

MARINE CASUALTY REPORT

ORIGINAL

FILE

SS BADGER STATE

EXPLOSION ABOARD AND EVENTUAL SINKING

IN THE NORTH PACIFIC OCEAN

DECEMBER 26, 1969

U.S. COAST GUARD

MARINE BOARD of INVESTIGATION REPORT

and COMMANDANT'S ACTION

ACTION BY

NATIONAL TRANSPORTATION SAFETY BOARD

DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C. 20591

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26 DECEMBER 1969

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SS BADGER STATE
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ACTION BY THE NATIONAL TRANSPORTATION SAFETY BOARD

This casualty was investigated by a U. S. Coast Guard Marine Board of Investigation convened at Seattle, Washington, on January 14, 1970. Representatives of the National Transportation Safety Board attended the proceedings as observers. The National Transportation Safety Board has considered only those facts in the investigative record which are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the casualty and to make recommendations.

SYNOPSIS

During a storm in the North Pacific Ocean in the early hours of December 26, 1969, the cargo of military explosives aboard the SS BADGER STATE broke loose. The ship radioed a distress call and made strenuous efforts to restrain the rolling bombs. An explosion followed which opened a hole in the starboard side, started minor fires, and caused other structural damage. The crew of 40 abandoned ship. The ship's liferafts were launched but blew away. While the lifeboat with 35 crewmembers was alongside the ship, a 2,000-pound bomb fell out of the hole in the ship's side and into the lifeboat, capsizing it. A merchant ship arrived about one-half hour after the explosion, rescuing 14 survivors. The BADGER STATE sank on January 5, 1970.

The National Transportation Safety Board determines that the probable cause of this casualty was the failure of the bomb stowage and packaging system to restrain the cargo under the ship motions that occurred during the adverse weather encountered on this voyage, particularly on the morning of December 26, 1969.

The following are considered to be contributing causal factors:

1. The lack of a stowage design criteria that could be correlated with environmental conditions, ship motions, or force loadings, which could then be implemented by

engineering design or tests.

2. Utilization of stowage practices which create "chain series" of potential failure points, dependent on custom-made supports that are sensitive to workmanship quality variations. In the method used, a break in the "chain" also caused all the other "connections" in the chain to fail. On the BADGER STATE, the sides of the vessel were used as fixed boundaries between which the cargo was wedged with blocking. With no intermediate boundaries, the loosening or failure of a single block or wedge released the whole row of pallets.
3. The vulnerability of the pallet band design to external impact forces which caused the banding to fail and to release the bombs.
4. The undesirable ship response characteristics caused largely by the relatively high metacentric height (GM), resulting from the manner of vertical distribution of cargo and fuel. This increased the acceleration forces at the ends of the rolls, causing increased side loads on the stowage. The lack of a full load of cargo and the fact that bilge keels were not reinstalled on the vessel after their removal in 1966 rendered the ship more responsive to wave forces.
5. The unusual severity of the storm which struck on December 26 and caused the ship to roll to 52°. The occurrence of the storm during darkness also made it difficult to see the direction of the oncoming waves and prevented conning the vessel to meet the waves head-on.
6. The inability of Fleet Weather Central to forecast the storms of December 25 and 26.

The following contributed to the loss of life subsequent to abandoning ship:

1. The failure of the ship's and air-dropped liferafts to remain in the vicinity of the accident where the crewmembers could board them.
2. The failure of the lifeboat painter which deprived the crew of a means to shear the lifeboat away from the ship.

3. The falling of a 2,000-pound bomb into the lifeboat, killing or injuring some crewmembers and overturning the lifeboat.
4. The lack of better techniques to detect a person in stormy seas and to retrieve him.
5. The characteristic which allowed the lifejackets to slide upward and to push the head forward, tending to drown exhausted or unconscious survivors.

SUMMARY OF FACTS

The BADGER STATE, a 441-foot C2-type cargo vessel, built in 1944, was owned by States Marine Lines, Inc., and under time charter by the Military Sea Transportation Service (MSTS). The BADGER STATE, loaded with fuel and water for the coming voyage and possessing an ammunition loading permit issued by the Coast Guard, commenced loading cargo under U.S. Navy supervision at the Naval Ammunition Depot, Bangor, Washington, on December 9, 1969.

During the loading period, a number of changes were made from the original loading plan. One change was made to improve the trim of the vessel. Some minor changes also resulted from the nonarrival of certain ammunition items. The master considered that the assigned cargo of about 5,000 tons would be too small to give the ship the desired riding qualities and asked for additional cargo. He was advised, however, that additional cargo was not available. The master then requested that a better vertical distribution of the cargo be made by putting a greater proportion of cargo at a higher level within the ship. As a consequence, the preload plan was changed in two holds and had the net effect of moving up one deck level 398 short tons of ammunition.

Inspection of the loading operation and of the blocking and bracing of the cargo was performed by the ammunition depot supervisory loading personnel and members of the ship's crew. During the loading operation, the steel banding which held the bomb pallets sometimes broke on the dock and in the holds and had to be replaced. Questions concerning the adequacy of stowage were resolved satisfactorily between the ship's inspector and the loading supervisors before any hatches were secured. This included the master's request that access be provided for inspection of all stowage areas while underway. This was accommodated in all hatches except in the No. 3 lower hold where it apparently was not practical. The ship also requested that the 2,000-pound bombs in the No. 5 upper 'tween decks be tommed (held down with bracing from the overhead). After a conference with the depot personnel, it was concluded that in view of the large weight of the bombs, this would not be necessary.

Loading of the BADGER STATE was completed and accepted by the ship's officers at 1420 P.s.t., December 14, 1969. The cargo consisted of 5,336 long tons of palletized unfuzed aerial bombs of 500-, 750-, and 2,000-pound sizes and associated crated hardware. Steel bands were used to hold the bombs to each other and to the metal pallet frames. The 2,000-pound bombs were packed two to a pallet, and the noses of these bombs protruded 29 inches beyond the pallet frame. These 2,000-pound bombs were stowed in one layer of 100 pallets in the No. 5 'tween deck. Wood planking was placed between the deck and the steel pallet frame as required. Wood sheathing and sweatboards were placed between the cargo and the steel hull. All void spaces between pallets were filled with wood blocking. Where the bombs were loaded nose to nose, they were kept separated with wood blocks. Due to a rise in the deck, about a dozen of the pallets in the center of the hatch were about 4 inches above the surrounding pallets.

In addition to the 5,336 tons of cargo, the BADGER STATE had on board at completion of loading 10,640 barrels (1,604 tons) of fuel oil, 611 tons of water, 9 tons of lubricating oils, and about 295 tons of dunnage (lumber securing the cargo). At the request of the ship, spare lumber was placed aboard in the event any stowage repairs might be required on the voyage. At this loading, the vessel's draft was 22 feet forward and 25 feet 4 inches aft, compared with mean full load draft of about 28 feet. The master calculated the metacentric height (GM) at between $5\frac{1}{2}$ to 6 feet. The GM was also separately computed by an MSTs representative as a check for minimum stability at a value of 4.7 feet. A postaccident check by the Coast Guard gave a calculated GM of 5.27 feet at departure and a final value of 4.20 feet on the accident date due to fuel and water consumption and free surface effects.

The BADGER STATE sailed the evening of December 14, 1969, for Da Nang, Republic of Vietnam, with a crew of 40. The sailing route was determined by the Naval Control of Shipping Organization (NCSORG) with the advice of the Navy's Fleet Weather Central, Alameda, California, which was aware of the vessel's cargo and destination. The original planned route took the vessel across the Northern Pacific at about latitude 51° N. to longitude 162° W., then diagonally south-southwest to latitude 30° N., and then toward the Luzon Straits.

On the morning of December 15, the BADGER STATE entered the Pacific Ocean on its intended course at a speed of 14.8 knots and soon began to encounter heavy weather. The ship was uncomfortable, with "stiff" riding characteristics and a "snap roll." The master instructed the engineer officer to slack all the fuel tanks so that the GM could be further reduced by creating additional free surface. Routine 8 a.m. reports of position, course, speed, and sea and weather were commenced to Commander Task Force 31 (CTF 31). Later that day, CTF 31 sent a diversion order (DIVERTORD 415), taking the BADGER STATE on a slightly more southerly route to permit a more rapid transit to the lower latitudes

if weather conditions became favorable. On December 16, the BADGER STATE reported on course and speed with following winds and seas, confused swells, and rolling to 40°. The crew routinely inspected the cargo and made repairs to the stowage as required. A second diversion order was sent to the BADGER STATE on the morning of December 17, directing the vessel southward to avoid severe weather; however, the ship reported its inability to comply completely due to heavy rolling to 45°. On this date, also, the vessel's steering gear was inoperative for about 1½ hours for minor repairs, during which time the vessel took several rolls to 40°. That evening, the BADGER STATE reported a shift of the cargo in the No. 3 lower 'tween deck of palletized 500-pound bombs. The sheathing, sweatboards, and other dunnage had splintered and one bomb was pressing against the hull. The ship reported, 4½ hours later, that the cargo had shifted in four additional holds. The ship's crew completed resecuring the cargo by about mid-morning of December 18. The vessel then requested a new routing since it could not comply with the last southerly diversion order received.

During the afternoon of December 18 (190145 G.m.t.), the BADGER STATE was given a new westerly course which would take it to a point about 35 miles south of Adak Island. During the afternoon of December 19, the vessel was slowed so that a cement patch could be placed over a small leaking area of hull in the shaft alley. Prior to reaching its turn point south of Adak at longitude 177° W., the BADGER STATE turned southwest at longitude 170° W. at 210530 G.m.t. and requested weather forecasts from Fleet Weather Central. During this period, continuous inspection and frequent repairs to the stowage were required in most of the holds. Blocking lumber was being broken by the shifting cargo. Where the blocking between bomb noses failed, some bomb noses slid on top of the opposite bomb, causing some banding straps to break. At 220218 G.m.t., a new diversion order directed the ship on a west-southwesterly course. Then the ship reported she had been hove-to for 6 hours because of extreme rolling to 35°, but the master considered he could comply with the latest diversion order. However, at 230900 G.m.t., the ship reported she could not adhere to the new course because of heavy rolling to 35°. Further shifting of the cargo had occurred and shoring material was becoming scarce. The master radioed "request urgently that you get me south to good weather as soon as possible." Fleet Weather Central sent a weather advisory direct to the ship at 220940 G.m.t. predicting gradually improving sea conditions with westerly progress. At 231720 G.m.t., Fleet Weather Central sent its first weather forecast direct to the ship and continued this service for the remainder of the voyage.

At 231920 G.m.t., the fifth diversion order was sent to the BADGER STATE for a southwesterly course with allowance for adjustment to suit the ship's needs. The ship reported at 232100 G.m.t. that she was running before swells on course 145°. Heavy banging noises were reported coming from the No. 3 lower hold which had no access for inspection. All cargo holds were reported in need of reshoring.

Diversion to a safe port for resecuring was requested. The BADGER STATE received its sixth diversion order to proceed to Pearl Harbor, 1,600 miles away to the southeast. Fleet Weather Central's forecast of 241920 G.m.t. included an outlook for continued improvement to the southward, with moderate conditions expected south of 35° north latitude. By 242300 G.m.t., the ship reported the situation was under control but continued reshoring was being done in all holds. Some cargo was steel-to-steel against the ship. The cargo tended to come adrift at rolls exceeding 20°. The captain radioed that an escort might be required if the situation deteriorated further.

