

# HANDBOOK OF DAMAGE CONTROL

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## INTRODUCTION

### EXCERPTS FROM ACTION AND WAR DAMAGE REPORTS

(Variously altered for reasons of security.)

#### Inherent resistance to damage.

"If the ship does not sink within a very few minutes after damage, she probably will survive for several hours."

"Possibly the best indication of the ability of the (BB) to absorb the damage sustained (2 torpedoes, 1 bomb, 1 near miss) without serious effect is the fact that she was dry docked without any underwater repairs whatsoever and with the use of only two pumps on the forecastle."

"... the resistance to gunfire damage was remarkable, and is typical of the ruggedness of modern U. S. destroyers. During the period of action, \_\_\_\_\_ was between two enemy columns at ranges from 1,000 to 4,000 yards, and received eleven direct projectile hits—resulting in considerable, although not vital damage, and starting numerous fires. Speed was reduced from time to time in order to facilitate extinguishing fires."

"The beneficial effect of having wing tanks filled is illustrated . . . had the . . . tanks been empty, the flooding . . . would have given the ship a list of about five or six degrees."

"U.S.S. \_\_\_\_\_ was a victim of an unusual combination of circumstances which resulted in heavy damage. Her survival speaks well for the ruggedness of her construction and the effectiveness of her crew under very trying conditions."

#### Watertight integrity and watertight integrity discipline.

*Open doors, hatches, and valves.*

"Apparently, one of the crew went through the port door in bulkhead 37 on the second deck and failed to secure it. A short time later it was noticed that water was flowing through this door and aft into No. 5 hold. After properly dogging the watertight door in bulk-

head 37, the water was immediately pumped out of the hold."

"Root valves for galley drains were not closed, and exhaust steam backed up in the lines and entered damaged compartments through ruptured lines. This was the result of an error in setting condition able."

"With the flooding of the shaft alley and shaft alley recess the water continued upward through the shaft alley trunk and through the access door leading into the steering room, completely flooding that space. *This door apparently had been left open.*"

"All hatches on the second platform deck were undamaged. One hatch was insecurely dogged down by personnel escaping from lower magazine spaces, and this resulted in a compartment over the magazine spaces being flooded with oil and water."

"In the hold all doors were undamaged; yet two doors apparently were left open by personnel escaping from magazine spaces, and this caused some progressive flooding."

"A bulkhead on the second deck was almost undamaged, but the watertight door in it was left open after the escape of personnel and the compartment flooded. When the door was closed by a diver the space was unwatered in 45 minutes."

"It appears that the sinking would have been avoided if more closures on the third deck could have been made, and if more pumps had been available. Water was permitted to infiltrate through open valves and fittings, mainly in ventilation ducts, fuel-oil lines and fittings, and plumbing drains."

"A five-inch magazine flooded completely through two doors left partially undogged by personnel evacu-

ating these spaces. The athwartship passage on the first platform level was flooded to the waterline because the watertight door leading from the damaged laundry space was left open."

"The ice machine room (on a heavy cruiser) flooded to a depth of about one foot through a door which was improperly dogged, and through an unblanked cable hole."

#### *Faulty maintenance.*

"The ship listed to port and flooding began forward on the third deck, through the open manholes of the voids underneath. Flooding aft on the third deck through loose manhole covers and leaking deck seams started at about the same time."

"The center motor room flooded from leakage around the eight-inch bulkhead fitting and through the ventilation trunk."

"The loss of the ship is entirely attributable to progressive flooding. The very important lesson to be drawn from this loss is that flooding boundaries must be determined quickly and maintained effectively."

"Analysis quite plainly indicates that progressive flooding in spaces below the second deck caused the list to increase to a point where water was free to enter the second deck in large quantities. When this occurred, capsizing was inevitable."

"The ship sank because of deficiencies in watertight integrity, by virtue of the lack of watertight bulkheads on the second deck, and failure of boundaries and fittings elsewhere which should have been watertight but were not."

