

Basically the marine chemist is a finder of facts with respect to the atmospheric and cargo residual conditions of tank vessels to be repaired. The practical duties of the marine chemist often go far beyond the actual testing of atmospheres in closed spaces aboard vessels. On the rivers he is called upon to recommend methods of cleaning vessels following the carriage of specific cargoes. He is called upon to recommend methods and procedures for handling various chemicals at docks and terminals. He is called upon to recommend types of safety clothes and equipment for use around specific cargoes. He is often called upon as a source of advice and information, by the barge lines and the ship repairers, for a variety of subjects in connection with the transportation and handling of chemicals and chemical carrying equipment.

He is fast becoming the liaison man between the water transportation industry and the chemical industry. This potential facet of his position in the water transportation industry was recognized by the marine chemist some 10 years ago and through his professional society, the Marine Chemist's Association, he developed an annual seminar which, for the past seven years, has been held on college and university campuses throughout the United States. The last seminar was held at the United States Merchant Marine Academy, Kings Point, N.Y. last June. The basic purpose of these seminars is to develop and institute the necessary techniques for handling and testing the multitude of new hazardous materials now being transported by water. As an example, one of the more pressing problems discussed at the last seminar was the development of a list of standard threshold limits for various toxic materials.

There has never been a great amount of research done on the subject of tank cleaning and gas freeing, with respect to tank barges. However, Laidlow, Spencer and Ayers, in 1960, did a study on "Gas Concentrations in Cargo Tanks" which produced some interesting results. The first result they obtained was that the simplest way to start cleaning a tank was to strip off as much of the residual material from the tank as possible prior to starting any washing procedures. While this procedure sounds logical, it is quite often the usual procedure to

partially fill a tank with water as the first procedure in tank cleaning.

The second fact they found was that tank washing did not materially lower the total gas concentration in a tank. They also found that where tanks contain residual gases, washing with an overhead spray system, consisting of several nozzles, will produce a uniform concentration of vapor in a tank a great deal more quickly than will a conventional tank washing machine.

It was also found that the most effective way of rendering a tank safe was by displacement; that is to exhaust the heavy layers of gas at the tank bottom to the point where the highest concentration is well below the lower explosive limit.

Further investigation by the research team developed the information that a portable steam exhauster designed to be used in a standpipe was the most efficient way to remove the heavy gases from the bottom of a tank.

Efficient evacuation depends on the ability to exhaust the relatively heavy gases concentrated at the bottom of a tank with as little disturbance and turbulence of the lighter atmosphere as possible. The jet effect of the incoming air must be minimized and time given for the heavier gases, which have liquid flow characteristics, to find its way to the point of suction through the many obstructions in a tank bottom.

By removing the heavier gases from a tank prior to washing it will be possible to send workmen in the tank with fewer pieces and less bulky safety equipment.

With the advent of the many new chemical cargoes being shipped on the rivers the procedures for gas freeing and cleaning barges are becoming more and more complex. It follows that the need for extreme care and accuracy on the part of the marine chemist is more pronounced than ever. My colleagues and I are quite often criticized for requiring additional, and what sometimes appears to be unnecessary, cleaning on a tank barge. But let me describe one accident which occurred because a chemist apparently "went along" with a barge cleaner and did not insist that all slops and ballast be removed from a vessel.

A barge was brought in for repairs in one of the river areas. Upon examination

on a February 15th it was found to contain about one foot of water in the bilge with some wax-like substance floating on top of the water. The wax-like substance did not burn on test and no further attempt was made to identify it. All tanks tested negative and showed no signs of gas. A certificate was issued by the chemist authorizing the yard to proceed with the repair work. Incidentally, the last known cargo the barge carried was reported to have been benzene.

Following drydocking and during plate removal work a fire started in the bilge. One fireman was injured when he fell. Damage to the barge was negligible. Samples of the bilge water, the wax-like material and of a solid mass found floating slightly below the surface of the water in the bilge were taken to the laboratory. The bilge water samples were tested for fire and flash points and were found to be negative. The wax-like material and the solid mass were examined and found to be frozen benzene and were highly combustible at increased atmospheric temperatures. If there had been a freak rise in temperature to 45°F. or above, which has been known to happen in February, the barge would probably have exploded with a resultant loss of life and property.

The point of this description of a minor fire aboard a tank barge is to emphasize that the marine chemist must not only consider the tank barge "as it stands," but he must also take into consideration the changes that the heat of burning and welding operations will cause in the confined spaces of a tank as well as the changes that a variation in atmospheric conditions will cause. It is a part of the marine chemist's responsibility to anticipate such potential hazards.

The specific duties of the marine chemist are confined to testing the atmospheric and residual contents of a tank barge. The chemist also has a moral responsibility to point out other hazards and conditions which, in his judgement, may develop into a dangerous situation during a repair operation.

One of the potential dangers which the marine chemist, through his education and training, can recognize is the health hazard resulting from the breakdown of coating products due to thermal decomposition. The newer plastic coating materials can be divided into five groups:

1. Coatings which are basically hydrocarbons and sometimes contain oxygen, such as polystyrene and phenol-formaldehyde.

2. Coatings which contain hydrocarbons plus chlorine.

3. Coatings which contain hydrocarbons plus nitrogen.

4. Coatings which contain hydrocarbons plus fluorine.

5. Coatings which contain metals, such as lead, zinc, chromium, carried in a plastic material.

The products in Class 1 will break down, in the presence of high temperatures, to give off carbon dioxide, carbon monoxide, aldehydes and organic acids including phenol vapors. Fortunately the phenol vapors are so irritating that men will not tolerate concentrations high enough to cause serious injury.

The products in Class 2 will give off hydrochloric acid gas, which is rather irritating as well as being toxic.

The Class 3 coatings may give off ammonia, hydrogen cyanide and nitrogen dioxide.

The Class 4 products are quite toxic when heated to their breakdown point. Between 350° and 800° F. the fluorocarbons give off fumes which cause chills and fever similar to metal fume fever, and above 800°F more toxic products are formed.

The Class 3 and 4 products are rather expensive and their high cost limits their application aboard ships and barges. However, some of the nitrogen containing resins of Class 3 are used in the manufacture of plastic foams.

The hazards of metal fumes, as found in the Class 5 products, are relatively well known.

Good ventilation in the burning and welding area is a help toward minimizing the exposure of the workmen to toxic concentrations of coating fumes. However, ventilation is not the complete answer. The only truly dependable solution to the problem is supplied air through a full face respirator.

The application of coatings to the interior of closed spaces is a field with which the marine chemist has recently become involved. Coatings such as vinyls, saran, epoxies, polysulfides, phenolic epoxies and inorganic zinc coatings are now commonly applied to barges as tank coatings.

All of these coatings, except the inorganic zinc silicates, require a flammable type solvent as a carrier. The MAC (maximum allowable concentration) of these solvents is in the range of 100 to 500 parts per million. Three types of hazards are found in the application of coatings in enclosed areas such as are found in tank barge cargo compartments. These hazards can be classified as follows:

1. Danger from fire or explosion.
2. Toxic damage to workmen from inhalation of the solvents.
3. Toxic or dermatitis hazard caused by contact with the resins or solvents used in the coatings.

It has fallen to the marine chemist to keep these hazards under control through design and planning of air flows and by the maintenance of safe atmospheric conditions through continuous gas analyses.

The marine chemist has no police powers with regard to the handling of vessels containing hazardous materials, nor does he desire any such powers. His authority to act comes from his certification by the National Fire Protection Association, and the requirements to use his services are contained as a condition of a number of the ship repairer's legal liability insurance policies. In relatively recent years this has been supplemented by policy action of the U. S. Coast Guard and the American Bureau of Shipping who have issued regulations prohibiting their personnel from entering a tank vessel until a gas free certificate has been secured by the owner, agent or shipyard. More recently the Department of Labor has entered the picture through the Maritime Safety Branch of their Bureau of Labor Standards, requiring that gas free certification from a certified chemist be obtained prior to workmen entering spaces in which hazardous cargoes had been carried. With these insurance requirements, policy regulations of the U. S. Coast Guard and the A.B.S. and the Department of Labor's safety rules, the marine chemist has now become, more or less officially, an integral part of the water transportation industry with respect to the carriage of hazardous materials.