Shortly after 2 a.m., December 25, a severe, unpredicted storm passed over the BADGER STATE. Hurricane force winds produced large confused seas. The ship rolled heavily and on one occasion, rolled 50°. The cargo was reported loose in all holds. An escort and shoring material were requested as soon as possible. The seventh and last diversion order was sent to the BADGER STATE at 260430 G.m.t. to divert to Midway Island as the nearest safe port. The SS FLYING DRAGON, about 500 miles away, was diverted to intercept the BADGER STATE and provide escort. By late evening of December 25, the BADGER STATE had temporarily resecured the cargo. She was running before a westerly gale and could not divert towards Midway without causing serious consequences to the cargo.

A second unpredicted storm hit the BADGER STATE in the early morning hours of December 26. One mountainous wave rolled the ship to port 52°. This dislodged the port lifeboat, damaged the davit and other launching accessories, and rendered the boat useless. The heavy rolls caused the bomb stowage in the No. 5 upper 'tween deck to fail. The metal bands on the pallets broke and numerous 2,000-pound bombs became adrift. With each ship roll, the bombs rolled or slid, striking each other or the ship's steel hull where the wood sheathing had been splintered away. Small holes were punched in the ship's side by the battering action of the bombs. Several bombs fell into the hold below through a hatch where the hatch boards had carried away.

All available crewmembers were turned to in an effort to stop the bombs from moving about the hold. Several of the hatch pontoons were forced partially open and all available nonflammable materials were thrown into the hold. This included mattresses, rags, frozen meats, mooring lines, and spare lifejackets. Finally, one end of a hatch pontoon was lowered into the hold on top of some of the bombs and the other materials. These efforts were partially successful, but loose bombs continued to roll around in the hold, generating heat and sparks in their collisions.

The master ordered a distress message broadcast upon first being informed that the 2,000-pound bombs were loose. This SOS activated the autoalarm on the Greek merchant ship KHIAN STAR which was 40 miles westward. The message was also received by the Navy's search and rescue

coordinator at Midway. The KHIAN STAR radioed the BADGER STATE that it was coming to assist. The crew aboard the BADGER STATE was now in a state of fatigue having worked long hours and having gone virtually without sleep for days because of the severe ship motions in the seaway. The master had been on the bridge almost continuously for 4 days.

When the KHIAN STAR appeared on the horizon, the master of the BADGER STATE attempted to alter course in the direction of Midway, still in hope of reaching a safe port. All personnel had been ordered off the weather decks for coming about. The beam swells produced excessive rolls on this heading, so the master continued to swing the vessel to place the seas on the stern. At this time, a low detonation occurred of one of the 2,000-pound bombs. The hatch pontoons were blown off, the booms were bent, and burning materials scattered about deck. A jagged hole about 12 feet long and 8 feet high was blown in the starboard side of the hull.

The master sounded the abandon ship signal. The boilers and throttle were secured and the engineroom was abandoned. All hands had previously donned lifejackets. Thirty-five crewmembers entered the starboard lifeboat and were lowered away as directed by the master who remained aboard. The heavy seas made launching difficult and one crewmember injured his foot slightly in the process. The lifeboat's sea painter either came loose from the vessel or parted during launching. When the boat was waterborne, the crew operated the hand-propelling gear, but without apparent effect because of the sea conditions, the relative motion of the ship, or failure to engage the clutch. Difficulties were encountered in shipping the rudder and it was never installed. The lifeboat drifted aft while being thrown against the ship by the seas. In one such encounter, a crewmember was seriously cut by the jagged edge of the hole that had been blown in the ship's side. When the lifeboat drifted further aft and was abeam and below this hole, a 2,000-pound bomb came out and fell into the lifeboat. Some men escaped by jumping out of the lifeboat as it capsized. Prior to launching the lifeboat, one of the men in the lifeboat had seen another bomb roll out of the hole but had not mentioned this to anyone. The master and the four crewmen remaining aboard were unaware that a bomb had fallen into the lifeboat and capsized it, although one crewmember had seen some of lifeboat occupants in the water and had thrown them about four liferings.

While the lifeboat was being boarded, four other crewmen were launching the ship's two inflatable liferafts on the flying bridge. After the raft is thrown over the side, the sea painter acts as a tripping device to inflate the raft and to keep the raft from blowing away before it can be boarded. Both rafts inflated; however, the port raft drifted away immediately and the starboard raft did likewise a short time later. Although the rafts had automatically deploying sea anchors, both drifted beyond the reach of any survivors.

The master and the remaining four crewmembers donned liferings over their lifepreservers and went into the sea over the port side. The waves were about 20 feet high and the water temperature was 48° F.

The KHIAN STAR saw the explosion aboard the BADGER STATE and about 30 minutes later arrived near the overturned lifeboat. Many of the crewmembers were still clinging to the boat. Some other crewmembers were far from the boat and swimming to get away from the ship which they feared would explode. Some of the men at the overturned lifeboat tried to swim to the KHIAN STAR but were carried out of reach by the large waves. The ship made a pass close to the lifeboat and using Jacob's ladders, net slings, and lines, managed to pick up five or six men. Two more passes were made and two or three men were picked up each time. Some men were hauled up almost to the main deck but were caught by large waves and washed away. Some were too weak to help themselves and in about an hour after the KHIAN STAR's arrival, many were dead, floating head down in the water. With no more survivors near the lifeboat, the KHIAN STAR searched the vicinity for others. One rescuer jumped from the ship with a line attached to himself but found that the man in the water was already dead. The last survivor rescued was located about 5 miles from the BADGER STATE.

At about the time the KHIAN STAR first reached the overturned lifeboat, a USAF rescue airplane arrived on the scene and dropped six liferaft kits and kits with food, medicine, and radio receiver-transmitters. The liferafts inflated and were immediately caught by the strong winds and flipped repeatedly over the waves and out of the area. However, a line from one liferaft fell near one of the survivors at the lifeboat who managed to hang on while six others got aboard with difficulty. Three of these six men were subsequently rescued by the KHIAN STAR.

Survival was made difficult by the cold water and the large waves which crested and broke, driving the men deeply underwater. Some swallowed a considerable amount of salt water until they learned to cover their mouths and noses with their hands whenever a wave broke overhead. Hanging onto the overturned lifeboat was difficult because the breaking waves would submerge it deeply and pull the survivors down with it. Albatross attacked the men in the water, but none of the survivors received any injuries in this manner. Some survivors had difficulties with their lifejackets. The jackets moved upward on their bodies and failed to keep their heads face up in the water. The deceased were seen floating face down. In their weakened state, some survivors could not haul themselves aboard the liferaft even with the assistance of those already aboard. Others could not hold onto the lines and ladders from the KHIAN STAR and fell back into the sea while being hauled up. Those who managed to be hauled aboard had to be carried below.

The KHIAN STAR rescued the master, two of the four men who had gone into the water with him, and 11 others, for a total of 14 survivors. The two liferafts from the BADGER STATE and another two dropped by the aircraft were found empty.

The search was continued by the KHIAN STAR, joined by Air Force and Coast Guard aircraft. The SS FLYING DRAGON arrived on scene about 27 hours after the explosion and commenced searching for survivors. A number of bodies were sighted and one was recovered. Other vessels transiting the area searched during passage. No more survivors were found.

The Navy salvage tug USS ABNAKI, with a Navy ordnance team aboard, arrived at the site at 310921 G.m.t. to attempt to salvage the BADGER STATE. However, evidence of fire and intermittent colored flashes indicated that the risk of coming close to the BADGER STATE was too great. The ship settled slowly by the stern as seas washed into the hole on her starboard side. The BADGER STATE sank on January 5, 1970.

The BADGER STATE spent 11 days in the North Pacific Ocean before the bomb exploded. For a departure route, Fleet Weather Central, Alameda, California, selected a northerly passage, intending to have the ship pass to the north of the storm centers. Fleet Weather Central had available wave height forecast charts (24- and 48-hour forecasts), U. S. Weather Bureau data, U. S. Navy Fleet weather data, and satellite weather photos. Although continued seasonal storm conditions were expected to prevail, they were not considered severe enough to warrant delay of sailing. Compensations in course and speed for limited periods were considered adequate to cope with adverse weather situations. During approximately this same period, three non-Navy controlled vessels were routed on a more northerly route than originally planned for the BADGER STATE. No difficulty was reported on their passage. Another C-2 vessel, the EMPIRE STATE, sailed from Bangor with a load of ammunition about 1 day after the BADGER STATE's departure. The EMPIRE STATE had a mean draft of 25 feet 2 inches, and followed essentially the same northerly route planned for the BADGER STATE. The EMPIRE STATE was forced to reduce speed during heavy weather but made her destination. The SS ELWELL departed Bangor on December 12 and followed a west southwesterly route for Okinawa. She encountered heavy weather and had to slow to about half speed for 3 days.

The two storms that struck the BADGER STATE on December 25th and 26th were not identified on the weather charts for those dates. The vessel was very close to the origin of the storm that struck on December 26. It was an intense storm that moved rapidly out of the area before it was identified.

Title 46 Section 170 of the U. S. Code gives the U.S. Coast Guard authority to regulate the carriage of explosives or other dangerous articles on vessels. The law also precludes use of this authority to limit or restrict the shipment, transportation, or handling of military

explosives by or for the Armed Forces of the United States. Detailed regulations for the transportation of military explosives are contained in 46 CFR 146.29 and are administered by the Coast Guard. Under these regulations, the Coast Guard is concerned with matters such as place of loading, adequacy of cargo handling gear, compatibility of various cargo, fire protection, and adequacy of stowage. Coast Guard inspection details are assigned where required to supervise loading, handling, or unloading of military explosives unless the commanding officer of such an Army or Navy facility declines the detail. No detail was assigned to the Bangor facility for this reason. Coast Guard participation in loading of the BADGER STATE was limited to the issuance of a loading permit based on the prestowage plan and its amendments, giving consideration primarily to the compatibility of various classes of ammunition.

The provisions of 46 CFR 146.29 concerning stowage standards were, nevertheless, applicable to Navy loading facilities by Navy Instruction OPNAV 8023.7B of August 16, 1965. The regulation concerning stowage aboard vessels (46 CFR 146.29-63) requires that "Military explosives shall be stowed and dunnaged as to prevent damage to the cargo or the vessel from shifting cargo caused by forces incident to the voyage of the vessel." Those detailed regulations to implement this goal are also of the general performance type, lacking specific requirements, and depending upon the judgment of experienced inspectors to determine whether the goals of performance are achieved. The nonspecificity is also sought to be compensated for by spreading the responsibility to two persons, including one who will be at risk when the stowage comes under stress. This is done by requiring that "the uppermost tier of military explosives shall be so secured to the mutual satisfaction of the Captain of the Port and the master of the vessel by tomming, bracing, and strapping top stowage with permissible cargo of sufficient weight and quantity or other effective means that no displacement can occur either upward or laterally."

On November 15, 1970, the Navy published the technical manual "Ship-loading and Dunnaging of Military Explosives Cargo Aboard Merchant Type Ships (NAVORD OP 3221)." This manual is intended to provide standardization and guidance, using the best loading practices and procedures that have evolved by experience at the various loading facilities.

ANALYSIS

The cargo securing process used aboard the BADGER STATE was essentially a method of wedging the cargo between the ship's sides and bulkheads by fitting wood supports cut to accommodate the varying shape of the hull and the cargo. The fact that in this process each block, brace, or spacer must be custom fitted to accommodate the space, affords numerous opportunities for creating points of weakness.