"The rupturing of the starboard fire-main riser (by bomb fragments) resulted in the flooding of A-405A, A-406A, and A-410A through splinter holes in the transverse bulkheads. Some water also leaked into the forward six-inch handling room through the reach-rod stuffing box."

"The stuffing boxes for the cables in the port wiring runs were noted to be leaking badly."

"Water entered the steering motor room through the ventilation system, cable stuffing tubes, and seams."

"Compartment C was unwatered and temporary re-

pairs were made to electric cable conduit stuffing boxes, thus stopping flooding."

"Torpedo explosion resulted in the immediate flooding of the forward engine room. There was slow flooding into the after engine room through cable stuffing boxes."

"No structural damage was incurred in the after fireroom, but the space flooded to the upper grating level due to copious leakage through electric stuffing tubes, through leaky main steam expansion joints, around number two and three propeller shafts, and through the open funnel drain."

"Water entered the I.C. room from the after gyro room through electric cable housings."

"Compartment C was flooding through electric cable stuffing boxes. When this condition was discovered the leaks were temporarily stopped and the space pumped out."

"All compartments below the third deck from frame xxx to frame xxx were flooded immediately except C— and C—. These two compartments flooded slowly through defective electric cable stuffing boxes."

"From the engine room the water entered the shaft alley through a leaky door and through unpacked glands around electric cable, and when the shaft alley was flooded, the water entered the after magazines through an electric cable hole in the deck of the handling rooms."

"The flooding of the shaft alley and after magazines through leaky doors, unpacked glands, and open cable holes again emphasizes the necessity of constant checking and searching for openings in "watertight" boundaries. Even though initially tight at the builder's yard, bulkheads must be checked by the ship's force at frequent intervals. This can readily be the margin by which the ship is saved or lost."

"The after engine room flooded to a depth of about five feet as a result of leakage through the bulkhead shaft stuffing boxes."

"An examination subsequent to damage revealed several holes in the watertight bulkheads aft of the ice machine room which had not been blanked off upon removal of electric cable. Had this space flooded com-

pletely one or more compartments aft of this space probably would have flooded. Routine air testing is for the purpose of detecting deficiencies in watertight integrity and should reveal such defects as these."

#### Fire prevention and fire fighting.

"The U.S.S. \_\_\_\_\_, in spite of her small size, would have survived damage to the hull had there been no fires. Watertight subdivision, stability characteristics, and reserve buoyancy were all adequate to absorb the damage without fatal consequences. After this ship was abandoned she was struck by three additional torpedoes. Even then she did not sink immediately. Considering the durability of this ship, it is unfortunate that fire caused her loss."

"The inability to control the fire was one of the vital factors which caused the entire situation to become hopeless in such a short period of time. Lack of pressure at upper-deck fire plugs prevented employment of effective fire-fighting measures. References do not contain any mention of attempts to cut out the damaged portion of the fire main forward."

"With two minor exceptions the engineering plant was intact and engineering personnel remained at their stations until the ship was abandoned. The inability to control the fire is disappointing in view of the excellent facilities provided, and the intact condition of the pumping plant. Low pressure to the fire plugs on the upper decks was caused by an open break in the forward loop of the fire main, *and the fact that this loop never was isolated from the rest of the system.*"

"Structural damage to the U.S.S. \_\_\_\_\_, although extensive, was not such that loss of the vessel was inevitable. The fires which resulted however, effectively prevented control of damage."

"These fires were fed by topside paint, life jackets, signal flags, airplanes, airplane spare tails, wings, parachutes, ships' boats, lubricating oil, and kerosene, which made the area between the bridge and the after bulkhead of the hangar an inferno beyond human endurance."

"These fires (and particularly one in the wardroom country) were the direct cause of the loss of this ship. Excess equipment, paint on bulkheads, records, and so forth in the officers' spaces and in ship's offices pro-

vided fuel for a fire which worked downward, exploding ammunition in five-inch hoists."

"This emphasizes the absolute necessity of permanently removing inflammables and of leaving ashore clothes, records, paint, and other materials that are not essential for war-time operation of the ship."