Some research work has been done on the subject of transportation of chemicals and petroleum products by water but, to my

knowledge, no serious, organized study has ever been made in connection with methods of cleaning tank barges for either change of cargoes or for repairs.

The river shipyard, due to the relatively small volume of tank cleaning, is economically limited in the amount of capital it can invest in a barge cleaning plant. It cannot resort to solvents or "mother" solutions to dissolve residues or wash down tanks because the yard cannot afford the capital investment required for the variety of solvents and chemicals that would be required, much less the investment in a reclaiming plant and the necessary storage facilities. The yard is, of economic necessity, limited to water, steam, air and low cost cleaning compounds as the cleaning agents. Add to this the factor that most barge operators consider barge cleaning a non-productive expense and time consuming operation, and we have all of the ingredients for inspiring the shipyard to engage in short-cuts and unsafe practices. While most of the shipyards resist this pressure to "get by" with the minimum amount of cleaning, the pressure is always there.

It is my sincere opinion that a research grant to some university, or other non-profit group, to conduct a study of processes and methods for cleaning various materials from tank vessels, using the limited types of cleaning agents available to the shipyard, would be of immense value to the industry by uncovering methods of cleaning that would reduce the cost and time required to clean and gas free tank barges.

The marine chemist's talents have never been fully utilized by the barge industry. There are probably a number of reasons why his talents and abilities have not been used more widely, and not the least among these reasons is the fact that the marine chemist has made no real effort to let the barge industry know the full scope of his knowledge and training.

Some of the fields in which the marine chemist is peculiarly well qualified to consult and advise shippers and barge line carriers concern the characteristics of cargoes in bulk, whether the cargoes be considered hazardous such as acids, caustics, sulphur and liquified gases or whether they are such commonplace materials as grains, which are subject to heating and souring.

Another subject is the compatibility of cargoes when moved in the same barge or in the same tow. The salvaging and reconditioning of contaminated cargoes is an area in which the marine chemist can be of particular help. The salvaging and recovery of chemicals and other cargoes from sunken or

stranded barges is also an area in which the marine chemist's knowledge of the characteristics of the various materials could be of benefit to the carriers. These are only a few of the areas in which the barge lines and shipyards can find the marine chemist of immense assistance.

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## A COMPANY'S LAWYER LOOKS AT THE MARINE SAFETY PROGRAM

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As a lawyer whose practice has, for the past sixteen years, been more or less confined to the admiralty and maritime field, I have had an opportunity to meet and know ship's masters, officers and crew members of a number of merchant vessels.

I spend a considerable part of my working time going aboard ship (mostly in port). I have had occasion to discuss most phases of ships' operations with the men responsible for same. I have also had the opportunity of discussing matters concerning ships' operations with the men assigned the duties of safety inspectors, safety engineers and/or safety directors of various steamship companies and stevedoring concerns.

In general, my work is confined to what may best be called the aftermath of the breakdown of safe operations aboard vessels.

Like the usual inexpert expert, I am not a trained safety engineer; I am not a licensed ship's deck officer; I am not a licensed marine engineer.

I have observed safety programs in operation. I have seen the end results of safety programs aboard vessels and I have seen them operate beneficially and I have seen them operate detrimentally. I want to emphasize now that I believe a safety program is something that every steamship operator should have. How a specific operator approaches safety, of course, must be individual to that operator's needs and requirements.

Some steamship operations are limited to the carriage of bulk cargoes or general dry

cargo, and some handle a combination general dry and liquid cargoes. Thus, safety requirements will vary with the nature of the trade. I will not try to single out any particular type of operator or particular type of operation.

I am directing my comments to the concept of safety aboard ship. Every company should have a safety program, and with that thought in mind, I think I should add that my basic work is the protection of vessel's operators from loss as a result of accident. Most of the time, I find myself in the position of defendant's counsel. Once in a while I am in the position of plaintiff's counsel, and sometimes I am in the unenviable position of being both defendant's and plaintiff's counsel at almost the same time in the same case. This seemingly inconsistent position occurs when, on one hand, we are defending a lawsuit and, on the other hand, in the same litigation, we are taking the position as claimant against another party whose fault, we contend, caused the incident, because of which our client was initially sued; so that we are really representing one client, but in two postures. Stevedore contractors are most vividly aware of the sort of case that falls within this category.

Why do we even think about having a special safety program aboard ship? After all, today the ships are carefully planned, designed and constructed. American merchant vessels are, for the most part, subject to inspection by the U.S. Coast Guard. They are also subject to inspection by the various

classification bureau representatives, insurance interests, cargo interests and other organizations whose interest is to make sure that a vessel is constructed, maintained and operated in such a manner as to be the safest possible equipment that man can conceivably design for its intended purpose. Many standards are set and promulgated for various phases of ships' operations.

The ship's Master, deck officers and engineers are examined carefully by the U.S. Coast Guard before they are licensed to serve aboard ship. All of these things are most important and all of these things occur day by day in the normal course of ships' operations under the flag of the United States of America.

Unfortunately, all of these fine procedures do not prevent accidents. Aboard ship you have people and people are not standard; they cannot be standardized. Some people are very conscientious about the way they perform their duties and they get good results. Other people are not so conscientious; they do not concentrate on the proper performance of their work. The result is that you have carelessness and carelessness creates accidents.

It is very difficult to determine, at first blush, what a man's potential will be when he is sent to a vessel for the first time. After he is there for a while, this can be determined by his superiors. What usually happens, as I am sure you realize, is that the average vessel's complement is a combination of potentials, some good and some bad. You have some men aboard who just shouldn't be on ships. You have some men aboard who are exceptional in their working methods and their safety consciousness is of the highest level.

We learn our native language as children and it becomes something that we have with us at all times. A person learns to swim and it is said that he never loses this ability. As we learn, there are many things that are first acquired by a conscious effort but day to day usage of such skills and talents, so learned, become sub-conscious, or automatic. This should also be true with safety and safety working procedures. Good safety procedures should become a sub-conscious or instinctive behavior.

Aboard a vessel are often found people of different ethnic, economic and geographic

backgrounds, these people have to work together for the common purpose of taking a ship safely from one port to another, load cargo, discharge cargo and various aspects of a vessel's operation. The primary importance of a safety program is to create an environment in which these men can work without being injured. The importance of safety, as far as the lawyer is concerned, is that it will create the ultimate defense of lawsuits. If there is no accident, there will be no lawsuit.

To successfully defend personal injury or property damage suits requires a certain amount of skill, knowledge and training on the part of the lawyer. However, if there is no accident, no incident aboard the ship, you won't need this skillful, trained, knowledgeable, and in some instances, expensive defender in the first place.

Now, I didn't come here to talk myself out of business. I will have work, I suppose, as long as I am able to perform it to the satisfaction of my clients. But, then again, my work can be minimized. My work can be assisted, as well as the general welfare of all maritime workers, all by effective safety programs aboard vessels.

To recover in a claim or lawsuit against a ship, there are certain things that have to be established by the claimant. Let us take, for example, the injured seaman. He has, as you undoubtedly are aware, two general legal bases upon which he can establish his claims. The first is the proof of negligence; the second is the proof of a breach of a warranty of seaworthiness. Negligence, for purposes of this discussion, is any act or omission that a reasonably prudent man, under the same circumstances, would not have performed or not have failed to perform. Unseaworthiness is created, primarily, by a defect, latent or otherwise, in the vessel's equipment or the temperament of its crew (i.e. vicious propensities, etc.). In the present day concept of unseaworthiness, a defect in the character of one of the vessel's crew, which, directly or even indirectly, causes an injury to another member of the vessel's complement also creates a bases for a claim.

You are all aware, of course, that longshoremen also fall within the general category of merchant seamen, for legal liability purposes, if they are injured aboard a vessel.