Since there are no intermediate boundaries between the ship's sides to constrain the cargo, errors of workmanship become cumulative. The quality of workmanship is not critical for small ship accelerations and small angles of inclination because friction will suffice to prevent cargo movement. The quality of workmanship also becomes a moot point where the forces from violent ship motions become so great that the lumber will be crushed or fractured regardless of workmanship. However, between these two limits, the workmanship of the stowage is vital to the safety of an ammunition ship. In the case of the BADGER STATE, there was no specification or design stating the environmental conditions, ship motions, or force loading the cargo securing system was required to withstand. The loading crew used stowage practices evolved by experience and transmitted from the older to the newer workers. These practices presumably had proved satisfactory in the past, but there was no established feedback information path from the unloading point or from the ship after the voyage for evaluating the effectiveness of the securing system. In the Navy's new technical manual, a feedback reporting system for stowage evaluation has been instituted. Despite this evident uncertainty as to the standards of stowage, the master was required to certify as to the adequacy of stowage upon completion of the loading. But as events later proved, this mutual satisfaction method of spreading responsibility to two parties, one of whom will be at risk, did not compensate for specific requirements and did not produce an adequate stowage. Although the master did certify in this case that the stowage was adequate, his requests for special cargo inspection openings, additional spare dunnage, additional cargo, tomming, and a change in loading plan, did indicate some lack of faith in the ability of the stowage system to cope with the expected sea conditions. Since the stowage was not designed to withstand any particular angle of roll and since the end product of the stowage effort could not be evaluated to determine its limiting roll capacity, the master could not know how close the stowage was to the failure point. Not knowing this, he was unable to make an earlier justifiable decision that the safety margin was so small that he should divert to a port of refuge.

Ships carrying ammunition were not required to take on spare dunnage since in theory underway repairs to the stowage were not anticipated. Spare dunnage was provided to the BADGER STATE, however, in response to the insistence of the vessel. The crew made repeated repairs to the stowage system but could not upgrade the installation to preclude continuing failures. The stowage design and practice used aboard the BADGER STATE evidently do not lend themselves to the correction of major weaknesses at sea.

The BADGER STATE's riding characteristics were predominantly determined by the ocean wave spectrum, the vessel's speed and course of encounter with these waves, the vessel's displacement and shape of underwater body, and the distribution of the cargo and fuel within the vessel. The forces on the cargo in turn were dependent upon the

acceleration responses of the ship to the ocean waves and upon gravity and friction forces.

One of the most easily controlled of these factors was the vertical distribution of the cargo. High-density cargo like ammunition, if placed low in the vessel, will increase the metacentric height (GM), an index of the stability of the vessel. A "large" GM will result in a short roll period with high acceleration forces at the outboard end of each roll. These forces will cause stress for both the crew and cargo. Too "low" a GM, however, will produce a low margin of stability, large angles of roll in long swells, long roll periods, and small acceleration forces due to roll. The master's concern for too large a GM was reflected in his request to move some cargo to a higher level. The change that was made to the pre-stowage plan, at his request, reduced the GM about 0.3 feet, or about 6 percent.

The master's initial request for additional cargo was also made to reduce the ship's response to ocean waves. The added mass and the increased damping effect from the increased underwater body would cause the ship to be less susceptible to the higher frequency of locally generated storm waves. The added load would also probably have raised the center of gravity and thereby reduced GM.

Although the captain stated he was satisfied with his calculated GM value of about $5\frac{1}{2}$ feet at completion of loading, he did take action to reduce this further upon sailing into the Pacific Ocean. Upon his orders, all the bottom fuel tanks were slacked off as consumption permitted. This free surface further reduced the GM value by about 0.5 feet.

The GM, at departure, was also calculated by an MSTS representative. But in this case, the objective was to ascertain that a minimum standard value was achieved for that loading to insure adequate stability. The result was considered very satisfactory, with a GM margin of 3.2 feet over the MSTS minimum requirement.

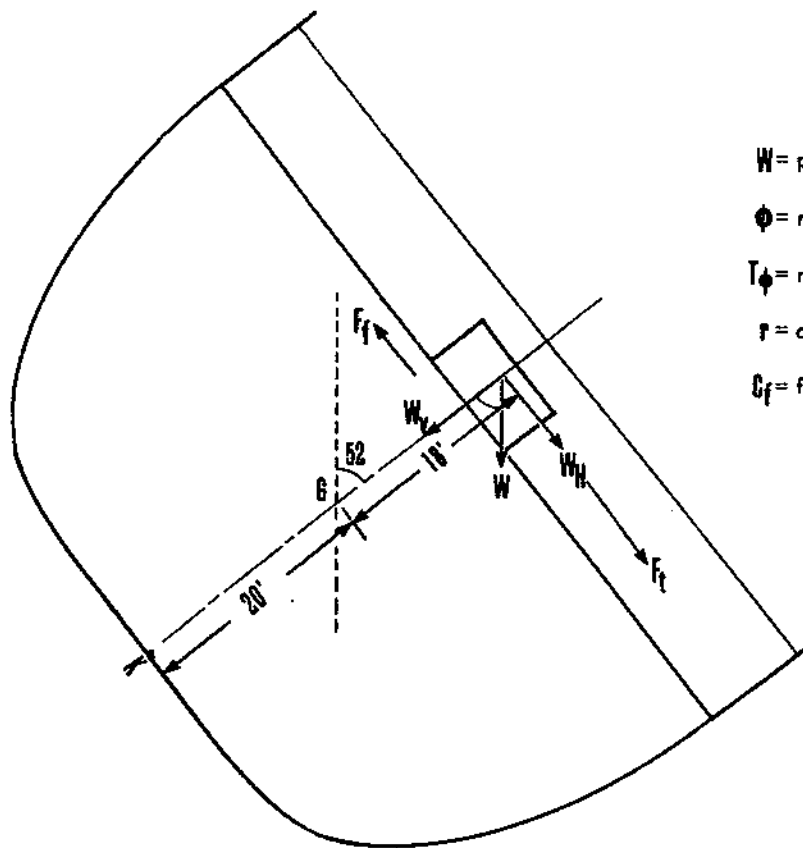
Although the "correct" GM value will be a compromise depending on what factors are being emphasized, it is evident from the testimony of witnesses that the resultant GM was considered higher than normal for a cargo ship of this type. The crew complained of the short, snappy roll, and of the difficulty of sleeping. With a high GM, the ship was responsive to a larger spectrum of sea waves which resulted in increased probability of greater rolling in irregular waves.

When rolling becomes excessive, a course change is the most effective remedy. This often results in ship slamming, which can then be avoided by large speed reduction. The net trade-off is a reduction in roll for an increase in voyage time, while still maintaining security of the cargo. This trade-off was implicitly the basis for all but the final diversion orders sent to the BADGER STATE. However, these diversion orders were intended to avoid future storms downtrack, whereas the BADGER STATE also had to contend with sea

conditions at its present location. It was these latter conditions which resulted in extreme rolling and precluded the ship from following the second and third diversion orders. However, the diversion orders had no ill effect in this particular case, because they were rescinded by later orders and the ship was essentially redirected to its original trackline. But the inability of the ship to alter course to avoid storms along its track because of local storm conditions can make the trade-off unattainable and that fact should be recognized. During a number of the storms, the BADGER STATE encountered local-wind-generated confused seas and two swell systems so oriented that no course or speed combination could be found that would reduce rolling to a reasonable minimum. The only defense was to use hard rudder in attempt to meet the larger waves head-on. In periods of reduced visibility, this technique would also fail as it did during darkness on the morning of December 26 when the ship was hit by a huge wave and rolled to 52° . The options of course change and speed reduction as fall back positions to minimize roll, therefore, cannot be assumed to exist at all times as substitutes for other safety measures for crew and cargo.

Properly installed bilge keels can increase the roll period and reduce the angle of roll, particularly at large roll angles. The removal of bilge keels from the BADGER STATE in 1966 undoubtedly aggravated its roll characteristics. However, it is not feasible to estimate the increase in magnitude of roll as a result of their removal.

The ship accelerations associated with roll, pitch, heave, surge, yaw, and sway all produced forces on the bombs, the pallets, and the dunnage. The pitch and roll angles also caused components of the bomb weight forces to be shifted from the decks to the blocking, sheathing, and sweatboards. The reduction of deck gravity force at ship inclinations in turn reduced the friction forces under the bomb pallets. Figure 1 illustrates the reactions of roll tangential accelerations, gravity, and friction by a bomb pallet when the BADGER STATE rolled to 52° . The additional forces caused by pitch, heave, yaw, and sway, and by roll centrifugal forces are considered small by comparison and may either add or subtract from the other forces, depending on the particular ship motions at that moment. Adjacent pallets would experience slightly different tangential forces due to the longer distance to the axis of roll (assumed to be center of gravity) and because the forces would be at a small angle with the deck. The variations, however, tend to compensate and would be small. Six 2,000-pound bomb pallets are assumed to have been in the forward athwartship row of bombs. This would result in a load on the support sheathing and blocking in excess of 14,000 pounds, which could not be sustained. Once the bombs commenced moving, they built up kinetic energy so that upon impact, this added a large force to those already described and further broke down any bounds. Therefore, although future rolls did not again reach this maximum value, the slack in the cargo allowed added forces to destroy the dunnage at lower amplitudes of roll.



W = pallet weight = 4075 lbs

Φ = roll angle = 52°

T_Φ = roll period = 11 sec.

r = distance to roll axis

C_f = friction coefficient

1. Assumptions:
 - a. roll axis is at G, center of gravity.
 - b. forces due to wedges hammered into voids are reduced to zero at large angles.
 - c. friction coefficient between wood (fir) and steel = 0.6

2. Forces parallel to deck = weight component, W_H + tangential roll force, F_t - friction force, F_f .

$$W_H = W \sin \Phi = 4075 \sin 52^\circ = 3210 \text{ lbs.}$$

$$F_t = \left(\frac{4\pi^2}{T_\Phi^2} \right) \Phi \cdot r \cdot \frac{W}{g} = \left(\frac{4\pi^2}{11^2} \right) \frac{\pi}{180} \cdot 52 \cdot 18 \cdot \frac{4075}{32.2} = 675 \text{ lbs.}$$

$$F_f = C_f \cdot W \cos \Phi = 0.6 \cdot (4075) \cdot \cos 52^\circ = 1510 \text{ lbs.}$$

$$\text{Net force parallel to deck} = 3210 + 675 - 1510 = 2375 \text{ lbs.}$$

3. For 6 pallets in a row athwartship, total force on sheathing on side of vessel = $6 (2375) = 14,250 \text{ lbs.}$

ATHWARTSHIP FORCES AT END OF ROLL ANGLE

FIG. I

The exact mechanism of the failure of the blocking and hull sheathing cannot be reconstructed. However, among the peak load points were those at the bomb nose blocking. With the bombs loaded nose to nose athwartship, the two outboard bomb noses had to carry the total load from the other bombs in that row at the maximum roll inclination. The bomb nose, with a diameter of 4.625 inches, had a centerline hole of 3.772 inches. This required the blocking, in contact with the two nose areas of one pallet, to support about 11,875 pounds over an area of about 11.8 square inches, with a resultant pressure of about 1,000 pounds per square inch. Another area of peak loading occurred where the hull curvature allowed only one bottom corner of the outboard pallet to press against the sheathing board and support the lateral forces of the entire row of bombs. Although some additional side support may have been added in the case of the BADGER STATE, even recent Navy-promulgated standards do not require any such additional side support for this "one-point technique of unit load positioning." Without additional support, the bearing surface of this technique is so small that the side forces encountered on the BADGER STATE would readily have crushed the sheathing support. Even additional support, in the form commonly used, probably would not have increased the bearing area on the sheathing and prevented crushing of the sheathing in this case. The compressive strength perpendicular to the grain fiber of Douglas fir varies with type, quality, and moisture content. Results of tests conducted on small clear specimens indicate that the coast-type Douglas fir has an average compressive strength of 440 p.s.i. in the "green" (38 percent moisture) condition to 870 p.s.i. in the air-dry (12 percent moisture) condition. Western hemlock, also reported as being used for dunnage has respective values of 390 and 680 p.s.i. Since the lumber used during loading was wet, the values applicable to the lumber aboard the BADGER STATE were probably near the lower values. Some of the stowage failures undoubtedly occurred because, at the large angles of roll, the dunnage was loaded beyond its compressive strength.