"It was approximately 12 hours from the time of the torpedo detonation until the fire was extinguished. Throughout the whole period of the fire, dense smoke, which resulted from the burning oil vapors, was a severe handicap. Rescue breathing apparatus was successfully used by the crew when entering smoke-filled spaces to quench smoldering embers."

"The failure of several sections of hose resulted in an unfortunate delay during the early and critical period of the fire. This permitted the fire to gain considerable headway before water was applied."

"That the fire on the U.S.S. \_\_\_\_\_, which was of major proportions, was at first successfully controlled and later extinguished despite inadequate fire-fighting facilities is a tribute to the skill of her personnel."

"Twenty-two different fires started during the engagement. All of these were brought under control quickly by prompt action of fire-fighting parties. The fact that these fires were put out speaks for itself."

"Fragments will start fires. They will also damage mains, fire plugs, nozzles, and fire extinguishers in the vicinity. Fire-fighting equipment on exposed decks should be shielded as much as arrangements permit."

"In cases of oil fires following a torpedo detonation, one of the most important measures is to bring into play promptly as many hose lines equipped with fog nozzles as possible. Time is the very essence of effective action in combating a fire of this type, inasmuch as the fire will accelerate swiftly and quickly advance beyond control of any facilities which are practicable to install on a warship."

"Rubber fire-fighting boots and gloves are of unquestionable value in fighting fires near ruptured electrical cables. Those who failed to use them learned their lesson the hard way."

"The bomb exploded upon contact. Fragments

pierced the hangar deck, and fires were started in three planes. The sprinkler system and water curtains in the two after bays quickly extinguished the fire."

"A small fire was started in B-2, but was quickly extinguished with the use of a gasoline handy billy."

"In the loss of this ship we again find some of the same lessons learned in the Naval actions of the Pacific. The presence of unessential inflammable material and the absence of adequate fire-fighting facilities prevented control of the fire."

"Fire immediately broke out . . . in the crew's quarters, G.S.K. storeroom, and small stores compartment. Clothing, bedding, linoleum, cork slab, and bulkhead paint burned in these spaces, producing a great deal of smoke. The fire was difficult to control due to lack of access. Wrecked bunks and bins kept men from the seat of the fire."

"Fire damage was extensive. Insulation on cables . . . was completely destroyed. The fires were under control in about twenty minutes."

"The bomb which detonated in the C.P.O. mess room started a fire in this compartment and the storeroom (below it) . . . filled the damaged area with smoke and necessitated abandoning the sick bay area. To permit the repair party to fight the fire, the smoke was vented topside by opening hatches on the second and main decks."

"In one place a heavy steel door had to be cut away to get into the linen locker where there was a very persistent fire. Rescue breathing apparatus was used while fighting the flames in enclosed spaces and in making inspections of smoke-filled holds and engineering spaces. During the fire-fighting operations on this ship, fog, solid stream, chemical, and mechanical foam were used."

"Although the fires started during the morning attack were extinguished in about two hours, they were very difficult to fight, and required the attention of a large number of the crew. These fires were fed by excess clothing, upholstered furniture, and excess material in squadron ready rooms."

"Mattresses, clothing, and upholstered furniture contributed greatly to the tenacity of the fire, and pre-

vented it from being brought under control early in the action."

"The bomb which detonated in the crew's mess room also started a fire in the wardroom mess room which contained a great deal of upholstered furniture. Dense smoke passed into the hangar where conditions were made extremely difficult for the repair parties. There was little if any fire in the crew's mess room (where the bomb exploded) *because no combustible material was present.*"

"The bomb hit in the uptakes started a heavy fire on the second deck in the photographic laboratory, where films caught fire, and in the executive office and the first lieutenant's office where papers caught fire."

"Repair parties extinguished the fire in the rag stowage in about one hour, except for some baled rags that smoldered (for about two days)."

"Fires were started in the Admiral's and Chief of Staff's cabin. Fire in the upholstered furniture of these cabins was very difficult to extinguish."

"Fires started in a compartment consisted mainly of burning and smoldering bedding and personal effects from lockers. These fires created dense smoke which completely permeated the area."