They do not receive maintenance and cure, unearned wages and similar benefits which are peculiarly within the scope of the legal relief available to injured seamen. But, they can sue for negligence, not Jones Act negligence, but common law negligence as amplified by the general maritime law, and unseaworthiness just as a seaman can, if the injury occurs aboard a vessel and, sometimes, on a pier. This is a situation which, I am sure, has come to your attention on many occasions and occupies a great deal of your time, as it does mine, in your day to day work.

It doesn't take much evidence in a seaman's Jones Act suit to prove negligence. Our United States Supreme Court has ruled that all that is needed is a mere scintilla of evidence to establish negligence in a maritime case. A scintilla is like a hair or a thread or a feather stroke in its weight or implication . . . a very slight thing indeed. Also, such slight proof of negligence or the slightest degree of unseaworthiness will justify a recovery of damages. As a matter of fact, today, in the resolution of complicated medical fact questions where there is conflicting medical evidence presented in Court at a trial, the court or a court and jury will resolve the medical issues even though the judge is not a doctor, nor are the jurors doctors. They make medical conclusions from the evidence presented and these conclusions are binding in the case.

I am sure that most of you have heard reference to most of these principles before. However, I came to talk of safety and how safety must be considered an important tool in the overall defense of maritime claims, lawsuits and associated procedures. Thus a little insight into the legal basis for maritime claims is necessary.

I previously suggested that safety is the purpose for the activities of many organizations, some created by statute, some created by agreement, such as the American Bureau of Shipping, the National Safety Council, the Marine Inspection Division of the U. S. Coast Guard, the agencies responsible for the enforcement of the statutes of the United States, the rules and regulations for safety in longshore work as distributed by the U.S. Department of Labor, the various international conventions for safety and the preser-

vation of life at sea, the safety rules of various city and state port authorities.

All of these entities are important and their published materials are most informative, but in essence those rules are printed and distributed not universally but to a selected few, and people concerned with the operation of vessels often do not see these different materials as a whole. They'll hear about a part here and a section there but they never see the whole picture. So what we've got to do is make the best use of these printed rules and regulations and give effectiveness to the purpose for which these promulgations were originally prepared.

This brings us, at last, to the safety program. How do you present an effective safety program on board ship? How do you get the safety concept across to the people on shipboard? These are the people who have to run the vessels, and it is their safety that we are concerned with.

Now, what is a safety program? It can be a very slight, once-over-lightly passing on by the shipping company employer of broad platitudes to its employees, such as: "we shall work safely; we shall be careful; we shall not have accidents" or it can be an intensive, worked-up program for use aboard ships that endeavors to lead people literally by hand from one place to another while they perform their duties. This latter type of program, I think, would slow down if not completely cripple efficient, practical ships' operations. The former type of safety presentation accomplishes very little. So we have two extremes and we want to find a happy medium.

Some companies, I am sure, prepare and distribute a manual of safety regulations. This is very good, but people must read these safety regulations. They have to understand them and then they have to put them into effect. This is where you run into trouble. You are dealing with people.

I, as most lawyers, am a little concerned about the preparation and distribution of a safety manual for use aboard ship. You already have the rules and regulations of the official organization and the quasi-official bodies to consider and comply with. Actually, not everybody ever sees all this material in any one working lifetime. Once the steamship company undertakes to issue a safety

manual, it must undertake the responsibility to see that its provisions are complied with to the letter. There can be no exceptions and there also has to be an effort in such a manual to cover every possible situation, to consider every possible interpretation and this is a task which is almost impossible to complete. It just can't be done.

However, any failure to cover all possibilities or any failure to comply with the rules in the manual all establish negligence in connection with an accident, the circumstances of which may suggest a failure to comply with the requirements of the manual.

What is the alternative? Encourage the ships' masters to be responsible for safety aboard their vessels. The master is responsible for the ship, thus you've got to start with the captain. And now, one assumes, there is a man in the company who is designated as the person in charge of safety. He may work alone, he may have a staff of one or more assistants, depending on the magnitude of the operation, and the responsibility placed on his shoulders by his employer.

Everyone involved in the safety program is seriously interested in doing the best job that he can and the deserved end result is to be a safety program that will permit efficient, practical operation of vessels and minimize the occurrence of accidents. After all, accidents don't benefit anyone. They don't benefit the company, they don't benefit the man who is injured, and they interfere with operations. They cost money, and it's the role of a safety program to cut out accidents. No one, even a successful claimant, ever really makes money from a personal injury. There is no way an injured person can benefit from being injured.

Now, if you don't issue a manual or pamphlets or brochures containing safety rules, how do you get the idea across that safety is essential aboard the vessel? I think you can present and promote safety by means of a personalized presentation, a sales program, if you will. You start your work with the ship's master, but you don't stop there. The safety director, or his appointed assistant, goes to the master and the ship's officers and discusses the purpose of safety with them. First, make it logical. Don't say "You shall do so and so, or A, B, C, D, E and then G will be the result." Describe by every-

day examples normal shipboard conditions and point out how potential hazard may be eliminated. Explain to them why it is important to eliminate the accident potentials; why the company is concerned with accidents; and why safety will be a benefit to all ship's personnel. After all, the ship's personnel are the people who may get hurt.

Safety is not aimed solely at the avoidance of personal injury aboard ship, it is also aimed at eliminating ship collisions and damage to cargo. The ship owner is certainly going to be concerned with this type of operational accident as well. After all, the safe carriage of cargo from one place to the other is of vital interest to the ship-owner. This, then, is also one of the desirable end results of a safety program.

Realistically, no one is going to be able to establish an effective program all at once. You've got to build it step by step, plate by plate. You will have to talk to the same people over and over again, but if you start out with the master, then work down to the chief officer, the junior officers, junior deck officers, the chief steward, chief engineer, the first assistant and talk to these people patiently in a series of conferences and work into their minds the ideas that you want to establish as your shipboard safety program. Then when the captain walks on the deck and sees oil there, he will have someone "clean it up" at once. The fact is that he has got to be consciously aware that there is oil there. A man may walk by a patch of oil three times and its existence will not register, in which event that person has not reached the state of safety-consciousness.

I've been to many ships where there are a remarkable number of accidents during the course of a voyage in a particular department. I've also been to ships where there is a deck, or an engine or a steward's department that doesn't have any reported accidents from one year to the next. One factor is usually constant in such situations and that is the little turnover of personnel.

However, that there is the low rate of reported accidents can usually be attributed to the department head. He's on top of his work, he's on top of his people. It's often been said the best safety program is good, competent leadership or heading-up of

a particular department. After all, safety is common sense. Safety is good seamanship. Safety is good organization of work. Do the job the right way and that is the safe way. If you know your job and do it well, you are going to do it safely. Therefore the first step in the safety program is to encourage ship's people to do their work in a proper manner.

I suggest that the shoreside staff safety man go to the ship at the end of each voyage, then look over the reports of accidents that have been made during the course of the voyage. He should also review the ship's repairs list. In the interest of safety, he should see that the repairs are made before the ship leaves the port or, at least if not then, before the ship sails on the next foreign voyage. To ignore defects in the ship's equipment is to ask for trouble.

Of course, the safety director must coordinate his work with that of the persons responsible for ship's operations and maintenance. He must emphasize to the men aboard ship and to the operator's shore staff that the repairs do not merely call for the expense of updating equipment, but the projected expense will help prevent accidents. In absence of an accident, no one will know what was saved. However, the intangible gain from an absence of accident is that no man-hours are lost, no slow down in operations and no lawsuits. If there is a reduction in claims, the insurance costs will be reduced, the company expenses will be reduced, lawyers' fees will be saved. After all, lawyers' charges are an expense added to steamship company operating costs.

One often finds that everybody aboard a ship in port is very busy, or at least strives to give that impression, but there is always twenty or thirty minutes during the 8 a.m. to 5 p.m. port working day, or even after 5 p.m., when you can talk to people aboard ship about safety. Ships work 24 hours a day, seven days a week and there is always somebody on board most of the time. You can get together with the master and the ship's officers, not necessarily as a group, to talk over ways and means of promoting safety in the general operation of the vessel. Once you start these talks, you'll find that you get some constructive thoughts from these people. If you encourage them to think

"safety," they'll come up with suggestions and ideas on their own.