Although all the dunnage used was admittedly wet, it probably had no opportunity to dry out in the cold, wet conditions that existed during the voyage. Consequently, any shrinkage that might have resulted from such drying out was not a factor in the loosening of the cargo. However, the moisture in the wood probably did lower somewhat the friction forces between the wood decking and the steel pallets which may have permitted some movement at lower angles of roll.

The master had requested that as an added measure, the bombs be tommed to prevent movement. This would have increased the friction forces at the deck slightly and may have prevented some movement at lower angles of roll. However, once the forces on the blocking and sheathing at large roll angles compressed the supports even a small amount, the added friction forces created by tomming could not prevent bomb movement and the tomming would have become dislodged and permanently ineffective.

In addition to the failure of the sheathing and shoring to contain the cargo, the banding on the pallets broke and released the bombs. The most feasible cause for band rupture would be from forces external to the pallet. The banding along the longitudinal axis was protected by the projection of the bomb nose and by blocking at the opposite end. The banding was also protected underneath the pallet and was not subject to any contact on top of the pallet for the single pallet height stowage. However, the bands were exposed to contact on the remaining two sides with the steel of other pallets. The vulnerability was particularly hazardous where the pallets on top of the hatch square were about 4 inches elevated above the adjacent pallets. This allowed the adjacent pallet steel frames to press against the unsupported bands. Band failure was then feasible due to either overstress in tension or by work hardening, due to repeated flexing with continuous rolling. Although the Coast Guard regulations required that the steel pallets be isolated from the steel deck or hull with wood sheathing, steel-to-steel contact between adjacent pallets was accepted. Many other bands undoubtedly broke when struck after the cargo began to shift freely. The remaining bands alone could not sustain the dynamic loads, and they had to fail at an accelerated rate.

Ships leaving the northwest coast of the United States during the winter can expect frequent storms. A diversion southward to the calmer weather of the southern latitudes can be made if the frequency of storms is sufficiently low and if the storms can be reliably forecast. Although for the first 4 days the BADGER STATE encountered such heavy weather along the northern portion of her transit that she could not comply with two divert orders, the weather was still sufficiently tolerable so that the ship traveled 1,373 miles at an average speed of 14 knots, compared to 14.8 knots full speed. The weather analysis during this period generally agreed with the weather reported by the ship. However, the weather forecasts for December 25 and 26 predicted improving weather conditions when in fact the worst storms of the voyage occurred. Since the BADGER STATE had already been diverted to Hawaii due to unsatisfactory cargo conditions, the options available, even if the storm had been predicted, were few. Additional delays at sea would increase the probability of further cargo shifting. Also, since these storms apparently spawned close to the ship's location, the margin of forecast time would have been very limited even with more data gathering stations. The ship would still have been unable to escape the storm's large span of high winds and seas.

The abandon ship signal was effective in being heard and recognized by all hands. The SOS signal was also successful in alerting rescue units and the nearby KHIAN STAR. The failure of both of the ship's liferafts to remain secured to the ship denied the crew an opportunity to use the rafts while awaiting rescue. The cause for this failure was not found except that there was evidence that the painters on both liferafts had failed. However, stronger painters would not have made any difference because the sea painter is normally fastened

to the liferaft through a "weak link" to insure that if the vessel sinks before the liferaft is launched, the liferafts will break away at the "weak link" and not be pulled down by the ship. But this "fail-safe" feature can be a built-in potential accident in situations where the forces of the storm on the liferaft secured to the ship may equal the buoyant forces on the submerged inflated raft. The Coast Guard is now proposing to increase the strength of the sea painters and to alter the method of rigging to permit including or omitting the "weak link" as the situation warrants.

The launching of the starboard lifeboat was essentially a satisfactory operation in view of the hazards attendant with lowering a boat in a storm with following seas. However, the parting of the sea painter deprived the lifeboat crew of an important element of control as a means of getting the lifeboat away from the ship while the ship still had some way-on and while the crew was having difficulty engaging the hand propelling gear and shipping the rudder. In this situation of drifting aft alongside, the lifeboat was endangered by the rolling of the ship, a crewmember was severely injured, and finally a 2,000-pound bomb fell into the lifeboat. Although at least one other bomb had been previously seen falling out of the hole blown out of the side of the ship, this was not common knowledge among the crew. Even if it had been, it is questionable that the lifeboat could have been diverted away from the hole once the sea painter parted. After the lifeboat capsized, the crewmembers found it difficult to climb aboard, hang on, or otherwise obtain support. The lifeboat did, however, provide a visible target for rescue ships and planes.

Some of the other survival gear proved inadequate for the stormy conditions that existed. Except for one which practically fell into the hands of a crewmember (but who was not himself saved), all the air dropped liferafts tumbled away in the wind. The sea anchors for these rafts failed to function as needed. The lifejackets were reported to slide upward, causing discomfort around the neck and pushing the head forward. Since some of the deceased were seen floating face down, these lifejackets would not keep an unconscious person face up to prevent drowning.

A most difficult phase of the rescue was the attempted recovery of the survivors. Despite heroic efforts by the rescue crew, the operations could have only partial success because the recovery process and facilities are not well advanced. Most of the developments in rescue technology have concentrated in disembarking people from a stricken ship, not in their recovery from the sea by a ship. Assuming that 35 survivors remained upon arrival of the KHIAN STAR, three out of six were recovered from the raft and 11 of the remaining 29 were recovered from the water.

By law, the Coast Guard has broad responsibilities for the safe loading, stowage, transporting, and unloading of military explosives and for the safety of the vessel, the crew, and ports the vessel must

enter. The detailed implementing regulations further specify that the Coast Guard Captain of the Port shall be assured that the stowage is secured so that "no displacement can occur either upward or laterally." Since the Coast Guard supervision and inspection of the loading at an Army or Navy facility is at the option of the facility and is generally declined, the means for carrying out this responsibility are in fact generally unavailable. This built-in contradiction was not shown to be directly involved as a factor in this accident; however, it is a confusion factor which could impede initiation of other corrective actions because of this separation of responsibility and authority.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this casualty was the failure of the bomb stowage and packaging system to restrain the cargo under the ship motions that occurred during the adverse weather encountered on this voyage, particularly on the morning of December 26, 1969.

The following are considered to be contributing causal factors:

1. The lack of a stowage design criteria that could be correlated with environmental conditions, ship motions, or force loadings, which could then be implemented by engineering design or tests.
2. Utilization of stowage practices which create "chain series" of potential failure points, dependent on custom-made supports that are sensitive to workmanship quality variations. In the method used, a break in the "chain" also caused all the other "connections" in the chain to fail. On the BADGER STATE, the sides of the vessel were used as fixed boundaries between which the cargo was wedged with blocking. With no intermediate boundaries, the loosening or failure of a single block or wedge released the whole row of pallets.
3. The vulnerability of the pallet band design to external impact forces which caused the banding to fail and to release the bombs.
4. The undesirable ship response characteristics caused largely by the relatively high metacentric height (GM), resulting from the manner of vertical distribution of cargo and fuel. This increased the acceleration forces at the ends of the rolls, causing increased side loads on the stowage. The lack of a full

load of cargo and the fact that bilge keels were not reinstalled on the vessel after their removal in 1966 rendered the ship more responsive to wave forces.

5. The unusual severity of the storm which struck on December 26 and caused the ship to roll to 52°. The occurrence of the storm during darkness also made it difficult to see the direction of the oncoming waves and prevented conning the vessel to meet the waves head on.
6. The inability of Fleet Weather Central to forecast the storms of December 25 and 26.

The following contributed to the loss of life subsequent to abandoning ship:

1. The failure of the ship's and air-dropped liferafts to remain in the vicinity of the accident where the crewmembers could board them.
2. The failure of the lifeboat painter which deprived the crew of a means to shear the lifeboat away from the ship.
3. The falling of a 2,000-pound bomb into the lifeboat, killing or injuring some crewmembers and overturning the lifeboat.
4. The lack of better techniques to detect a person in stormy seas and to retrieve him.
5. The characteristic which allowed the lifejackets to slide upward and to push the head forward, tending to drown exhausted or unconscious survivors.

RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The U. S. Coast Guard, with the assistance of the U. S. Navy and U. S. Army, develop a military explosives stowage criteria to meet specific vessel response to dynamic environmental conditions. These criteria should include shipboard measurable parameters of angles of roll and period of roll. This information needs to be provided the master of the ship so that he can determine the safety margin remaining in a threatening situation and select available options accordingly.

This information is also important to the operational commanders and the weather routing service to permit a basis for weather routing or diversion to ports of refuge when sea state predictions exceed the design limits.

2. The U. S. Coast Guard, with the assistance of the U. S. Navy and U. S. Army, conduct a design study to develop, on an engineering basis, stowage design requirements in support of the criteria required above. These design requirements must not only be structurally adequate but should minimize the susceptibility of the stowage to a chain reaction from single-point failures and should minimize the dependence of the stowage to quality of workmanship resulting from prevalent custom-fitting of dunnage. The study must also recognize that the hull and bulkheads work somewhat in a seaway and, therefore, cannot be considered as providing rigid supports for blocking and bracing, particularly in heavy seas.
3. The U. S. Coast Guard seek to remove the inconsistency of being legally responsible for vessel and port safety, while at the same time having no authority to require a Coast Guard inspection of the loading or unloading of a vessel at an Army or Navy facility.
4. The Coast Guard include in its study of life preserver improvements, the reported tendency of lifejackets to slide upward and their failure to rotate a person to a face-up position.
5. The Coast Guard study the means of improving embarkation methods and equipment, and procedures for controlling inflatable liferafts at embarkation stations. It is recognized that the regulations are being revised to provide this in the case of sea painters for liferafts. However, this is considered only one facet of the hazards existing with the problem areas cited. (This same recommendation was made by the National Transportation Safety Board after the loss of the SS PANOCENIC FAITH on October 9, 1967).
6. The Coast Guard study means for improving the retrieval of survivors from the sea by merchant vessels in rough seas.

7. The Navy improve its 2,000-pound pallet design to reduce susceptibility of the banding to being struck and broken by external forces.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

Adopted this 21st day of October 1971:

[REDACTED]

Chairman

[REDACTED]

Member

[REDACTED]

, Member

[REDACTED] and [REDACTED], Members, were absent, not voting.



DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
COMMANDANT (MVI-3)
U.S. COAST GUARD
WASHINGTON, D.C. 20591

. 5943/BADGER STATE

A-13 Bd

15

Commandant's Action

on

The Marine Board of Investigation convened to investigate circumstances surrounding the fire, explosion and abandonment of the SS BADGER STATE in the Pacific Ocean on 26 December 1969 with personnel casualties

1. The record of the Marine Board of Investigation convened to investigate subject casualty has been reviewed, and the record, including the Findings of Fact, Conclusions, and Recommendations, is approved subject to the following comments and the final determination of the cause of the casualty by the National Transportation Safety Board.