"The dense smoke, the wreckage of lockers and bunks, and the damage to the fire main hindered repair party personnel in fighting the fires."

"Rescue breathers had to be employed in order to rescue injured personnel."

"Since there was no water pressure available on the fire main, the fire was fought by a bucket brigade. It was finally extinguished by a handy billy set up on the main deck."

"Central station was also filled with smoke which entered through the ventilation system."

**Drainage of damage water, and obstacles encountered.**

"The three gasoline handy billies were placed in operation to unwater a flooded compartment, but were not of much use due to the fact that large quantities of bedding and personal gear were continually plugging the suction lines."

"Damage-control personnel did not function smoothly. There was confusion in getting started, and difficulty in getting submersible pumps in operation."

"The need for additional drills and training was brought home. There was delay in getting electric submersible pumps and gasoline driven handy billies into operation, due to inability to find proper couplings for connecting up sections of hose. Further, the leads on the submersible pumps were not long enough to reach a power outlet, and had to be lengthened before the pumps could be used, power outlets in the vicinity of the damage being dead because electricity had been cut off in the damaged, fuel-oil filled areas as a precaution against fire."

"Two portable electric submersible pumps were rigged to pump out A-202L. One burned out and the other had a ground which required two hours to bake out. The latter then was used to clear A-202L of water."

"The main circulator was started and put on bilge suction, and flooding in the forward engine room was quickly controlled although the pump operated close to capacity."

"... no suction could be taken from the damaged oil tanks . . . because the suction manifold was submerged . . . and had also been broken by the bomb."

"No pumping was carried out forward as power was never regained. All compartments were flooded with oil making it impossible to use a handy billy."

"Submersible pumps clogged up due to the presence of paper, clothing, and other loose gear from flooded living compartments."

"Debris resulting from an explosion will always clog submersible pumps. Such pumps should have large basket screens; these are being made on this ship."

#### Engineering and electrical aspects.

"Boilers Nos. 1 and 2 were subsequently secured, due to the failure of the fire main in the forward fire-room. This resulted in loss of cooling water to the lubricating system of the forced-draft blowers."

"The action of the ship's force in pulling all power

circuits to the forward turrets when these turrets were out of action was an excellent move, and undoubtedly prevented further trouble such as fires from shorted circuits."

"The U.S.S. \_\_\_\_\_ had an extremely serious casualty just as the first phase of the action ended, losing all electrical power at 1800 and not regaining it until 1815. This casualty apparently resulted when electrical faults appeared in the five-inch system which had locked circuit breakers."

"The salvage and rescue work was seriously handicapped by absence of light."

"Considering the violence of the explosions which resulted in the loss of one-quarter of her length, the lack of machinery difficulties and electrical difficulties is remarkable. *It is clearly evident that considerable effort was expended on the myriad details of maintenance, and that such efforts paid dividends.*"

"Two fuel tanks, which were required to be kept full of either fuel oil or salt water at all times inasmuch as they constitute a portion of the liquid protection for the after magazines, *were empty.*"

"Excellent design, material upkeep, and operating procedure was evidenced by the ability of the after engines to run unattended at 290 r.p.m. for a period of about two hours without casualty."

"Shell hits put the supply blowers out of commission and caused considerable difficulty with heat in the after engine room. It was kept in operation, however, by frequent changes of the watch. *Operating personnel wore plenty of clothing for heat insulation.*"

"All light and power were lost in a few minutes because of salt water in the fuel oil . . . from the rupture of fuel-oil tanks from the forward torpedo." (Improper distribution of fuel-oil service arrangements.)

"The explosion drove metal splinters into the cables, causing short circuits which resulted in blowing the circuit fuses of the energized circuits. Tests showed other circuits to be shorted also."

"Cables running in wire ways . . . were torn loose from hangers and ruptured in some cases. Those . . . that passed through a non-tight bulkhead and

were not fitted with bushings were sheared by the edges of the drilled holes. The explosion also ruptured the air lines to the forward guns . . . ."

#### Damage-control organization and training.

"The performance of the ship in sustaining and successfully combating such extensive damage is gratifying to say the least. The success of damage-control measures indicates thorough preparation both in material readiness and training of personnel."

