspections cannot identify defects prior to a catastrophe. The attitude of managers toward surveys conveys implicit guidance to

2 IMO Assembly Resolution A.744(18) - see SOLAS regulation XI/2

operating personnel who interact with the surveyors. For example, does management view the inspections as an inconvenience or are the inspections viewed as opportunities to determine the condition of the structure, ensure compliance, and identify defects for maintenance planning? This "corporate attitude" will have a greater impact on the decisions made at the "working" level than written company policy alone. Regulatory and class inspections, however, are not the only processes for determining the condition of the structure. Too often, shipowners may be content to allow the regulatory or class inspection process to be the only monitoring or "quality control" process. This is contrary to the precepts of the ISM Code and other quality systems that enforce the notion that the responsibility for ship safety belongs to the owner.

There are many ways in which a shipowner may monitor the structural condition of a ship. One is through use of operating personnel aboard the vessel and at shore-side terminals where they interact with the vessel. Not only are the crew in the best position to know the condition of the ship on a day-to-day basis, they obviously have the most to lose if a defect becomes critical while at sea. An inspection by personnel familiar with potential defects and their common locations can be a valuable monitoring resource outside of the required class inspections. This includes general surveys of the cargo holds and deck structure after cargo-handling events. These surveys can identify defects and their causes so that necessary repairs may be performed. A second way of assessing the condition of the structure entails the use of analytical tools, such as crack growth rate prediction, determining of the probability of detection of defects during surveys, and calculation of critical crack length. Although some tools are still being developed, they can provide insight into the expected condition of the structure based on its service and previous inspection results. Coupling this method with non-surveyor personnel monitoring the condition of the structure will enhance the inspection process.

Identifying Deficiencies

Increased attention to cargo operations and repair processes will help control the development and spread of structural deficiencies. While defects will continue to be generated by operations, several steps will help identify structural deficiencies. As noted above, the first is an owner who is an active participant in the class inspection program (ESP). This would include ensuring complete preparation and providing adequate time and assistance to the surveyor. The second is developing a self-inspection program that makes use of operating, shore facility, and company personnel. The third step is using analytical methods to predict the structure's condition. Providing simple inspection guidance to the operating and shore facility personnel is another. Detailed training more suited to a class surveyor is unnecessary. Commonly occurring defects can be identified by marine officers and other personnel familiar with the ship structure through non-detailed inspections following cargo operations. The document that follows this paper, *Bulk Carriers-Inspection Guidance for Terminal Personnel and Crew*, is an example of non-technical guidance that can help operating personnel identify structural deficiencies.

Repairs

Due to time constraints, bulk carriers often use voyage, or riding, repairs, performed either by the ship's crew or a riding crew. The quality of these repairs has been under increasing scrutiny for several years. These repairs are not always conducted by qualified personnel and can often, at best, be considered temporary. Consequently, the repairs often have not met class standards and have masked or worsened existing structural deficiencies. To avoid these problems, IACS has recently published new Unified Requirements (URs) concerning voyage repairs. These requirements require greater documentation and class participation in riding repairs. IMO is considering regulating these types of repairs. As with ensuring structural integrity, the responsibility for conducting proper repairs lies with the vessel owner. The owner must ensure that adequate repair standards and procedures are developed, communicated, and followed. The ISM Code requires the development of procedures to ensure that structurally sound repairs are routinely completed. These procedures are required to address maintenance planning, record keeping, qualifications of repair crews, and reporting of maintenance shortfalls or non-conformities.

Training

Inspection is a key aspect of any structural maintenance program. Training should not be restricted to surveyors alone, nor should it be a one-time qualification or indoctrination process. It should targeted the inspectors' level of expertise, aim to expand their knowledge, and refresh previous training. Using operating and shore facility personnel to monitor a vessel's condition requires training them in bulk carrier operations, such as understanding the effects of improper loading, the damaging aspects of cargo removal, cargo properties, and common structural defects. Frequency and presentation methods are important for a successful training program. Training is another direct reflection of management's commitment to quality. Providing continuous training not only increases the knowledge and proficiency of the organization, but it sends a clear message to staff and crew of its importance. Education level, responsibility, environment, and other personnel elements should be considered in determining training techniques that will be most effective.

An Example of Non-Technical Guidance

The U.S. Coast Guard, with the assistance of IACS and Class NK, developed *Bulk Carriers-Inspection Guidance* *for Terminal Personnel and Crew*. This document is provided in the appendix. The paper was submitted to the IMO Sub-Committee on Ship Design and Equipment (DE) 39th session in January, 1996. It is not intended as an exhaustive account of all the potential structural problems found aboard a bulk carrier. It is, however, a useful resource for non-technical personnel involved in bulk carrier operations. The Sub-Committee proposed to the Maritime Safety Committee (MSC) that this paper be adopted as an Assembly Resolution to provide inspection guidance to ship's crews and terminal personnel. The draft resolution was approved by MSC 66 in May, 1966, and will be submitted to the 20th Assembly, scheduled in the fall of 1997, for adoption.

Conclusion

The ultimate responsibility for ship safety lies with the owner. Reliance on regulatory and class inspections as a quality control measure will not guarantee that a vessel maintains its structural integrity. Increased focus on the human element issues related to cargo operations, the inspection process, deficiency identification, repair procedures, and associated training are the only ways to ensure that the structure of the ship is properly maintained. This may necessitate a cultural change in a company's approach to safety, requiring a recognition that most failures can be traced to human elements. The precepts needed to effect this change are contained in the ISM Code and other quality systems. These measures are a more efficient and less costly safety investment than developing additional structural standards or stability requirements and will not require expensive or advanced technology to improve the safety of bulk carriers and save lives at sea.

References

1 U.S. Coast Guard, "Prevention Through People: Quality Action Team Report," Washington, DC, 1995.

2 Bea, Robert, "The Role of Human Error in Design, Construction, and Reliability in Marine Structures (SSC-378)", Ship Structures Committee, Washington, DC, 1994.