It has been the practice in some steamship companies to encourage the ships' masters to organize a safety committee aboard ship. They hold safety meetings during the course of a voyage; they prepare notes of these meetings and send them back to the shore side safety division in the main office of the company. This procedure shows a promotion of interest in safety, but I don't think it is a good practice to write up minutes of these meetings.

At this point, I must talk strictly as a lawyer. My limited experience in this connection has been that the master and the department heads reach the conclusion they've got to prepare minutes to prove that they had a safety committee meeting. It usually doesn't suffice that they report that on such and such a day they together, at such and such a time, discussed safety for such and such a period. They start talking about recent accidents aboard the ship and they talk about ways those accidents should have been prevented.

This may be a good idea, but it should not be written up. These minutes are available later to be disclosed to all parties to a lawsuit and it will hurt the defense because sometimes a definitive, critical analysis of the accident and the cause of the accident is written up. Also, the comments may be founded on hearsay or gossip and prove to be erroneous. The result may be a pre-judgement of the matter before all of the facts are known. These faulty minutes may be used against the shipowner defendant in a lawsuit. The reports are business records of the shipowner and are binding on him. These comments at safety meetings are not always based on a complete and thorough investigation of all of the circumstances of the accident. It often happens that the vessel's officers are embarrassed by the occurrence of accidents on the ship and they are ready to blame everyone else but themselves, even though some personal act of neglect on their part may have had something to do with its occurrence. It's not a good idea to have safety meetings where you have prepared written statements of accusation of self-confession of fault about accidents.

I suggest that the safety director, the safety engineer, the safety inspector, go to

the ship at the end of the voyage and visit each department head and discuss the accidents that occurred in the department and suspect how they may be eliminated in the future. If it is fault of equipment or fault of design, something should be done to remove the hazard. Don't risk a second accident. Always bear in mind that anytime there is a lawsuit that involves a second accident with a piece of equipment it will be an embarrassing development. In the event of a claim, the claimant's attorney usually finds out about it. Someone is always available to offer the comment "Oh, that same thing happened before, about three months ago, and they did nothing about it—now it's happened again."

In the course of his work, a safety director should be very circumspect in what minutes and notes he prepares. Once a lawsuit starts, the company records are discoverable by the other side. An innocent comment can be interpreted to mean something other than what was intended and it may so be analyzed in a court proceeding. All court actions are adversary proceedings, each lawyer represents a side with an interest. That interest is to win the case and it's all in the viewpoint as to what a particular comment or thought meant when it's put down in writing one day and read two years later in the courtroom.

It's all right to discuss accidents and their modus operandi and to think about them, but don't make copious notes. You are not on a fault-finding mission when you go aboard ship to discuss accidents and how to prevent them. You are there to find out what happened and how it can be prevented in the future and you must do something about it. To make accusations and offer the comment that, "You were wrong and this is your responsibility" does not prove anything.

The thing to do is to take steps to see that it doesn't happen again. Patiently talk to the people involved. Keep in your own mind what has happened, you know who or what was wrong. Patiently discuss the operation, the work being done, the equipment being used and endeavor to show the department head or the officer in charge of the work how this accident could have been avoided and should be avoided in the future. If this is done often enough and is done long enough and patiently (the key word

in any safety program is patience, because safety isn't going to work out in two or three months), it's going to develop gradually over a period of years. In the end, there should be the promotion of a conscious concept of safe operating methods, and you will find that you'll get more and more suggestions from ships' personnel as to how safety can be improved if you don't take the wrong tack with them. Don't put them on the spot. Don't have long written memoranda passing back and forth between the safety division and the ships' personnel about who did *what and which*. Keep it *informal*, but keep it *constant*. It is a full time job.

Another thought I have is that the safety director of the company should be responsible for making informal safety surveys of ships and ships' operations. He shouldn't have to rely entirely on what the shipboard people tell him. He should go down to the ship, look the ship over, and make his own conclusions as to what is in good shape and not in good shape. Now, this doesn't mean you're going to rebuild a ship every time it comes to port, but look over the cargo stowage, look over the way work is being done. Check on the longshore operations.

Don't write a letter to the stevedore and point up his short comings, but tell a person in a responsible position in the stevedore contractor's office about what you saw. After all, the stevedore doesn't want to have accidents either. The ship gets sued by the longshoreman. The ship's owner, in turn, sues the stevedore because the steamship owner takes the position that the stevedore didn't do the job right, breached his contract by not performing his work in a careful, safe and workmanlike manner and in many, many cases the steamship company gets back part if not all the money it may pay to an injured longshoreman on the grounds that the ship, being the host, was held to be liable for the accident. Then it is proven that an operational fault on the part of the stevedore and his employees caused the accident.

The safety survey should be handled informally. You make your own notes in pencil or ink, if you wish, but don't try to build up a catalog of problems with each vessel. It may become a permanent record. After the safety survey, talk to the master about your findings and how to improve the situation, then throw away your notes. Don't

keep them. Don't make a permanent record. Whenever your safety survey suggests following through with somebody in a superior position in the steamship company, by all means do so. Don't hesitate to undertake this responsibility, but a detailed memorandum or report should be prepared only in the most extreme situations. Instead, keep it informal, but keep in there pitching.

Of course, the time will come when somebody may say "Well, what's he doing, he's talking all the time. I don't know what he does, what do we pay him for? He does a lot of talking, but what does he accomplish?" Well, all right, if this is true, you're doing your job but you've got to convince your superiors that this is your job, and your over all proof of a job well done will be a reduction in the number of accidents, reduction in losses, reduction in accident insurance costs, reduction in general expenses.

The claim department personnel may have time to take it easy while you, as the safety man, may be working seven days a week, twelve hours a day but, you must be getting results. Your job is to put the claim department at ease. Now, if this begins to happen, then the safety program has begun to assume and meet the obligation that is being imposed on it.

You know, you can walk around ships as I have, and you discover certain homey little touches—like the crew hangs its wet wash in the upper engineroom spaces to dry, or if it's a good, warm engineroom, they may even stretch their clotheslines across the main grating area. Well, this is something that you must stop. You'll never see it in port. You often have to go to sea to see it. However, once you have an accident that results from this, you certainly know that you've got to tell every engineer on a ship, and the master of a ship, that this is not to be done.

Seamen are going to get hurt in ways which the safety program cannot prevent. When the men are ashore on "legitimate shore leave" they often get hurt. A man who jumps out of a window eluding a jealous rival for a fair lady's hand and breaks a leg can't be saved by a safety program. The man should have been more circumspect in his acquaintanceships, so he wouldn't run into this hazard.

However, we're talking about shipboard situations and this is where something may be accomplished. I say that safety is a conscious concept. It has to be delivered to the persons to be beneficial as a means of avoiding painful injuries. In the final analysis, the master of each vessel must be the person who is responsible for the development of safety consciousness on his own ship. The success of any safety program must necessarily depend on the interest shown by the master and the officers of the vessel in seeking out and taking steps necessary to correct unsafe conditions and practices. It is not necessary that unsafe conditions and practices would immediately suggest the possibility of personal injury. Even if it is remotely possible that a person would be injured by the existence of an unsafe condition, it should be eliminated.

The same will hold true of an unsafe practice. Quite frequently, the ship's personnel are not aware of the potential danger in certain day to day practices aboard their vessels until after an accident happens. This is the biggest hurdle to be overcome but it can be overcome by the program of personal discussions and direct education of the ship's personnel. The vessel's officers must be encouraged to make every effort to carry out their own duties in a safe manner and, in that respect, serve as a good example to the unlicensed men aboard ship.

You frequently hear the term "good seamanship." Good seamanship suggests safe practices. What is reasonable and proper under the circumstances, in all probability, will be what is safe as well. During the day to day work aboard a ship, the vessel's officers must take it upon themselves to see that any condition observed aboard the vessel, whether it amounts to an unsafe condition or an improper working procedure, should be remedied with the facilities available on the vessel, and supplementary to that, correction of defects, corrective instructions, should be given to any of the vessel's personnel who is found to be carrying out his work in an improper manner.