"This cruiser suffered a torpedo hit aft, resulting in the loss of two propellers and steering control. Despite the radical reduction in fighting efficiency, this ship continued in action, engaged an enemy battleship, and sank an enemy destroyer the following morning. This record is impressive, and is a tribute to the skill of her personnel."

"Damage-control training should be based on coping with the most adverse combinations of conditions."

"A damage-control party functioned in an efficient manner and is deserving of high praise for its action after the battle damage was incurred. Fires, slight flooding, necessary shoring of bulkheads, removal of injured personnel, and necessary pumping and rigging of emergency electrical leads were all handled in a highly commendable fashion which showed the direct result of *constant instruction and vigilant training*."

"Training of the crew in watertight-integrity discipline *must* emphasize the danger of leaving watertight hatches and doors open. An obvious lesson is the danger of opening scuttles for visual observation of damaged spaces below. Sounding tubes or air escapes should be utilized for this purpose, where installed. Air-test fittings can always be used. Under no circumstances should any hatch be opened where there is even a slight possibility of the space below being flooded."

"To date the U.S.S. ——— is the only U. S. warship to survive two torpedo hits. This was a noteworthy achievement, and was made possible by the prompt and effective damage-control measures taken by the crew."

"Although the hull of the U.S.S. ——— absorbed the effects of structural damage in a satisfactory manner, complete loss of propulsion and electrical power

was narrowly avoided. This could have occurred easily had the engineering force been less vigilant."

" . . . undoubtedly would have sunk after the first torpedo struck had she not been beached quickly. The remarkable, persistent, and skillful efforts of her entire crew not only saved her, but also most of her cargo, sorely needed at that time. . . . the inflexible determination of her personnel . . . the key to her ultimate survival and return to service."

"Immediately after the shell hit was received, both repair parties were dispatched to the scene of the action and the first lieutenant supervised their activities. Minor fires caused by exploding 20 mm. shells were quickly put out. As the fire main was ruptured, a jumper was rigged between two risers on either side of the break, thus putting the magazine sprinkling system back in operation. It was gratifying to note the skill with which the repair parties operated."

"At 0659 this ship experienced a heavy explosion aft. The damage-control party upon immediate investigation ascertained that there had been serious damage from the explosion, and reported small scattered fires which were quickly brought under control. It was realized by the damage-control party that electrical power in the after part of the ship could cause serious fires due to broken leads, and steps were taken to secure all electrical power in the damaged area. Inasmuch as power was required by the submersible pumps (in case of flooding) and for welding and cutting equipment in the damaged compartments, portable electric leads from the power casualty system were rigged, and were available almost immediately."

"A report was received by messenger that compartments B-1, B-2, and B-3 were flooded, that depth charges were set on safe, and that there was an oil fire in B-3. This fire was put out with foam, as there was no water pressure available. There were two subsequent fires in the same compartment that were extinguished by the same means. Compartment B-4 was not damaged, and the generator located there kept running. Under the leadership of the assistant engineer officer, the rigging of emergency power cables was commenced at once. The repair party immediately began shoring the forward bulkhead located in compartment B-4. The work of repair parties in evaluating and repairing damage and in the extinguishing of fires was outstanding."

"This ship was hit by a six-inch shell from a shore battery. Before the hit was received speed was 15 knots. Just as the hit was received speed was increased to 25 knots for evasive purposes, but the port engine slowed momentarily until the plant could be cross-connected and both engines shifted to steaming on the forward fireroom. The after fireroom was properly secured by the watch, and all action incident to the cross-connecting of the plant was carried out, despite rising water and escaping steam in the fireroom. The fireroom was flooded to a depth of approximately 12 feet. An exterior temporary patch of boiler plate, held in place by a turnbolt in the center of the plate and padded with mattresses and pillows was put into place. After this the fireroom was pumped dry, using three submersible pumps in addition to the main drain. No further difficulty was experienced with flooding."