SYNOPSIS OF FINDINGS OF MARINE BOARD OF INVESTIGATION

1. The dry cargo vessel SS BADGER STATE sustained an explosion and fire at about 0830 local time, 26 December 1969, in the North Pacific Ocean, 550 miles north northeast of Midway Island. The vessel was ordered abandoned. Thirty-five of the crew of forty were lowered to the water in the starboard lifeboat. As the boat drifted aft a 2,000 pound bomb fell into the boat from the hole blown in the side of the ship causing the lifeboat to capsize. Fourteen survivors were rescued from the water by the Greek vessel KHIAN STAR. The BADGER STATE finally sank on 5 January 1970.

2. The vessel loaded 5,336 long tons of cargo consisting of 500, 750 and 2,000 pound bombs at the Naval Ammunition Depot, Bangor, Washington. A Completed Hold Inspection form was signed by the Master on 14 December 1969.

3. The BADGER STATE sailed on 14 December 1969 for DaNang, Republic of Vietnam. The voyage across the North Pacific Ocean was routed by the

Naval Control of Shipping Organization. Soon after sailing the vessel encountered high winds and heavy seas until abandoned on 26 December 1969. The vessel's heading was directed in various westerly and southwesterly courses to avoid the weather, although at times the vessel rolled as much as 45° resulting in the shifting of cargo in numbers one, three, four and five holds. The crew was able to stow and resecure the cargo with extra lumber which had been put aboard in Bangor. After 23 December 1969, the crew was almost continuously reshoring and resecuring cargo. By Christmas Day the completion of the voyage was in doubt. Cargo was loose in all hatches, the vessel had taken rolls of 50°, and the crew worked without interruption in an attempt to secure the cargo.

4. During the early morning of 26 December 1969 while hove to, the vessel rolled 50° to starboard and 52° to port upon meeting an unusually large sea. Inspection of number five hold revealed that 2,000 pound bombs were loose from their pallets and striking each other and the ship's side. Small holes began to appear on the starboard side where the bombs had struck the shell plating. At about 0830 an explosion in number five hold blew off the hatch covers and the Master ordered abandon ship.

5. Thirty-five of the crew boarded the starboard lifeboat. Once waterborne the boat drifted aft, and while alongside of number five hold the men in the lifeboat saw a large irregular hole in the shell plating of the vessel at the 'tween deck level caused by the explosion. A 2,000 pound bomb rolled out through the hole landing in the boat causing it to capsize; and shortly thereafter the five remaining members of the crew, including the Master, went over the side wearing life preservers and using life rings. The SS KHIAN STAR, enroute to Japan, changed course to come to the assistance of the SS BADGER STATE. Eleven of the thirty-five who abandoned the ship via the lifeboat and three of the five who went over the side jumping in the water were rescued by the SS KHIAN STAR. One body was retrieved from the water and identified. There are twenty-five other members of the crew missing and presumed dead.

REMARKS

1. In concurrence with the Board's Conclusion No. 1, it is considered that a combination of factors caused the casualty. The evidence of cargo coming adrift in all cargo holds attests to the severe forces imposed on the blocking and bracing by the extreme rolling in the heavy weather. The shifting and movement of cargo was localized and resecured by the ship's crew until the 2,000 pound bombs began to move.

2. The record of the investigation supports the fact that the 2,000 pound bombs located in number five upper 'tween deck were stowed athwartship-aisle. Wooden wedges were used to secure the cargo because of the broken stow of the pallets supporting the 2,000 pound bombs.

There is evidence that the wedges used were wet from the rainfall that occurred during the loading of the cargo. The use of wet wedges and wedges without nails may have also contributed to the initial movement of the cargo.

3. It is evident from the record that the deck under the 2,000 pound bomb pallets in number five 'tween deck was covered with deck stripping only, in place of a full layer of dunnage. Due to the extreme rolls of the vessel it is possible that the pallets were able to move more easily on the stripped deck. Once the pallets started to move it was only a question of time until the steel bands holding the bombs to the pallets broke and the bombs were adrift.

4. The 2,000 pound bomb pallets in No. 5 upper 'tween deck were stowed so that the noses of bombs on one pallet were bearing against the noses of bombs on the adjacent pallet, without dunnage or nose boards placed between the bombs. Upon encountering rough weather, the pallets could have shifted enough so that the five-inch diameter nose plates no longer bore against each other, and the noses of bombs on adjacent pallets were able to override each other. It is probable that further vessel motion supplied enough force to allow the noses to wedge apart the bombs. It is possible that this action resulted in the loosening or breaking of the bands tying the bombs to the pallets.

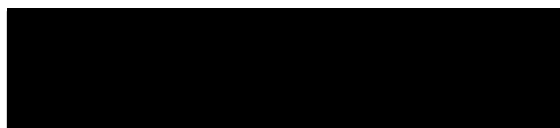
5. In concurrence with the Board's Conclusion No. 4 it is considered that the vertical placement of the cargo gave the vessel a large metacentric height, and therefore stiff riding features with a quick roll. If bilge keels had been installed it is possible the rolling effect would have been dampened.

ACTION CONCERNING THE RECOMMENDATIONS

1. The Naval Weapons Handling Laboratory at Naval Ammunition Depot, Earle, New Jersey, has completed one phase of a two part study and review of loading and shoring procedures for military cargo explosives in ships. A review of the second phase will be made to determine possible ways of implementing the recommendations.

2. A study is currently being conducted by a consulting firm under contract to the Coast Guard to determine methods of improving the effectiveness of life preservers as personal lifesaving devices. Once the study is completed, and the results analyzed changes in lifesaving devices will be considered.

3. The U. S. Coast Guard Marine Safety Council conducted a public hearing on 29 March 1971. The agenda included a proposal to increase the breaking strength of sea painters for inflatable liferafts to 3,000 pounds for rafts of 10-person or greater capacity, and 1,500 pounds for rafts of less than 10-person capacity. Also in the agenda was a proposal to change the method of rigging. The recommendation to increase the length of the sea painter was considered as an agenda item but in light of the increase in painter strength proposed for the 1971 Public Hearing, any reasonable length increase would only have a very marginal effect. Final action by the Council on agenda items will be taken after 15 May 1971, the deadline for submission of comments by the public.



C. R. BENDER



DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Address reply to:
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Seattle, Wash. 98104

5943/SS BADGER STATE
Marine Board of
Investigation
26 May 1970

From: Marine Board of Investigation
To: Commandant (MVI)

Subj: SS BADGER STATE, Official Number 245136, explosion
and abandonment with loss of life on 26 December
1969; subsequent sinking on 5 January 1970;
Pacific Ocean

1. At about 0830 (+12 Zone Time) on 26 December 1969 the SS BADGER STATE, while on a voyage from Bangor, Washington enroute Danang, Republic of Vietnam, loaded with ammunition, suffered an explosion which holed the ship's starboard side in way of number five 'tween deck and started a fire in that space. The incident occurred while the vessel was in heavy seas at 36°48' North, 172°40' West after the cargo of bombs had come adrift in several holds. Soon after the explosion the vessel was abandoned by all forty crewmembers approximately 550 miles NNE of Midway Island. The starboard life boat, containing thirty-five of the crew, was capsized while still alongside by a 2000 pound bomb which fell into the boat from the hole blown in the side of the ship. Fourteen of the crew were rescued by the nearby Greek vessel KHIAN STAR and the remainder are dead or missing at sea and presumed dead. The derelict vessel subsequently sank on 5 January 1970 in position 40°11' North, 167°46.2' West.

2. Vessel data is as follows:

Name:	BADGER STATE
Official Number:	245136
Radio Call:	KWGE
Service:	Freight
Length:	441.2'
Breadth:	63.2'
Depth:	36.7'
Gross Tons:	8,166
Net Tons:	4,837
Year Built:	1944, Wilmington, North Carolina
Home Port:	New York
Propulsion:	Steam Turbine
Hull Type:	C2-S-AJ1
Master:	

License: No. [REDACTED], Master, Oceans, Radar Obs.
 Owners: States Marine Lines, Inc.
 90 Broad Street, New York, N.Y.
 Time Charterers: Military Sea Transportation Service
 Department of the Navy
 Coast Guard Inspection: Biennial: Seattle, Wa. 11-1-68
 Mid-period: Seattle, Wa. 12-13-69
 Drydock examination: San Francisco, Calif. 1-28-69
 Previously dry docked in 1966 at which
 time bilge keels were removed.

3. Record of deaths and injuries:

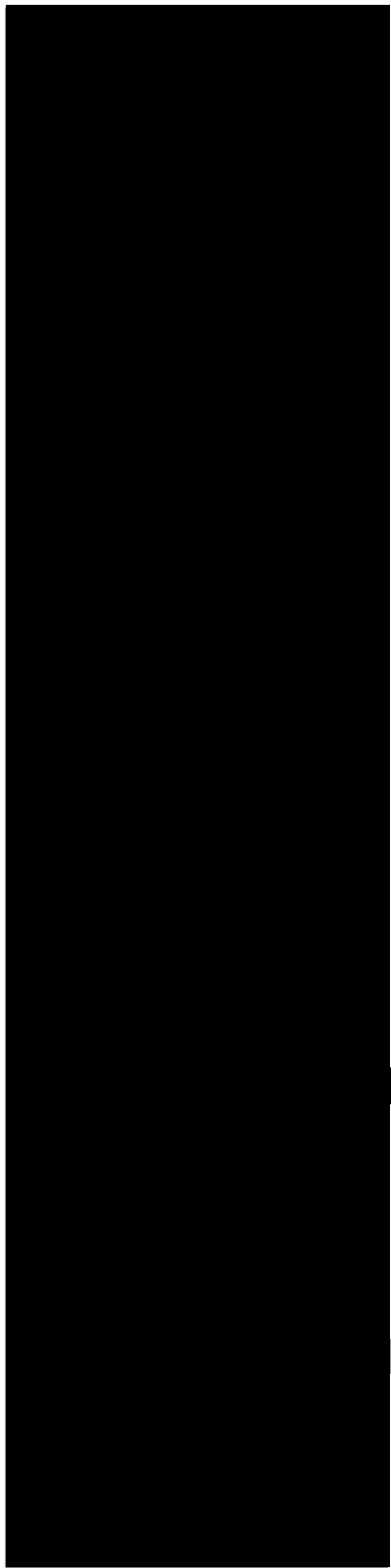
<u>NAME AND ADDRESS</u>	<u>COAST GUARD LICENSE/MERCHANT MARINER DOCUMENT NUMBER</u>	<u>POSITION</u>
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a. Deaths

KALEIWAHEA, John S. [REDACTED]	[REDACTED]	Ordinary Seaman
-----------------------------------	------------	--------------------

b. Missing and presumed to be dead

[REDACTED]	[REDACTED]	Wiper
	[REDACTED] License [REDACTED]	Chief Engineer
	[REDACTED]	Oiler
	[REDACTED] License [REDACTED]	Third Mate
	[REDACTED]	Steward
	[REDACTED]	Able Seaman
	[REDACTED] License [REDACTED]	Chief Mate
	[REDACTED]	Messman



[REDACTED]

Able Seaman

[REDACTED]

Messman

[REDACTED]

Able Seaman

[REDACTED]

Bosn

[REDACTED]

Galleyman

[REDACTED]

Messman

[REDACTED]

License [REDACTED]

Radio Officer

[REDACTED]

Electrician

[REDACTED]

Ordinary Seaman

[REDACTED]

Oiler

[REDACTED]

License [REDACTED]

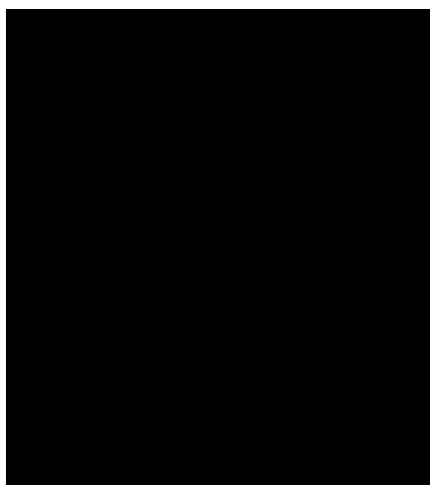
2nd Assistant
Engineer

[REDACTED]

Able Seaman

[REDACTED]

2nd Electrician



Fireman/Watertender



Oiler



3rd Assistant
Engineer



Second Mate

c. Injured



Cook/Baker

4. The weather at the time of this casualty was as follows:

Strong westerly gale winds of 40-50 knots with visibility of 5 to 6 miles; high west-northwesterly swells which occasionally crested to heights 30 to 40 feet when merging with a secondary swell system from the west-southwest. The air temperature was 49° F and the water temperature about 56°F.

