Damn the Torpedoes – The U.S. Navy's Most Costly Weapon Technology Failure

An Online Continuing Education Course for Engineers

Course Number: M-2082

Credit: 2 Hours / 2 PDH / 2 CPD

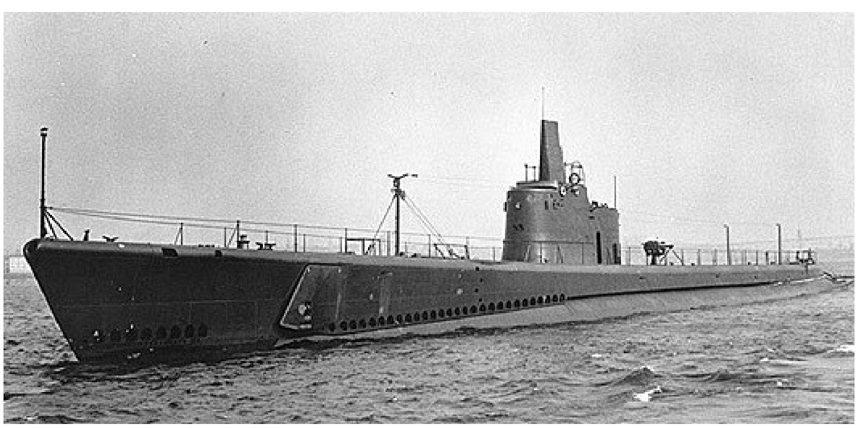
Damn the Torpedoes – The U.S. Navy's Most Costly Weapon Technology Failure

James S. Bluma, P.E.

Following the devastating attack on the U.S. Navy's Pacific Forces on December 7, 1941, at Pearl Harbor, only two elements of these forces remained essentially intact. These two elements were the U.S. Navy's aircraft carriers and their Pacific Fleet submarines. The aircraft carriers could deploy Wildcat fighter planes, Dauntless dive - bombing planes and Devastator torpedo planes. The Devastator and the Pacific Fleet submarines carried the newly developed and untested Mark 13 and Mark 14 torpedoes respectively. The Mark 13 and the Mark 14 were identical except for external features added to the aerial dropped Mark 13 that allowed it to regain attitude and depth control more rapidly after being dropped into the sea from an airplane. These features increased drag and limited its submerged speed to 40 knots versus 46 knots for the Mark 14. The performance and reliability of both the Mark 13 aerial torpedo and the Mark 14 submarine torpedo were vital to stem enemy territorial expansion in the Pacific Theatre. These new and untested torpedoes were equipped with a recently developed top secret fuze that was intended to detonate the torpedo warhead upon contact or in a desirable proximity of the target. The U.S. Navy refers to these fuzes as "exploders," and it is by this name that they will be referred to in this course. The first testing of the Mark 14 torpedo when combined with the highly complex and secret Mark 6 – Mod 1 exploder would take place in combat within days of the Pearl Harbor attack.

The weapons system that would deliver the Mark 14 torpedo would be primarily the Gato Class submarine (Figure 1) and other Fleet type submarines. This class was developed concurrently with the Mark 14 torpedo and could accommodate and fire the longer 21 - foot long Mark 14 versus the 15 - foot Mark 10 torpedo that it was intended to replace.

Below, **Figure 1**: Gato class Fleet submarine developed for operation with the U.S. Pacific Fleet. The six bow torpedo tubes and four stern tubes combined with its speed and endurance would give this type the potential to be a very formidable and effective weapon.