This imposes a high degree of care on the ship's officers. The law does this in any event. The law requires that all possible measures be taken to avoid accidents. It is part of the ship's supervisory personnel's duty to work safely, and if they object to

this, they can't really be considered to be completely effective in the performance of their work.

What you are really doing, under the guise of a safety program and in the form of safety suggestions, is asking them to do their work in the proper, safe and efficient manner that one would expect them to do in the ordinary course without any safety instructions.

To assist in the overall success of any safety program, the master of the vessel will have to be the man responsible and in fulfilling the requirements of this responsibility, he should make frequent inspections of the entire vessel, including, but not limited to, the living quarters, engine spaces, deck spaces, holds, machinery, equipment, storage spaces and, in so doing, be on the lookout for any condition that might suggest itself as being a possible cause of personal injury or even the illness of personnel.

A safety program should not be restricted to the prevention of accidents. It also should be involved in the prevention of illnesses. Now, illnesses, as often as accidents, are productive of much personal injury litigation. A man who gets T.B. working aboard the vessel will usually endeavor to support his claim for damages with the statement that his living conditions were unsatisfactory. Either they were too hot or too cold; the food was bad; the galley was dirty; native longshoremen were allowed to come aboard the vessel and use toilets and make use of crew mess facilities, galleys and things of this nature. This may or may not be true. However, all efforts should be made by ships' personnel officers to prevent the build up of actual foundation for such claims.

An effort should be made to find out if the forced air ventilation or air conditioning system or other equipment used to relieve heat or to relieve cold in the living quarters are actually working as they should. If not, prompt measures should be put into effect to eliminate these complaints. If the food is bad, people are going to get sick. It doesn't have to be tuberculosis, it can be diarrhoea. If the whole ship comes down with diarrhoea, you're going to get a ship-load of claims. It always happens. If the water comes through the pipes into the faucets or the scuttlebutts in a dirty or rusty condition, you're going to get claims.

A man may be afflicted with the worst hangover in the world or he may have gastroenteritis produced by excessive consumption of alcohol, but he'll be the first to shift the blame from what he drank to what he ate aboard ship.

All of these things, however, are part of the day to day operation of the vessel, in that sanitary measures and living conditions should always be subject to scrutiny. The chief steward is only doing his job when he sees that there are no problems in this area. He is not doing the ship or anybody a favor if he tries to save the owner money by serving food that has begun to spoil. He may have a good record as far as his savings on the purchase of stores are concerned, but the savings will be paid back ten times over in claims because of illnesses as a result of eating such food.

All of this, in my opinion, is a matter of concern to the safety division. This is part of the program that has to be enforced by the safety director. The safety program can't stop with the finger-mashing, arm-tearing, epidermis-ripping machinery. It involves every phase of the operation and the effectiveness of the program cannot be judged in immediate results. If you start with a safety program today, it will not begin to prove its worth until two or three years from today.

Where does all this leave us as far as printed safety promotional materials, safety meetings, posters and bulletins are concerned? These are time-honored methods used in an effort to promote safety aboard vessels or in the shore side industrial installations. There is really no difference between a ship and an industrial plant ashore, except that the ship moves from place to place and visits foreign countries and crosses the vast oceans. The ship and the shore side factory have the same accident potential. You've got moving machinery, you've got metal walking surfaces, you have areas where accidents are just waiting to happen and with the slightest carelessness or inattention on the part of a seaman these circumstances will spring up and be the basis for the occurrence of an accident.

I believe bulletins, on most ships' bulletin boards, are good as long as they don't try to get too specific for individual situations. Don't print up definite instruction as to how

a definite job aboard ship is to be done. This will leave the implication that if it isn't done in just that way, you have a violation of safe procedure. After all, if you consult experts as to what is the right way or the wrong way to load cargo, what is the right way or the wrong way to conduct a search at sea for someone that's fallen overboard, or what is the right way or wrong way to operate a vessel, generally, you'll get three or four different, and often opposite, opinions on the point.

So that to try and pinpoint specific problems and suggest solutions is to merely create a possible liability where none might exist ordinarily. Your safety program and your own hard work are going to be used against you and will be used to cause the very thing you started out to prevent, that is, a loss to your employer because of a particular injury or illness that's made the subject of a claim.

You can have your own visual aid presentations, if you want to use them, in putting your ideas across aboard ship. Visual aids and films are both good but in dealing with a working ship, you can't always effectively use this form of presentation. In any event, do not leave such material aboard ship for others to use.

I feel that the discussion with the captain, the deck officers, the engineers, the chief steward and other department heads, working bosses and persons of responsibility aboard the vessel, is the best approach. Safety must become a personal thing with

them, give them the idea that safety is part of their job and they are required to use it; that you're just there to help them figure out ways to do the job better and safer. This, to me, is the most effective safety approach, and the safety director must take the responsibility on himself to look for problems aboard ships while they are in port and to see to their correction without need of lengthy, written communications between the master and the safety director and vice versa.

My whole purpose is to give you the idea that safety is a living, working concept. It should be handled that way. After all, if everyone used real common sense in their work there wouldn't be any problem, but they are not going to think and act safely at all times unless they are encouraged to do so. The men aboard ship have talents, in this area, that they never knew they had. They don't know their own strength and you'd better help them develop these talents by discussions, by example, by continual encouragement.

It can't be done by strong criticism. It's got to be done by constructive criticism. It cannot be destruction of spirit or will. You've got to be fair about safety development and you've got to be frank; you've also got to be sincere. When you make a suggestion that you find later isn't followed through, don't hesitate to comment about it then. Ask for an explanation. Then encourage the person to look out in the future to make sure that there isn't a repetition.

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## SAFETY CONSIDERATIONS IN THE BASIC DESIGN OF U.S. MERCHANT SHIPS

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In considering a ship from the point of view of safety, it seems that the safety which is a product of basic design may often be overlooked, taken for granted, and sometimes even eliminated in repairs and conversions. The distressing aspects of individual injuries focus attention on local causes and

the need for remedies. There are situations, which fortunately seldom arise, which nevertheless could be catastrophic if suitable forethought had not been applied. Through experience and codification, many safety considerations are incorporated into the basic design of a ship.

The scope of this paper is limited to considerations which affect the safety of the ship as the protecting vehicle for personnel and cargo. Emphasis is directed to safety for dry cargo ships because of their predominance in the current U.S. ship replacement program. Occasional reference will be made to passenger ships which, in general, have more stringent requirements.

Let us consider the basic function of a merchant ship. Simply stated, it is to deliver its cargo (including passengers) from point of loading to point of discharge in good condition. This requires:

1. A floating, upright vehicle
2. Means for controlling or positioning the vehicle
3. Means for carrying and protecting the cargo
4. A continuous intelligence function—receipt, determination, dissemination of information plus decision making
5. Provision and maintenance of shipboard personnel and equipment required to carry out the foregoing

The above items have a direct relationship to the safety of the ship as a whole which, of course, is fundamental to the safety of the individual.

Directly opposed to the foregoing requirements for safe passage are the general hazards which may be encountered at sea. These can be grouped in the following manner:

1. Insufficient buoyancy due to flooding caused by:
  - a. Structural failure
  - b. Collision
  - c. Grounding
  - d. Shipping of water through openings
  - e. Mechanical failure
2. Insufficient stability due to:
  - a. Flooding
  - b. Improper initial loading
  - c. Change in loading under way by:
    - (1) Shifting of cargo
    - (2) Consumption of fuel
3. Fire
4. Explosion
5. Loss of control of ship by:
  - a. Loss of power

- (1) Propulsive
- (2) Electrical
- b. Loss of propeller
- c. Loss of rudder
- d. Derangement of steering gear
- e. Derangement of ground tackle

6. Loss of intelligence functions by:
  - a. Loss of power
  - b. Derangement of equipment
7. Injury to or loss of personnel

Though a ship might be constructed by the most skilled of craftsmen, and though it might be manned by the most skilled of mariners, it could easily succumb to one of these hazards through lack of proper basic design.