5. On 8 December 1969 the SS BADGER STATE under time charter to the Military Sea Transportation Service arrived at Pier 91, Seattle, Washington, completing Voyage 46 and commencing Voyage 47. A Coast Guard mid-period inspection, as well as voyage repairs and preparations for another trip to Viet Nam carrying ammunition were started. Upon application by the Commanding Officer of the Seattle, Washington office of the Military Sea Transportation Service the U. S. Coast Guard Captain of the Port, Seattle, Washington issued a permit on 8 December 1969 for loading of the cargo on the BADGER STATE under U. S. Naval supervision at the Naval Ammunition Depot, Bangor, Washington. After taking fresh water and capacity bunkers the vessel shifted to the Naval Ammunition Depot, Bangor on 9 December 1969 where voyage repairs, Coast Guard inspection and other preparations continued.

6. Loading of the explosive cargo commenced during the early evening of 9 December and continued on a two shift basis (day and swing) until completion on 14 December 1969. Weather during this period was damp and rainy for the most part. Partially loaded hatches were left uncovered during graveyard shifts to facilitate changing of batteries in electric forklifts. Hatch tents were not used during loading operations.

7. On 10 December 1969 the Planning Department at Naval Ammunition Depot, Bangor made a change to the loading plans in order to improve

the fore and aft trim of the vessel. The change prescribed that 200 tons of cargo originally scheduled for number five upper 'tween deck was to be loaded forward with 100 tons to go into the number one lower hold and the other 100 tons into number two deep tank. When the Master became aware that his vessel was scheduled for only about 5,000 long tons of cargo he requested that additional cargo be assigned to the BADGER STATE, on the theory that loading the ship deeper would give her an easier ride. When the Master was advised that there was no additional cargo available for his vessel Captain [REDACTED] then requested a better vertical distribution of cargo. On 11 December 1969 the Planning Department at Bangor changed the pre-load plan in order to move weight upward as follows: 260 short tons scheduled for number three lower 'tween deck were exchanged with 25 short tons originally scheduled for number three upper 'tween deck; 188 short tons originally scheduled for number five lower hold were exchanged with 25 short tons planned for number five upper 'tween deck. The master's request for additional cargo was not pursued by him after these changes in the loading plan. Other minor changes (necessitated by nonarrival of cargo, etc.) were made as the loading progressed. The changes did not involve compatibility of cargo and therefore no approval was sought from the Coast Guard Captain of the Port. Loading thereafter progressed without major problems. Differences of opinion between ship's officers and Naval Ammunition Depot, Bangor personnel concerning blocking and bracing of the cargo were resolved to the ship's satisfaction. During this period both fifteen-man liferafts (U.S. Rubber Co.) were serviced at an authorized servicing facility and returned to the vessel. The mid-period reinspection was completed by the Coast Guard inspectors on 13 December 1969 with no outstanding requirements.

8. Most of the cargo consisted of palletized un-fuzed aerial bombs (500, 750 and 2,000 lb sizes) and associated hardware components. The 2,000 lb. bombs containing an explosive known as tritonal were loaded in number five 'tween deck in one hundred metal pallets containing two bombs each. Several steel bands hold the pallet halves and bombs intact in the unit. The loaded unit weight is about 4,053 lbs. and the overall size of the loaded unit is 24 1/4" H X 99" L X 38" W. The pallet specifications are designated as "Naval Ordnance Systems Command Weapons Requirement, Palletizing WR-54/127A". The pallets which were loaded in a single layer covered most of the deck area in number five upper 'tween deck. The pallets were stowed in the athwartship direction except for two rows near the center of the hatch square. The pallets in these two rows (containing twelve to fourteen pallets each) were stowed in the fore and aft across the entire hatch. The rise of the deck at the hatch square caused some of the pallets to be about four inches higher than the adjacent pallets. There is no indication that any type of wooden separation was used between the rows of unequal heights. Void areas between the pallets were blocked out with wooden shoring. At the after end of number five upper 'tween deck thirty three pallets of crated bomb fins and couplers were stowed (single layer) on top of the 2,000 lb. bomb pallets. A wooden retaining fence was constructed to prevent fore and aft movement of this material.

9. Loading of the last hatch was completed and signed off by ship's officers at 1420 PST, 14 December 1969, and the vessel departed Naval Ammunition Depot, Bangor for anchorage in nearby Thorndike Bay at 1537, where radar repairs were completed and the ship made ready for sea. In addition to the cargo the ship had loaded stores, fuel, and water. She had on board 5,336 long tons of cargo, 10,640 barrels of fuel oil, and 600 tons water. Mean sailing draft was about twenty-three feet with a five and one-half foot trim by the stern. The metacentric height (GM) was between five and six feet

10. The BADGER STATE departed her anchorage in Thorndike Bay during the early evening of 14 December 1969 with the Master and thirty-nine crewmembers aboard, enroute to Da Nang, Republic of Vietnam under MSTs Sailing Order No. 187. The intended voyage was under the Naval Control of Shipping Organization (NCSORG) routing which, in this instance, was via the North Pacific Ocean. Exact routing and vessel positions were under a Confidential security classification because of the nature of the cargo. The ship encountered heavy weather soon after leaving port but continued on her voyage.

11. Commander Task Force 31 (CTF 31) sent a diversion order (Divertord 415) to the BADGER STATE at 160040 GMT December 69, which directed a more southwesterly route to avoid weather. The BADGER STATE complied and at 161830 GMT when at 50.4 North, 136.2 West on course 262°T, making 15 knots she reported a 30 knot easterly wind, easterly swells of 12 feet, rolling to 40°, and an eleven second rolling period. Some minor cargo shifts had occurred, but were being adequately handled by the deck force and no message report was made. During the early morning of 17 December the vessel was stopped for approximately 1-1/2 hours while engineers repacked the after starboard steering engine ram, which had been leaking hydraulic fluid excessively. This same ram had been repacked by a private repair firm in port before the vessel sailed. The vessel was maneuvered with her single engine during the repairs, but nevertheless rolled to 40° several times. Following this repair no further problems were experienced with the steering gear.

12. CTF 31 sent another Divertord (No. 417) to the vessel at 171830 GMT which directed the vessel almost due south to avoid weather, with the recommendation that seas be kept as close to the stern as feasible. At 171930 GMT the BADGER STATE notified CTF 31 that she was unable to comply completely because of rolls up to 45° with 30 knot winds and 12 foot seas from 110°. At 180000 GMT in position 51.2 North, 146.8 West the BADGER STATE submitted a casualty report to CTF 33 advising that cargo in number three lower 'tween deck had shifted due to heavy rolling, resulting in steel to steel contact with the ship and estimating two hours for resecuring. This problem involved the athwartship shifting of a row of palletized 500 lb. bombs in the vicinity of frame 72. The extreme outboard pallet had crushed the bracing and sheathing and one of the vessel's frames had penetrated the pallet load allowing one bomb to rest against the frame. Crewmembers removed this bomb, made a special pallet to contain it,

and resecured the affected cargo, utilizing extra shoring material which had been placed aboard prior to departure from Naval Ammunition Depot, Bangor. Resecuring was completed by 180430 GMT, but by then further problems had developed. At 180430 GMT the vessel reported having found cargo adrift in number one upper 'tween deck, number four upper 'tween deck, number four lower 'tween deck, and number five upper 'tween deck and estimated six hours to resecure same. The ship at position 50.8 North, 148.6 West was experiencing variable winds from the south and east to 35 knots, with confused sea and swells to 20 feet. Securing was completed by 181900 GMT and the vessel reported that she was proceeding on her assigned mission. At 181930 GMT however, the BADGER STATE reported that she was unable to get the wind aft in order to follow Divertord 417 and requested further routing from Fleet Weather Central Alameda. The barometer had bottomed out at 955 millibars at 180900 GMT and was slowly rising.

13. The 190145 GMT Divertord 1 from CTF 33 rerouted the BADGER STATE in a generally westerly direction (intercepting the original route about 275 miles southeast of Unimak Island) to a point 35 miles south of Adak Island before turning southward. The vessel complied until a leak in the shaft alley was discovered and reported to cognizant commands at 200100 GMT. A small wasted area (approximately 10" diameter) was discovered in the port shell plating in the shaft alley near frame 166, about five feet below the propeller shaft level. It was leaking water moderately through several small holes. The ship was slowed until temporary repairs could be made. A cement box patch was completed by 202000 GMT and the ship reported that a reduced speed of 13.0 knots was intended to prevent the temporary repair from vibrating loose. The repair was of no further concern once the cement had properly hardened.

14. The BADGER STATE was about 280 miles south-southeast of Adak Island at 220218 GMT when CTF 33 sent a new Divertord due to weather. This latest diversion directed the ship to proceed west-southwest. At 220700 GMT the BADGER STATE acknowledged the latest diversion order but also reported having been hove to on a westerly course for the past six hours because of extreme rolling to 35 degrees on any other course. Weather in the ship's vicinity was west-northwest winds at 25 knots, 8 foot seas from 300°, and 8 foot swells from 250°. While hove to the upper drain valve on the in-board side of the port boiler superheater developed a small leak. Inasmuch as the vessel was running at reduced speed because of weather, it was decided to make necessary repairs while the problem remained minor. The port boiler was taken off of the line and after being allowed to cool the pinhole leak was repaired by electric welding. The port boiler was placed back on the line after having been secured for approximately fifteen hours and no further boiler problems developed. Thereafter when the First Assistant Engineer informed the bridge that the boiler was back in service he was told that no increase in speed was desired due to adverse weather conditions.

15. The BADGER STATE had been riding very "stiff" since her departure from Puget Sound and had what witnesses described as a "snap roll", which was very uncomfortable.

Her rolling period was never timed at more than eleven seconds nor more than twelve seconds during the voyage. By 230900 GMT the BADGER STATE was 315 miles south of Adak Island and reported further shifting of cargo in number four lower tween deck. The vessel reported that she was unable to hold the recommended course due to rolling to 35° and that she was running out of shoring material. The Master urgently requested that the vessel be diverted south to good weather as soon as possible. At about this time the crew was almost continuously reshoring and resecuring cargo. The off-watch personnel from other departments were assisting the deck gang. Fleet Weather Central Alameda began sending the BADGER STATE specific weather forecasts for her area at 231720 GMT and continued this service periodically for the remainder of the voyage.