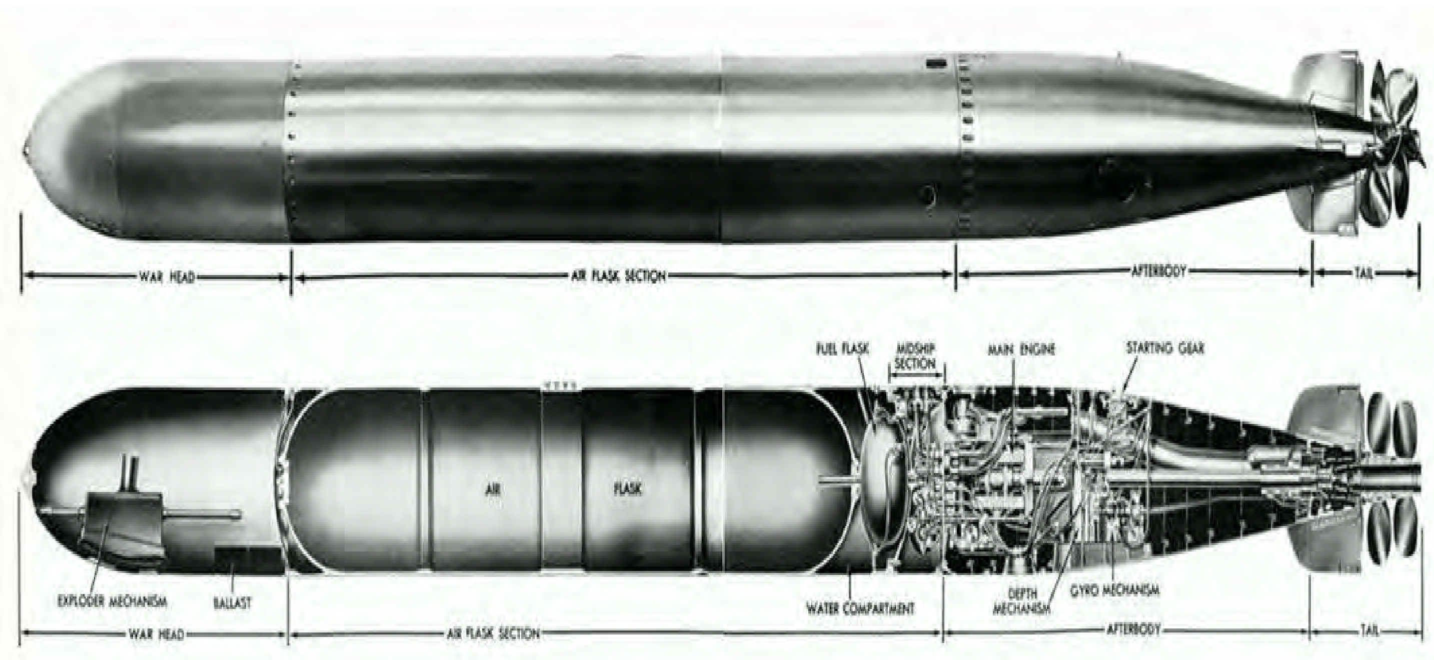


Development of both the Mark 14 torpedo and the Gato class submarine began in 1931. At its conception, the Gato class was intended to be a tactical weapons system that would operate alongside Battle Ships and supplement them in combat with enemy surface ships. In 1931 the Battle Ships in the U.S. Navy's fleet had a top speed of 22 knots and the new submarines had to have nearly the same top speed to keep up with or scout ahead of them, this is why this type of submarine is often simply referred to as a Fleet submarine. With a surface displacement of 1,525 tons, the Gato class and other Fleet types were much larger and faster than the 840 Ton S – class submarines that the Navy had operated in the Atlantic with a surface speed of 21 knots versus 15 knots for the S – class boats. The Fleet type submarines were 312 feet long with a beam (width) of over 27 feet. When running on diesel power, at the surface, its engines produced 5,400 shaft horsepower and when submerged, its four electric motors produced 2,740 shaft horsepower giving them a high (for the time) submerged speed of 9 knots. Their range of 11,000 nautical miles combined with their endurance of 75 days on patrol and ability to remain submerged for up to 48 hours would make them ideal for the role that they would play in the Pacific war. By the time that war broke out for the United States in late 1941, the newest Battle Ships in the U.S. Navy's fleet could exceed 30 knots. The higher speeds of the newer Battleships, Cruisers and Aircraft Carriers meant that the Fleet submarines could not operate alongside them in a tactical role. A new way of applying these Fleet submarines in a strategic way had been developed; they would be used as hunter/killer ships in enemy waters to blockade Japan to reduce or cut off their supplies of material and fuel and also to ambush enemy fleets.