"In a surface engagement between a destroyer and an enemy submarine the destroyer attempted to ram, and in so doing suffered a five-inch hole two feet above the waterline in an engine room, and completely sheared one propeller shaft. Damage-control measures were instituted immediately. Mattresses backed with heavy shoring were used to block off the hole and the leakage was completely stopped. A wire strap was taken around one of the blades of the useless screw and secured to the deck. This prevented the screw from turning and banging against the ship's side while the ship was underway. Further repairs were made later by ship's force, who welded a temporary patch on the hole in the engine room."

"Damage-control measures taken immediately after the explosion:

1. An immediate inspection was made of the watertight integrity throughout the undamaged portion of the ship.
2. C and R soundings were instituted immediately.
3. The damaged area was inspected for possible points of weakness, and to see if the ship showed signs of breaking in two.
4. Watches were posted adjacent to spaces where the damage was centered for the purpose of detecting fires and any breaking noises.
5. The forward bulkhead of B-4 was shored across its entire width to take care of any undue pressure that might be exerted while under tow.
6. All handy billies were rigged and suction taken over the side because fire-main pressure was lost.

7. Cans of aerofoam were distributed to the handy billies to take care of any possible fire."

"Damage-control measures were seriously handicapped by the following:

1. There were only three survivors in the forward repair party and two of these were disabled.
2. All light and power were lost forward.
3. The damage amidships prevented the after repair party from getting forward to assist in the control of flooding.
4. The forward repair locker was destroyed, although damage-control equipment was distributed throughout the ship.
5. The continuing attack."

#### Miscellaneous.

##### *Magazine sprinkling.*

"Whether or not to flood magazines is one of the most difficult damage-control decisions to make, particularly in the heat of action . . . in this case it appears that flooding of the after magazine might have been avoided . . . it seems that a good criterion would have been whether decks and bulkheads bounding the magazines had been dangerously warm. . . . As a precautionary measure, it probably would have been sufficient to sprinkle the magazines for a period just long enough to obtain an adequate cooling effect."

"The forward magazines . . . were flooded as a precautionary measure . . . The forward hold and the small-arms magazines flooded because of leakage from the forward magazines. Free surface in these compartments contributed to the loss of metacentric height."

##### *Communications.*

"Ship's personnel were well pleased with the performance of sound-powered phones. No failures were experienced except in cases where lines were actually severed."

"With the exception of two dead circuits to the flooded firerooms, the sound-powered phones remained in normal operation. The general electrical power failure caused all other telephones to go dead."

"Each topside repair patrol talker should be equipped with telephones with sufficient length of lead to allow access to any point of his patrol area."

"It is recommended that more drills be held to exercise communication by messenger."

"Due to a misunderstanding originating from poor communications, flooding was commenced in an eight-inch powder magazine."

*Personnel protection.*

"Unengaged personnel should lie down on deck in action, especially in air attacks, to reduce blast and shrapnel exposure. Insofar as possible they should also lie clear of doors and hatches."

"Anti-flash clothing should be worn during battle by all personnel below decks as well as topside."

"Rubber boots with non-skid soles are an absolute necessity for damage-control parties working in an area where the decks are covered with fuel oil and water."

"The value of protective clothing and eye shields was again demonstrated. Those so equipped escaped serious burns."

"One uninjured member of mount \_\_\_\_\_ gun crew stated that he did not wear his jacket at the time

because it hindered his movement between the mount and the ready projectile stowages on the shield. He stated that he can now move without undue difficulty with his life jacket on."

"In several instances fragments penetrated and tore kapok jackets without injuring the men wearing them. The value of the kapok jacket as protection against fragments has been pointed out before . . . It is believed that all hands of this vessel have learned their lesson . . ."

"The importance of . . . having and wearing life jackets and helmets was strongly pointed out as a result of this action."

"It is of importance to note that of personnel killed one man was merely a spectator when he was fatally hit. He had come out of the galley to witness the action, and had failed to put on a life jacket which previously had been furnished him . . . The collar of a jacket would (probably) have prevented passage of a fragment which was the direct cause of his death."

"Three men had strolled on deck from their normal battle stations in order to witness the action. All were hit. None had his life jacket on."