16. CTF 33 sent Divertord Four due to weather at 231920 GMT diverting the BADGER STATE generally southwesterly, with the provision to adjust course and speed for best ride of ship until weather conditions permitted the diversion. At 232100 GMT the vessel was on course 145°T, running before the swells at 14.5 knots. She reported a heavy banging noise in number three hold which the crew was unable to inspect because there was no access to that compartment. The Master advised that all cargo holds needed reshoring and requested diversion to a safe port. The 240043 GMT message from CTF 33 (Divertord 5) directed the ship to proceed toward Pearl Harbor some 1600 miles to the southeast, as local conditions would permit. This order was acknowledged by the BADGER STATE by a message at 242300 GMT which reported the situation under control, but advised that the vessel had to heave to several times to keep from rolling as cargo was coming adrift in rolls of 20 degrees or more. The BADGER STATE message advised that an escort was not required at the time but might be if the situation deteriorated. The 241920 GMT forecast from FLEWEACEN ALAMEDA indicated that winds southwest to west-southwest 20 to 30 knots, decreasing to 15 to 25 knots, could be expected during the next 24 hours. Southward of latitude 38° North, seas with the wind 12 to 16 feet high gradually decreasing to between 7 and 11 feet high were forecast. The forecast also predicted continued improvement with southward progress and moderate conditions expected south of 35° North. The BADGER STATE was in approximate position 42.1 North, 176.1 West on course 210°T at 10 knots.

17. At 252000 GMT the vessel reported that she had gone through a storm the night before, that she had taken rolls of 50°, the cargo was loose in all hatches, and that she was presently rolling to 45° and unable to heave to because of confused swells. The vessel's course was 200°T, speed 7 knots with 20 knot winds and 10 foot seas from 320°T and 20 foot swells from 200°T. The situation aboard the BADGER STATE had become quite critical by this time. The crew was working almost around the clock trying to secure the cargo. Although the vessel never pounded, sleep was almost impossible because of her stiff riding characteristics in a seaway. The Master was on the bridge almost continuously from 22 December until 26 December. Gear that had been secured in place for years, such as spare engineroom equipment and saloon pantry refrigerators,

was coming adrift. At 252230 GMT the vessel corrected her previous position report and requested an escort and shoring material as soon as possible from CTF 32, who had been an information addressee on the previous messages recently addressed to CTF 31. Divertord 814 (260430 GMT) from CTF 32 ordered the BADGER STATE to divert toward Midway Island to provide a safe port for resecuring cargo and to await weather abatement. The Commanding Officer, Military Sea Transportation Service Pacific (COMSTSPAC) notified the BADGER STATE by message (260715 GMT) that the SS FLYING DRAGON had been requested to rendezvous with his vessel and furnish assistance and that both ships would proceed to Midway Island.

18. The FLYING DRAGON O.N. 247 556, was enroute from Sasebo, Japan to Long Beach, California when diverted. At 261100 GMT she was on a course to intercept the BADGER STATE which was over 500 miles to the northeast. CTF 32 was notified by the BADGER STATE at 261319 GMT that she was running before a westerly gale and feared any diversion toward Midway would cause serious consequences to cargo, which was already resecured.

19. At or about 261300 GMT (0200 +11 zone time) the BADGER STATE while hove to, encountered a mountainous sea and took a 50° roll to starboard, then rolled heavily to port 52°. During this roll the turnbuckle which dead ended the after falls of the port lifeboat carried away. This allowed the after arm of the gravity davits to roll down its track to the extended position. The securing gripes had also carried away and the after falls paid out until the broken turnbuckle jammed in one of the fairlead sheaves. This allowed the stern of the Number Two lifeboat to hang down over the side at an awkward angle as the forward davit remained in its stowed position. The boat was therefore useless and efforts made to resecure it were abandoned because of the heavy weather and severe rolling.

20. After the heavy rolls a check of the holds revealed that the cargo in number five upper 'tween deck was adrift and some of the 2,000 lb. bombs had broken loose from their pallets. The entire crew that was off watch was turned to in an attempt to secure the bombs or stop them from rolling and sliding. The bombs were striking each other and sliding into the ship's structure, causing sparks which were visible in the darkness. All hands were advised to put on their life jackets or have them close at hand. The forward end of the forward hatch pontoon on number five hatch was raised to about a 45° angle, using winch power with the booms remaining cradled and crewmembers threw all available items such as mattresses, linens, and reefer stores, into the opening. The after end of the after pontoon was also raised in a similar manner and mooring lines, engine room and deck stores such as rags, asbestos packing, and other available material was thrown into the hatch in attempts to prevent the bombs from sliding and rolling. There is no evidence that paints, oils, or any other such substance was utilized for this purpose. Efforts by the crew to contain the bombs by throwing material into number five hatch were partially successful in the

area immediately under the hatch square. Some lines and other material were also thrown down through the mast house entrance to the forward end of number five hold, however most bombs were completely out of their pallets and those which were forward of the hatch square could not be contained because there was no way to get material in on top of them. A portion of the wooden decking and hatch boards had carried away in the number five upper 'tween deck and at least two 2,000 lb. bombs were observed to fall through this opening down into the number five hold immediately below. In a further effort to contain the bombs one end of the number two steel hatch pontoon (second one aft on the hatch) was lowered into the number five upper 'tween deck on top of the material already thrown into the space. The pontoon did not go all the way into the space and the upper end was leaning against the starboard side of the main deck level hatch coaming.

21. Knowing that the KHIAN STAR was enroute Captain [REDACTED] considered the possibility of removing part of his crew to her, with the remainder staying aboard and attempting to get the vessel to a safe port. He had already given orders for the starboard lifeboat (No 1) to be made ready for launching. A list of volunteers was started but never completed since every crewmember who was asked volunteered to remain aboard. Testimony indicates that all personnel on board performed their duties to the best of their ability under arduous circumstances during the morning of 26 December 1969. The vessel was being conned by Captain [REDACTED] who was trying to keep her hove to on the best heading into the seas using about 50 to 60 propeller RPM's ahead. This attempt was thwarted by large swells from the west-northwest and swells also coming out of the west-southwest and heavy rolling continued.

22. Shortly after daylight (predicted sunrise was at 261845 GMT) the 2,000 lb. bombs were striking the starboard side with such force that several small holes had been punched in the shell plating by the noses of the bombs. These holes were about four to five inches in diameter immediately above the number five upper 'tween deck, between the forward end of the hatch square and the forward bulkhead of the hold. Daylight made it easier for the vessel to be conned into the confused swells, but she was still rolling to 20°. By this time all material which could be used, including the frozen meats and stores, had been placed in the number five upper tween deck space and the bombs were still rolling around violently. Several informal radio messages were exchanged with the KHIAN STAR.

23. The KHIAN STAR was sighted visually by the BADGER STATE at about 262000 GMT. Captain [REDACTED] then made the decision to come about in an attempt to head for Midway Island to the south-southeast. All personnel were ordered off the decks and full sea speed was ordered. As the BADGER STATE came around she rolled heavily and it was apparent that she would be unable to hold a course for Midway with the largest swells on the starboard beam. The Master continued bringing the vessel around to about 135°T until she was riding better with the swells on the stern. Shortly thereafter an explosion occurred in the number five hold which blew off the

remaining hatch pontoons and set the number five booms askew. Smoke emitted from the hold and small amounts of materials such as mattresses and linens which had been blown out through the hatch square were burning on deck. The flash and smoke was observed from the approaching KHIAN STAR which was about four miles away. It has been determined that the explosion was a low order detonation of a 2,000 lb. bomb in number 5 upper tween deck. Expert testimony adduced indicated that if the detonation were not of low order the most probable result would have been the complete destruction of the vessel as the adjacent explosive cargo detonated and that even the explosion of one 2,000 lb. bomb would have resulted in almost complete destruction of the vessel's stern section

24. Captain [REDACTED] immediately sounded the abandon ship signal on both the whistle and general alarm. After checking with the bridge by telephone, the engineers closed the throttle and secured all of the fires in the boilers. The shaft alley door remained open as the engine room was abandoned. The First Assistant Engineer [REDACTED], the last person to leave the engineroom, proceeded to the bridge, noticing that the starboard lifeboat had been lowered to the boat deck and was embarking personnel. After checking with the Captain he proceeded to the flying bridge and assisted the Bosun, [REDACTED], in throwing the port inflatable liferaft over the side. [REDACTED] had removed the cradle straps and was tying the tripping line (which was also the painter) to the ship when [REDACTED] arrived. The liferaft inflated, but drifted away from the vessel very rapidly. Believing that he would be unable to catch up with the liferaft, [REDACTED] proceeded to the lifeboat along with [REDACTED]. The starboard inflatable liferaft was launched from the flying bridge by Cadet Engineer [REDACTED] and Able Seaman [REDACTED]. [REDACTED] tied the painter to the liferaft cradle before the raft was thrown over the starboard side. The two halves of the case were seen to separate, but both men left the vicinity before seeing this raft inflated. Both rafts were later seen adrift by the KHIAN STAR in a fully inflated condition. When [REDACTED] and [REDACTED] left the starboard wing of the flying bridge the raft was tending aft, as the vessel still had about two knots of forward way on. Both he and [REDACTED] then proceeded to the starboard lifeboat.

25. The two inflatable liferafts aboard the BADGER STATE were stowed in cradles on the port and starboard sides of the flying bridge deck. These rafts are normally equipped with a 100-foot painter whose breaking strength is 1,000 lbs. This painter also acts as a tripping line for the CO2 inflation device. The distance from the flying bridge rail to the mean waterline was about 54 feet when the liferafts were launched. A sea anchor deploys automatically when the inflation device is tripped. There is no evidence that the liferafts were intentionally released or whether the liferaft painters parted or came untied. Captain [REDACTED] was supervising the preparations for launching of the starboard lifeboat. It was being boarded by personnel from the boat deck as it swung with the ship's roll. The BADGER STATE was stern to the sea and losing its forward momentum. The sea painter had been led out and all personnel were wearing life jackets. Second Mate [REDACTED]

was entering the lifeboat when one of his feet was caught between the ship and the swinging boat. The extent of this injury is not known, but he returned to the ship and was able to walk without assistance.

26. Able Seaman [REDACTED], manned the lifeboat winch and 35 crewmembers were in the lifeboat (62 person, hand propelled) including Chief Mate [REDACTED] and Chief Engineer [REDACTED]. [REDACTED] was in the stern attempting to ship the lifeboat rudder. The BADGER STATE had lost most of its forward momentum and was beginning to fall off its course. Captain [REDACTED] decided to lower the lifeboat before the vessel got broadside to the sea and ordered the boat lowered immediately. As the boat became waterborne, two or three large seas carried it back up to the boat deck level before the falls could be released by Deck Maintenance [REDACTED] who was manning the releasing gear. The sea painter either parted or came loose from the vessel at this time. The falls were released and the boat drifted aft in spite of the fact that men were working the hand propelling mechanism, whose clutch may not have been properly engaged. A jagged hole of irregular shape about 12'L X 8'H was seen by the men in the lifeboat. It was located at the forward end of Number Five hold at the upper 'tween deck level. At least one large bomb was seen to roll out of this hole and fall into the water as the boat drifted aft. Able Seaman [REDACTED], prior to boarding the lifeboat, had seen a bomb roll out of the starboard side of the ship but due to the urgency of the abandon ship situation he had not reported the incident. A wave threw the boat up against this jagged area and Electrician [REDACTED] received a gash about 6 inches in length on his forehead from the protruding metal. When the boat was almost abeam of Number Five hatch, a 2,000 lb. bomb came out through this hole and fell into the midship section of the lifeboat. Several men jumped or fell out of the boat at this time and the lifeboat capsized.