For this reason, regulations and standards affecting basic design as well as construction and operation have been set up in this country and throughout the world to insure the inclusion of proper criteria of safety in ships. The following is a summary of organizations who participate directly in the establishment of ship (and personnel) safety in the design stage:

1. By direct statutory regulation
  - a. The International Convention for the Safety of Life at Sea—SOLAS (Administered in the U.S. by the U.S. Coast Guard)
  - b. U.S. Coast Guard
  - c. U.S. Public Health Service
  - d. Federal Communications Commission
2. By other requirements such as insurance, permission for passage, subsidy, etc.
  - a. The American Bureau of Shipping
  - b. Various agencies for local and specialized purposes such as the Panama Canal Authority, the St. Lawrence Authority, the Suez Canal Authority
  - c. The Maritime Administration of the U.S. Department of Commerce
  - d. The owner and his design agent

Having introduced the requirements for the safe functioning of a ship, the hazards it must endure, and the organizations concerned with overcoming those hazards via the design stage, let us now examine some of the features which are derived from such basic design considerations.

It is difficult to think of a more basic

design requirement than that of the ship's floating, (buoyancy in the more technical language of the naval architect) which can be prejudiced by the several hazards previously noted.

Structural failure has occasionally caused the loss of a ship. Hull scantlings are basic design information and for merchant ships are generally derived from the ABS Rules. Derivation of these values is ultimately based on past successful design correlated with the calculated hogging and sagging stresses for a wave height equal to 1/20th the length of the vessel. Failures have almost always been associated with a local stress raiser condition, such as a sharp hatch corner, or with material deficiency, such as notch brittleness. ABS Rules now specify a type of steel with notch toughness to withstand alternating stresses in cold waters. Avoidance of local stress raisers is also covered by the rules and by plan approval. Anyone who has been on a ship pounding and straining in a heavy sea appreciates the basic hull structural safety derived from these rules.

Collision is another means of losing buoyancy rapidly. From the earliest days of steel ship construction, a collision bulkhead has been required forward. It has taken time, however, to cope with the possibility that a ship might be on the receiving end of a collision, and to make effective provision for it. This is accomplished through subdivision of the ship by vertical watertight bulkheads, so spaced that the flooding of one or more of the holds or spaces will not cause the ship to sink.

The SOLAS convention of 1929, 1948, and 1960 established increasingly definitive requirements for passenger vessels subdivision which have been put into U.S. law by the Coast Guard. The greater the size of the ship and the number of passengers, the greater the subdivision.

For cargo ships, however, there is no SOLAS or Coast Guard requirement for subdivision. For subsidized U.S. cargo ships, the U.S. Maritime Administration, via Design Memorandum No. 1 signed by Admiral E. S. Land in 1937, has required a factor of subdivision of 1.0. This means that each ship is capable of sustaining the flooding of one hold or space without sinking. Stability considerations will be discussed later.

From time to time the wisdom of this

requirement is re-examined, since in some cases it limits the length of holds for special cargoes. But peacetime and wartime experience has justified it. Many an American ship would have been lost without it.

In all considerations affecting flooding and loss of buoyancy, every effort is made to cope with the situation by pumping. Requirements for bilge pumps are standard with the Coast Guard and SOLAS. There is, however, a degree of flooding beyond which it is impossible for pumps to handle; subdivision carries on from that point.

One of the most effective means of preventing flooding due to grounding is the provision of a double bottom or the equivalent in a tank. ABS requires them for all ships 300 feet and over in length, and SOLAS requires a complete double bottom for passenger ships 249 feet or greater in length. Detailed requirements exist as to their configuration, such as the limiting of the bottom surface of any local well (sometimes necessary for condensate pumps) to within eighteen inches of the skin. This and the other detailed requirements are implicitly directed towards maintaining integrity of the inner skin in case of deformation and puncture of the outer skin through grounding. Fortunately, double bottoms are also desirable for functional purposes, such as the carriage of fuel and water and the provision of a flat surface for the stowage of cargo.

Flooding can also occur through the shipping of water through openings in the hull or decks in heavy weather or when the ship is in a listed condition. The ideal situation is to have no openings, but this is unattainable for practical reasons. Adequate hatch and often sideport openings are a necessity for loading and discharging the ship efficiently. The design and construction of their covers and closures must be such that they are rugged and reliable in service. The scrutiny of all parties in plan approval is directed to this end. Other requirements, such as stop and check valves for overboard discharges, have their origin in this flooding consideration.

The possibility of flooding due to mechanical failure of the stern tube shaft seal is considered in the SOLAS requirement that all passenger ships have a separate compartment around this area. On single screw cargo ships, this possibility is usually taken

care of by the containment of the shaft alley, the bulkhead gland, and the watertight door at the aft end of the engine room. Other mechanical protrusions, such as bow thruster drive shafts and active stabilizer shafts, are also examined from this point of view.

Closely associated with the foregoing discussion of protection against loss of buoyancy is the aspect of stability. It is possible for a ship to remain buoyant and yet cause loss of life to its passengers and crew; the extreme case being that of a ship capsized. The effects of loss of buoyancy and stability are mutually dependent and augmenting and usually result in progressive flooding and sinking of a vessel unless specific provisions have been made in its basic design.

With regard to loss of stability due to flooding, after assuring buoyancy through subdivision, as previously discussed, each condition of flooding is examined to ascertain how much stability remains in the damaged condition. The worst anticipated service conditions are assumed for the intact ship prior to flooding. Often the calculations show that there would be insufficient stability in a particular service condition. Corrective measures are then devised to assure stability for these conditions in service through requirements for fixed ballast or the filling of certain fuel oil tanks with liquid ballast. Other features, such as longitudinal bulkheads and tanks, which might prejudice stability in the damaged condition are examined and cross-flooding ducts are provided if the effect is serious. Here again as with subdivision, stability in the damaged condition is required for passenger vessels only by SOLAS and the U.S. Coast Guard. The Maritime Administration is the agency invoking these requirements for cargo ships. The net result is the same as for subdivision—a safer ship for peacetime and a more able ship for national defense.

Insufficient stability can also result from improper loading of cargo, shifting of cargo under way, and consumption of fuel and water. The loading of cargo and the pattern of consumption of fuel are items subject to the decision of the master. Accordingly, it is required by SOLAS and the Coast Guard that the master be provided with sufficient information to determine the metacentric height or stability of the vessel at all times. The required inclining of the ship at the

time of delivery checks its inherent stability, and the required stability booklet is directed towards enabling him to determine the stability for other conditions of loading. The carriage of bulk cargoes, such as grain, presents special hazards due to a possible shifting in heavy weather. Accordingly, provisions for grain or shifting hazards are made—the net effect being somewhat similar to that of swash plates in a tank.

The next major hazard is fire, probably the most devastating and terrifying of all the peacetime hazards at sea. Here, the ideal solution would be to have a ship built of fireproof material carrying fireproof cargo. Turning to reality, we try to cope with fire in the design stage through as extensive a use of fireproof materials as possible, containment, detection, means for extinguishing, and provisions for the escape of personnel. SOLAS and Coast Guard requirements for passenger vessels are extensive and exacting, whereas cargo ship requirements are less stringent.

Regarding fireproof materials, SOLAS defines incombustible material as "that which neither burns nor gives off inflammable vapours of sufficient quantity to ignite a pilot flame when heated to approximately 1382°F (or 750°C). Any other material is a 'Combustible Material'." For passenger vessels, the Coast Guard requires the extensive use of incombustible materials for ceilings, linings, furring, and insulation in accommodation and service areas. For cargo ships, the rules generally discourage the use of combustibles but do not specifically prohibit them except for corridor, bulkheads and deck coverings within accommodation spaces.

Containment is effected by the use of fire resistant bulkheads, generally designated Class A and Class B, leaving the capability of preventing the passage of smoke and flame up to the end of the one-hour and the one-half-hour standard fire tests respectively. On passenger ships, main vertical zones not more than 131 feet in length are established through the use of Class A bulkheads. Other spaces which present a fire hazard to accommodations, such as galleys, motion-picture projection rooms, and machinery spaces, on U.S. passenger ships are similarly isolated by this type of bulkhead, in conjunction with the use of a detection system and the use of incombustible material. Foreign passenger

ships by the SOLAS convention have two other methods of construction from which to choose. Method I permits divisioning within a zone by Class B bulkheads and does not require detection on sprinkler and fire detection systems. Except for passageways in accommodation spaces and for emergency generator rooms, Class A or Class B bulkheads are not required for U.S. cargo ships.