On December 8th, the day after the Pearl Harbor attack, Japanese air forces attacked allied bases in the Philippines to destroy the air defenses stationed there in order to clear the way for an invasion and occupation of the Philippines. By December 10th, the U.S. Navy had 28 Fleet submarines each carrying twenty-four Mark 14 torpedoes in place to ambush the approaching Japanese invasion fleet, this was the largest grouping of submarine firepower ever assembled and was expected to inflict heavy losses on the invaders. After firing hundreds of torpedoes at the 80 approaching troop transports and support ships, only one ship, a troop transport carrying approximately 1,000 troops was sunk. General Douglas Macarthur was astonished by the dismal performance of the defending submarines and would escape Manila by PT boat during this first battle for the Philippines. The Japanese were able to land over 129,000 well-equipped troops to defeat the American and Filipino forces stationed there who surrendered on May 8, 1942. Allied losses included 23,000 U.S. and over 100,000 Filipino troops killed or captured, most of those captured would not survive. This battle is considered America's largest military defeat and it began with the first testing of the Mark 14 torpedo and its Mark 6 exploder. Many submarine Captains complained about the new torpedoes performance with a large number reporting that they had seen their torpedoes explode at the targeted ship through their periscope from a distance of about 1,000 yards and seeing the ship continuing on as if undamaged. In May and June of 1942, a similar performance of the nearly identical Mark 13 torpedo was observed when dropped by Devastator torpedo planes during the battles of Coral Sea and Midway. The battle of Midway was a great U.S. Navy victory however the four enemy aircraft carriers sunk there were destroyed by dive bombers, not torpedoes.

For 21 months, several flaws had combined to render the Mark 14 torpedo (Figure 2), upon which the lives and success of submariners depended, virtually impotent. From the onset of Mark 14 production, inherent defects had existed within the design of both the torpedo and the Mark 6 magnetic influence and contact inertia exploder mechanism. Each flaw that was discovered and corrected exposed another malfunction. The author of the official naval history of submarine operations during WWII would later write that "the only reliable feature of the Mark 14 torpedo during the first 2 years of the war was its unreliability".

Below, **Figure 2**: Mark 14 torpedo with cutaway showing the Mark 6 exploder mounted in warhead at left. (Images from original U.S. Navy training manual)



After the initial Japanese naval onslaught in late 1941, the U.S. Southwest Pacific Command was established. Rear Admiral Charles Lockwood assumed command of all former Asiatic Fleet submarines and divided the flotilla between the Australian harbors of Brisbane and Perth/ Fremantle. Unlike a number of flag officers who held a wide variety of posts during their careers, Admiral Lockwood considered himself to be a true submariner. He would prove to be an extremely pragmatic commander and a widely respected leader. This would serve him and his country well during the dark months after Pearl Harbor.

As yet unaware of their torpedoes' faults, submarine Captains reported an alarming number of pre-matures, duds and inexplicable misses during the first full year of the war. Frustrated Captains watched helplessly as their torpedoes passed under their target, detonated fifty feet from it or impacted without detonating. In response to repeated requests by field commanders, The Navy Bureau of Ordnance (Bu Ord.) conducted test firings to evaluate the depth control of the Mark 14. By February 1942, the bureau reported a variance of 4 feet in depth control during the initial 880 yards of run. Since 4 feet of depth would make little difference when engaging a capital ship, and since most attacks took place at the 1,000 - yard range, the bureau concluded that the torpedoes were not at fault, rather it must have been the crews' inexperience and errors that were causing the failures. The bureau argued that even if a torpedo did slip under a shallow draft target, the magnetic detonator would activate the warhead. Faced with such apparently sound arguments, the submariners could only redouble their fruitless efforts. After five months of desperate action, little enemy shipping tonnage to show for their sacrifice and continued pleas from his Captains for reliable torpedoes, Lockwood decided to conduct his own tests.