27. Captain [REDACTED] Second Mate [REDACTED] Third Mate [REDACTED] Fireman-Watertender [REDACTED] and Able Seaman [REDACTED] remained aboard the BADGER STATE. Captain [REDACTED] had left the area of the starboard side after the lifeboat falls had been released and was not aware that the lifeboat had capsized. No actual muster of the crew had been taken so some of the men who had stayed aboard went through the passageways in the midship house shouting to see if anyone else remained on the ship. Mr. [REDACTED] saw some men in the water on the starboard side and threw three or four liferings into the water and then proceeded forward to the main deck. All five remaining aboard assembled on the port side of the main deck near number three hatch. At Captain [REDACTED] direction they all obtained liferings for use in addition to the life preservers they were wearing. Thus equipped, Second Mate [REDACTED] and Able Seaman [REDACTED] went over the side together followed by Third Mate [REDACTED] Captain [REDACTED] and finally Fireman-Watertender [REDACTED] who was somewhat reluctant to enter the cold, rough water. Fearing that the vessel might blow completely up at any moment, most personnel left the area of the BADGER STATE as soon as practicable. A number of men remained

with the overturned lifeboat as it drifted away from the abandoned vessel, while others became separated from it or struck out on their own for the approaching KHIAN STAR.

28. The KHIAN STAR approached the area of the BADGER STATE in position 36°48' North, 172°40' West at about 262100 GMT and saw the overturned lifeboat and a number of persons in the water. The Master of the KHIAN STAR, Captain [REDACTED] had Jacobs ladders rigged over the side and stationed most of his nineteen man crew on the main deck with lifelines, life preservers and liferings. At this time the KHIAN STAR had a freeboard of about eleven feet and was rolling 30 to 50 degrees as the large swells were occasionally sweeping over her main deck. Captain [REDACTED] approached the overturned lifeboat and five or six crewmembers were picked up. Some of the BADGER STATE survivors were washed away from the lifeboat by the large waves. The lifeboat was approached twice more during the rescue and two or three men rescued each time. The overturned lifeboat struck the sides of the rescuing vessel a number of times. When there were no more survivors near the lifeboat Captain [REDACTED] began maneuvering to pick up individual survivors who were scattered about in the area.

29. Shortly after the KHIAN STAR approached the lifeboat for the first time, the USAF rescue plane Number 50969 from Hickam AFB arrived on scene and dropped several MA-1 liferaft kits in the vicinity of the survivors. After inflating, these were seen to be flipping over and over as they were driven before the gale force winds. A line from one of the air-dropped liferafts fell into the hands of Third Cook [REDACTED], who was in the area of the overturned lifeboat. While Third Cook [REDACTED] held the line, Able Seaman [REDACTED] went to the raft and assisted Third Mate [REDACTED] aboard. [REDACTED] then entered the raft and pulled Ordinary Seaman [REDACTED], Bosun [REDACTED], Ordinary Seaman [REDACTED] and Wiper [REDACTED] aboard the raft. The Electrician [REDACTED] was hanging on alongside of the raft, but [REDACTED] and the others were too weak and exhausted by their ordeal to bring him aboard. [REDACTED] shouted encouragement to those in the raft with him. The raft was filled with water and one of the men ([REDACTED]) was so exhausted and sleepy that he could not hold his head up. [REDACTED] slapped his face several times to revive him. When the KHIAN STAR approached, the liferaft was almost washed aboard her by the heavy seas. Lines were thrown down and tied around [REDACTED] and [REDACTED] who were hauled aboard. [REDACTED] grabbed onto a nearby Jacobs ladder and clung to it while he and the ladder were hauled aboard the rescuing vessel. During the rescue efforts some of the crewmembers who made their way to the KHIAN STAR were washed from the ladders by the seas which swept the deck of the KHIAN STAR, soaking the rescuers who were sometimes up to their waists in sea water.

30. Captain [REDACTED] conned his vessel during most of the rescue operation. His crew were down on deck to rescue and assist the survivors. The rescued BADGER STATE personnel were rushed to clean dry rooms, stripped of their wet clothes and given rubdowns and other first aid measures. Most were extremely

cold and weak and unable to walk by themselves when brought aboard. The survivors were rescued in any manner possible. One survivor was brought aboard upside down as a lifeline tangled around his leg; while another was tangled up in a cargo net and hauled aboard in that fashion. Injuries to the survivors were very minor considering the unfavorable weather conditions. Some of the men in the water were attacked by Albatross, however none of the survivors reported receiving actual injuries from them. The birds evidently concentrated on the very weak or deceased. Several survivors complained that their life jackets (Kapok - adult Model No. 3 - Atlantic Pacific Mfg. Co., CG Approval No. 160.002/6/1) rode up under their arms and failed to keep their heads out of the water because of no collar. They reported seeing some of the other less fortunate personnel floating with their faces down in the water.

31. By noon (270000 GMT) fourteen survivors were aboard the KHIAN STAR. As the vessel approached one of the crewmembers in the water, an Able Seaman from the KHIAN STAR tied a line around himself and jumped into the water to assist. The man in the water, Able Seaman [REDACTED] was apparently dead however and the seas prevented recovery of the body. The Greek sailor attempting the rescue was Able Seaman [REDACTED] Identification Number [REDACTED] Captain [REDACTED] had been rescued and went up to the bridge to assist Captain [REDACTED] as soon as he was able to do so. With the aid of two U. S. Air Force aircraft the two liferafts from the BADGER STATE were located and found fully inflated with no personnel in them. Other rafts dropped by the aircraft were also found empty. The rafts were not recovered because of the adverse weather conditions. The KHIAN STAR searched throughout the night and most of the next day without finding other survivors.

32. The USS ABNAKI (ATF-96) was dispatched from Pearl Harbor at 270400 GMT with a Navy ordnance team aboard to examine and possibly salvage the BADGER STATE. Air Force and Coast Guard planes conducted day and night searches of the area, with negative results. The SS FLYING DRAGON arrived in the general area (37°16' N, 172°22'W) at 272300 GMT and commenced searching. She sighted the overturned lifeboat and several bodies which she was unable to recover. The body of one seaman was recovered at 280215 GMT. It was later identified to be Ordinary Seaman John S. KALEIWAHEA, [REDACTED], and turned over to proper authorities at Los Angeles, California. Inasmuch as her fuel supply was low the KHIAN STAR departed the scene for Yokohama, Japan at 280500 GMT with all fourteen survivors aboard.

33. The FLYING DRAGON continued searching the area. A Coast Guard aircraft making a night search from 281105 GMT until 281450 GMT reported seeing an orange glow coming from the BADGER STATE, but observed no actual flames. Other vessels passed through the general search area and nothing significant was reported. The USS ABNAKI arrived on scene at 310921 GMT December 1969 and relieved the SS FLYING DRAGON which departed the area. By 312310 GMT all hope of finding other survivors was abandoned and the

case was closed for search and rescue purposes. Approximately 8,000 square miles had been searched. A total of seven ships had participated and five aircraft sorties had been flown.

34. Between 311600 and 311630 GMT, intermittent white, red and orange flashes were observed aboard the BADGER STATE from the ABNAKI. It was therefore determined that boarding the BADGER STATE presented an unwarranted risk to personnel aboard the ABNAKI, and further salvage attempts would not be made. The ABNAKI remained in the area to warn approaching traffic of the danger until final disposition of the derelict was decided. By 2 January 1970 the vessel had drifted to position 39°06.5'N, 168°12'W. She was settling slowly by the stern with seas washing into the hole in her starboard side at the number five upper tween deck level. No smoke was emitting from the damaged hold nor were there any signs of life aboard the vessel. The ABNAKI observed the damaged ship from a distance of 4,000 yards on 3 January 1970, with no apparent physical change being observed. Thereafter, surveillance was maintained from a distance of five to seven miles. Radar contact was lost at 052210 GMT January 1970 in position 40°11'N, 167°46.2'W. Recovery of debris by the ABNAKI confirmed that the BADGER STATE had sunk.

40. After continued rough weather the KHIAN STAR arrived at Yokohama, Japan late in the evening of 10 January 1970 and disembarked all crewmembers of the BADGER STATE the following day. Survivors reported excellent treatment while aboard the Greek vessel and had only the highest praise for its crew.

CONCLUSIONS

1. The casualty was caused by a combination of factors. After a shift of cargo the 2,000 lb. bombs came adrift from their palletized stowage. A low order detonation of one of the bombs occurred as a result of impact or heat generated as the bombs slid and rolled in number five upper 'tween deck. The detonation resulted in a hole in the starboard shell plating and possibly additional damage to the forward bulkhead of number five hold. This would allow progressive flooding as water entered number five hold through the holed starboard side and possibly through the underwater shell plating damaged by the explosion or fire, causing the abandoned derelict to eventually sink.
2. Most of the loss of life occurred as the result of a 2,000 lb. bomb falling through the hole in the starboard shell plating into the lifeboat containing the crewmembers who had abandoned ship. The capsizing of the lifeboat by the bomb threw the occupants into the water and rendered the lifeboat useless for rescue work. It could not be determined whether or not the lifeboat sea painter parted, came unsecured from the vessel, or was released prematurely. Neither could it be determined if the sea painter was firmly attached to the ship before the lifeboat was launched.
3. There is evidence that the painters on both the port and starboard inflatable liferafts failed, however this could not be verified as the failure was not observed nor were the liferafts recovered to permit examination.
4. Contributory factors were the heavy rolling of the vessel (up to 52°) induced by the extreme weather conditions, and the increased dynamic forces on the cargo resulting from the vessel's stiffness and short period of roll. The large metacentric height (GM) of the vessel, which was substantially dependent on the vertical distribution of cargo contributed directly to the vessel's undesirable rolling characteristics. Bilge keels would have moderated, to a limited extent, the rolling motion of the vessel.
5. The repairs made to the port boiler, steering gear, and the hole in the shell plating in way of the shaft alley were adequate. The vessel had full power and steering capability up to the time she was abandoned.
6. The BADGER STATE was loaded in the customary manner with substantially the same type of blocking, bracing, sheathing and dunnaging as other ammunition carrying vessels.
7. No specific fault could be found in the routing of the vessel in view of the generally bad weather prevailing across the North Pacific Ocean.
8. Although the lifejackets in use were approved for vessels on international voyages, the number of complaints received indicates a lack of efficiency under prolonged use or adverse sea conditions.

9. The casualty may have been prevented or its effects minimized if the Master had returned to port or sought shelter as soon as the cargo started to shift after leaving port. The course of action followed under the circumstances was reasonable, however, in view of the initial success of the crew in relocking and bracing the cargo.

10. Throughout this ordeal the actions of the Master and crewmembers of the BADGER STATE were in the best traditions of the sea. Although their untiring efforts failed to save the vessel, the calmness and devotion to duty which they exhibited undoubtedly prevented an even more extensive loss of life.

11. Rescue efforts by all participating units were timely and exhaustive considering the remote area in which the casualty occurred. The prompt response of the KIHAN STAR and subsequent rescue efforts of her crew undoubtedly saved the lives of the fourteen survivors. Able Seaman [REDACTED] of the KIHAN STAR, made a heroic, although unsuccessful, attempt to rescue Able Seaman [REDACTED]. These commendable actions on the part of the KIHAN STAR, her Master and crew will be the subject of separate correspondence.

RECOMMENDATIONS

1. That further study be given to the stowage, blocking and bracing of explosives aboard ship to determine if there are means to prevent shifting of cargo on vessels rolling to 52°. This determination should be based on reliable statistics, study of other cases, and detailed analysis. In this case not only was the vessel lost and not available for examination but the breakdown of the blocking, bracing, and palletizing was so complete and extensive in number five upper 'tween deck that the results of further examination of that hold would most likely have been inconclusive.
2. That study be continued to determine if lifejackets might be improved for use in extremely adverse weather conditions.
3. That further consideration be given to requirements concerning length, breaking strength, and methods of rigging inflatable liferaft painters.

[REDACTED]
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