Fire and smoke detection systems on U.S. passenger ships protect public space, cargo spaces, and other areas which have high potential for fire such as paint rooms, film lockers, and storerooms. Cargo ships have a smoke detection system monitoring cargo spaces and other areas having a fire potential.

Comprehensive means for extinguishing fires are required for U.S. passenger and cargo ships, with the more extensive requirements being for passenger ships. Means include two or more fire pumps, an extensive firemain and hose facility, fixed CO<sub>2</sub> systems for cargo and other relatively inaccessible spaces, CO<sub>2</sub> or foam systems for boiler spaces, sprinkler systems for special passenger ship areas, hand extinguishers, gas masks, and other portable fire-fighting equipment.

Means for escape of personnel from fire areas is covered in considerable detail by both SOLAS and the Coast Guard for passenger ships. It is generally based on the principle that two separate means are required, and that access between the two within the space protected must not be restricted.

It should be noted that although the SOLAS convention of 1960 accomplished a great deal in upgrading world side shipboard protection against fire, the requirements of the Coast Guard for U.S. cargo and passenger vessels still result in a higher degree of safety.

The hazard of explosion seldom materializes on U.S. ships today, probably because of the stringent rules of the Coast Guard regarding the construction of pressure vessels and the setting of safety valves. This is a far cry from the early river steamboat days when many a disaster occurred from boiler explosion. Although normally taken for granted, it is an important area which is protected by proper basic machinery design coupled with proper operating practice.

Other potentials for explosion or rupture, such as ships tanks and receivers, are also closely regulated by Coast Guard rules for design, construction, and testing.

With the ship reasonably well protected against sinking, capsizing, fire, and explosion, it now becomes necessary to provide assurance that its position afloat can be controlled. The most obvious requirement is that its propulsive and electric power be available. Equally necessary are the requirements that the propeller, rudder, steering gear, and ground tackle be available and in working order.

Concerning propulsive power, there is little doubt that the safety of the ship is generally dependent on it and vitally so under certain conditions, such as a violent storm at sea, proceeding with a lee shore, proceeding and maneuvering in congested waters. Although there are ABS and Coast Guard rules covering various aspects of construction and materials used in machinery and electrical components and their systems, the reliability and consequent availability of equipment on merchant ships depend greatly on the basic design, the integrity and skill of the manufacturer, and upon the operational and maintenance practices of the owner and crew.

Historically, where continuous operation of a plant depends upon a component, component redundancy or systems back-up has been incorporated into the design. Examples of redundancy in marine power plant design are numerous, such as boilers, auxiliary generators, feed pumps, lube oil pumps, fuel oil pumps, and fuel oil heaters. Examples of systems back-up are the auxiliary feed system, lube oil gravity tank system, and auxiliary circulating water system cross connection. Some components have inherent redundancy usable for operation at reduced leads such as cross-compound turbines, the two high-speed trains of reduction gears, and the tubes in heat exchangers. Many of these features are currently being re-examined and the techniques of reliability assessment are beginning to be applied, hopefully to obtain rational, comparative answers to the problems. Carrying on with the pioneering efforts of the Navy, the space, and the electrical industries, the Society of Naval Architects and Marine Engineers has established a panel to assist in the development of meaningful methods and criteria for the marine

industry. The emphasis is definitely on "meaningful" since, as every student in first year algebra knows, it is quite possible with a very small amount of algebraic manipulation to prove that "one" is equal to "two."

The problems inherent in the increased use of centralized control deserve special note. To date, in this country, definitive rules and regulations have not been adopted because of the controversial issues involved. ABS has issued a guide, and the Coast Guard has proposed a set of tentative regulations. At present, however, the official status of these documents is purely "advisory." Nevertheless, from these past several years of development, several fundamental principles for safe design have developed. First, local control which bypasses the central control system must be provided to permit continued operation in case of system failure. Second, control systems must be designed on "fail safe" principles. Third, sufficient manpower must exist to bring the ship safely to its destination in case of complete failure of the centralized control system.

With these broad principles in mind, the designer must advance into the basic design, creating a system which is adequate and safe for the intended manning but which is also economic. It is entirely possible to truly automate every component, every valve, every system using complex monitoring, feed back, and computer technology. At the present time, however, the cost of such a system would be very high. Furthermore, the introduction of the additional equipment and the many safeguards creates greater opportunity for control system failure and false alarms. Reliability analysis can be a useful tool in aiding the designer to reach a proper decision.

Returning to the consideration of measures which have been adopted in the basic design to assure continuous propulsive power, today's plants are dependent on electric power for continuous operation. Two full-size ship's service generators are therefore required by Coast Guard rules. Furthermore, an emergency generator outside of the machinery space is needed to supply vital lighting, communication, and other services. It is evident that electric power is so vital that redundancy plus back up is used to assure its availability for vital services.

The propeller and rudder are also obviously necessary for ship control, and the adequacy of design is closely controlled by ABS rules and plan approval.

The vital nature of the steering gear and its control system are recognized in the ABS and Coast Guard requirements by the requirement for back up or redundancy. Most units today are designed on the redundant principle (with the exception of the hydraulic ram itself) with two power units, two control systems, and two separate power supplies.

As a last resort in coastal and inland waters, the anchor can be used to control the ship's position. It is, of course, most often used in a routine manner. Here again its importance to ship safety is reflected in the ABS requirement that all ships have two bower anchors. The important function for the safety of the ship is to get the anchor down and the chain out. It is significant that the function of recovery, while very desirable, is not redundant and only one power unit for the anchor windlass is required.

Having endowed the unsinkable, upright, fire and explosion proof ship with reliable means for controlling its position, it is now necessary to provide an intelligence capable of directing the movement of the ship and making the decisions required by routine and emergency shipboard situations. In a general sense, this is presently accomplished through a man-machine relationship informed by an externally oriented information system plus an internal information system. The external information system includes radiotelegraph, radiotelephone, radio direction finder, radar, Loran, and facsimile systems as well as flags, whistles, horn, searchlight, and blinker light. It is interesting to note that the radar, Loran, facsimile, and UHF systems are not required by SOLAS or the F.C.C. Their presence, however, in foul weather and in congested waters is indeed an aid to the navigation of the ship.

The internal information system includes the engine order telegraph, alarm systems of all types, rudder angle indicator, watch call, data logging, and numerous other systems. Vital systems for ship safety such as the engine order telegraph or bridge to engine room servo-system for centralized control are fed from the emergency bus and also

have a back up system of voice tubes or sound powered phones.

The review has been concerned with the safety considerations in basic design directed towards keeping the ship intact, controllable, and inhabitable as a vehicle. If, however, disaster should strike, provision is made to abandon ship. The stringent rules of the Coast Guard and SOLAS regarding the provision, construction, equipping, and launching of lifeboats and other life-saving equipment define closely what the basic design must include. Amongst other regulations, the latest rules require that sufficient lifeboat capacity be provided on each side to accommodate all persons aboard a cargo ship plus liferaft capacity for at least one-half the total complement. For passenger ships, the impracticability of such a provision is recognized, and lifeboat capacity is provided on each side for one-half the number of people aboard with an additional provision for 25 per cent of the total number of persons in the form of liferafts. In this sense, it is somewhat safer to travel on cargo ships.

What can be concluded from this discussion of safety considerations in the design of U.S. merchant ships?

The first conclusion is that, in addition to detailed consideration for individual safety, broad and fundamental considerations of safety are incorporated into the basic design of U.S. merchant ships.

The second conclusion is that a "completely safe" ship is not feasible. A recognition of the other factors involved is always necessary. For illustration, a "completely safe" ship from the point of view of subdivision would have very close spacing of its bulk-

heads but would not be able to carry cargo of any magnitude. On the engineering side, the "completely safe" ship would have at least two propellers, two rudders, and two machinery plants. In competitive situations, this would be disastrous. The decisions to be made for ships in this respect are little different from those which are made for other modes of transportation.

The third conclusion is that there is always a considerable amount of evaluation required of an owner and a designer to match different degrees of protection against the effectiveness to be realized and the economics of the situation. It is not an unhealthy attitude to examine all features including those of safety with an economics probe. It would be, however, very unhealthy to render a decision in such matters on economics alone. The necessity for regulatory participation in safety matters originated to a large degree from this type of approach.

The fourth conclusion is that U.S. merchant ships today incorporate the highest standards of safety in the world. There is little doubt that this contributes to the higher cost of U.S. ships. This approach is derived from and supported by the average American's concern for safety of personnel. It is also possible that in the long run the extra investment pays off with a lower casualty rate and with ships better equipped for national defense.

It is gratifying to note that the upgrading of the international safety requirements of SOLAS at the 1960 and previous conventions was greatly influenced by the U.S. position on safety. It is an international accomplishment in which the citizens of the United States can take pride.

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## A REVIEW OF MARINE CASUALTIES

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A review of recent significant marine casualties has become a recurring part of the Coast Guard session of the National Safety Congress. As representatives of the

marine industry, I am sure that you are aware that the master of the vessel involved in a marine casualty is required to make a report to the Coast Guard and the case is

investigated to determine the cause to the extent possible. Upon completion of the casualty investigation involving a commercial vessel, the local marine inspection office forwards the record of the investigation to the commandant.

The Casualty Review Branch within the Merchant Vessel Inspection Division of the Office of Merchant Marine Safety is directly responsible for the custody and review of these records. Its primary function is the analysis of the accident and the compilation of statistics for use in the development, improvement, and enforcement of materiel and operational standards. After abstracting and coding the varied information from the reports for automated data processing procedures, the cases are reviewed for content, accuracy, and policy in conformance with established laws, regulations, and merchant marine safety directives. They are also reviewed to determine what further action, if any, should be taken.

If the investigative report reveals a technical or engineering problem involving electrical equipment, boiler or other machinery equipment, lifesaving appliances, hull structures, or doubtful stability, it is referred to the Merchant Marine Technical Division. A rather recent addition to this Division is the Chemical Engineering Branch which concerns itself with the problems enumerated in the transportation of chemicals in bulk. Similarly, if it concerns the inspection or manning of vessels, it is referred to appropriate personnel within the Merchant Vessel Inspection Division. If it involves personnel action concerning licensed or documented seamen or state pilots, it is referred to the Merchant Vessel Personnel Division. In addition, it may be referred to the Office of Operations if it concerns cargoes within the purview of the Dangerous Cargo Regulations.

Information from these reports is often referred to various Advisory panels of the Merchant Marine Council and to industry associations.

The Casualty Review Branch also maintains liaison with many governmental agencies which have a direct interest in vessel operations and allied marine industries. The Casualty Review Branch maintains significant interest in activities involving mer-

chant marine safety which are too numerous to discuss at this time.

The frequency rate of marine casualties has remained fairly constant for a number of years. During the past year, however, there has been an encouraging reduction in the number of casualties which have resulted in loss of life. Although sheer coincidence may account for a portion of this reduction, there is evidence that the increased use of bridge-to-bridge radio, inspection of aging vessels conducted by the traveling inspectors, and greater utilization of the information gained through the investigation of marine casualties have played a significant part. Further, the use of automated data processing has permitted problem areas to be scrutinized on a recurring basis.

#### *Fiscal Year 1963*

There were 2134 vessel casualties such as collisions, foundering, fires and explosions, and groundings reported and investigated by the Coast Guard Marine Inspection Offices during Fiscal 1963. Of these casualties there were 84 cases in which a total of 230 American or foreign persons lost their lives. It is readily apparent that deaths as a result of casualties to fishing vessels and towing vessels, 68 and 58 deaths respectively, are most significant.

Foundering and capsizings of fishing vessels accounted for 47 of the 68 deaths. The most notable fishing vessel foundering was that of the *Midnight Sun* which alone accounted for 11 lives. Foundering and capsizings of towing vessels accounted for 18 deaths with the foundering of the *Gwendoline Steers* on Long Island Sound claiming nine of these lives.

Towing vessels colliding with pleasure vessels remains a problem on our inland waterways with nine of these casualties accounting for 13 deaths, while other collisions involving towing vessels accounted for 24 lives. The most notable collision involved the Norwegian tank vessel *Boheme* and the uninspected tug *Bonnie D* pushing four tank barges in the Mississippi River wherein 20 crewmembers on the flame engulfed tank vessel perished.

The disappearance of the molten sulphur carrier, the *Marine Sulphur Queen*, accounted for the greatest single loss, with

a total of 39 persons missing and presumed drowned.

Explosions and fires on board tank vessels and tank barges killed 12 shore workers and one crewmember. Casualties involving freight vessels were insignificant with only one death as a result of a cargo fire and one death as a result of the material failure of a towing shackle while being used with a nylon hawser. There were no passenger lives lost during this year as a result of marine casualties to large inspected passenger vessels.

#### *Fiscal Year 1964*

During Fiscal Year 1964 there were 2308 vessel casualties such as collisions, foundering, fires and explosions, and groundings which were reported and investigated by the Coast Guard. Of these casualties there were 93 cases in which a total of 191 American or foreign persons lost their lives. Once again, deaths as a result of casualties to fishing vessels and towing vessels accounted for a high number of the total, 69 and 43 respectively. Twenty-seven cases of foundering or capsizings of fishing vessels accounted for 51 of these 69 deaths.

Towing vessels' foundering and capsizings accounted for 15 lives. The most notable was the disappearance of the *Meitowar* with the loss of four lives off the east coast. Severe weather conditions, the age of the vessel, lack of adequate watertight closures and lack of stability were contributing factors to the loss of this vessel.

Collisions with pleasure vessels and other collisions accounted for 23 of the 43 lives lost in casualties involving towing vessels. The most noteworthy collision involved the *Rebel Jr* wherein the unlicensed operator while on watch alone, in the middle of the night, lost consciousness, with the result that the tug and tow veered from the intended course and crashed into the Lake Pontchartrain Causeway. Immediately after, a bus plunged through the opening into the lake with the resultant loss of six lives.

Fires and explosions on tank vessels and tank barges accounted for 10 deaths. In addition to the six lives lost in the *Bunker Hill* and *San Jacinto* disasters, three more lives were lost on tank vessels and one life was lost on a tank barge. The small inland

tanker *Newark*, while loading a cargo of fuel oil, suffered a flash fire and explosion causing fatal burns and injuries to two crewmembers. A large tanker, the *Cities Service Norfolk*, while discharging gasoline suffered an explosion and flash fire in the amidship pumproom. The resultant force catapulted an able seaman into a railing, killing him almost instantly. On the tank barge *Murray Mac* a shipyard worker was killed when an explosion occurred during hot work repairs to the bottom of a hollow skeg.

With reference to casualties involving freight vessels and barges, two casualties claiming three lives involved fires and explosions as a direct result of the ignition of paint vapors. Boiler explosions of steam boats with the attendant disastrous loss of life during the 1800's have all but disappeared from the marine scene today, however, one boiler casualty on the Great Lakes resulted in the loss of one life.

The casualty record of small passenger vessels was marred during this fiscal year by the capsizing of the motorboat *Two Georges* with the resultant loss of five lives. It is significant to note however, that since these vessels came within the inspection laws and regulations in July of 1958, the toll in death has been significantly reduced. Once again, there were no passenger lives lost during this year as a result of marine casualties to large inspected passenger vessels.

#### *Fiscal Year 1965*

Last but not least, but notably significant, are the casualty figures for Fiscal Year 1965. There were 2179 vessel casualties such as collisions, foundering, fires and explosions, and groundings which were investigated by the Coast Guard. This means that there were fewer casualties than the previous year and about the same number of casualties as in Fiscal Year 1963. The greatest difference is found in the casualty and death rate involving all vessels which is considerably less than for prior years.

During 1965 there were 56 cases in which a total of 125 American or foreign persons lost their lives. As I have previously mentioned this compares with 93 cases and 191 lives lost during 1964 and 84 cases with 230 lives lost during 1963.