Lockwood and his team bought 500 feet of netting from local fishermen and moored it in deep water just outside Frenchman's Bay near Albany, Australia. A Mark 14 was obtained from an incoming submarine, the Skipjack, whose crew was very willing to offer it for the tests. Lockwood's men modified the Mark 14 by replacing the warhead with an exercise head. This replacement head contained a calcium chloride solution that made its weight exactly the same as the TNT filled warhead. The modified torpedo was loaded into a submarine and Lockwood ordered a series of test firings. Set to run at a depth of 10 feet, the torpedo was launched at the net from a distance of about 900 yards. When divers inspected the net, they discovered that the torpedo had cut through the net 25 feet below the waters' surface. The next day, two additional test firings were made that penetrated the net eight and eleven feet deeper than set. Since he believed that this extra depth had also kept the magnetic detonators from working properly, Lockwood ordered all of his submarine commanders to adjust their torpedo depth settings accordingly. Most of these Captains, not wanting to take chances, set their torpedoes for zero depth. Lockwood and his staff realized however that the malfunctioning torpedoes needed to be corrected and compensating for unpredictable variations in depth control was not an adequate solution.

The Bureau of Ordinance responded to Lockwood's test results by stating that they were flawed and thus not conclusive. The stateside Bureau claimed that improper trim conditions had been created when the field testers used an exercise head that was slightly shorter than the warhead. Undaunted, Lockwood's team lengthened their exercise head to warhead length and immediately produced the same results. In response, Commander James King was brought out of retirement and made chief of the bureau's research and development section to address the depth control problem. King had earlier been responsible for adding additional high explosive to the Mark 14 warhead and for designing the torpedo's excellent twin counter-rotating turbine engine which eliminated the additional gearing otherwise required to drive the two counter-rotating propellers. He immediately began to conduct tests similar to Lockwood's, launching torpedoes into nets from submarines, not from barges, as had been the common practice. Not surprisingly, King achieved the same results as Lockwood. On August 1, 1942, he advised the fleet that the Mark 14 torpedo ran approximately 10 to 12 feet deeper than set.

The initial culprit was the depth control mechanism. This intricate and sensitive device sets the tension of the depth spring to correspond with the water pressure at the desired running depth. The two controlling elements within the depth mechanism are the hydrostatic valve or diaphragm and the tamping pendulum which countered the effects of wave action and limited the maximum rate of both ascent and descent of the torpedo. Ideally, when the torpedo reached the prescribed depth, the force exerted on the diaphragm by the water would equal the force exerted on the diaphragm by the spring. The setting was adjusted and indicated on a graduated dial called the depth index wheel and these settings could be made and read when the torpedo was in its launching tube.

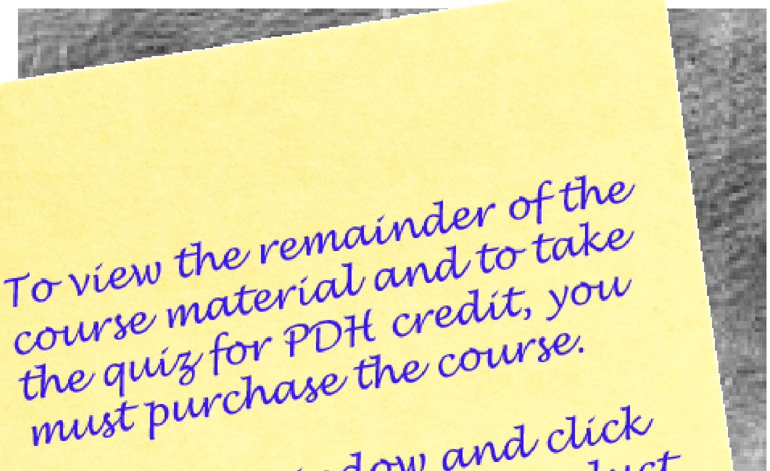
On previous torpedo models such as the Mark 10, the hydrostatic valve was located in the middle section of the weapon just behind the warhead. To increase range and speed, this space became filled with larger air and fuel tanks on the Mark 14 as well as its aerial and surface-launched variants the Mark 13 and 15 and as a result, the valve was moved further aft. This revised layout was originally perceived as a benefit because the depth control mechanism would be closer to the rudders it controlled. Its final location was the tapered section of the torpedo near the tail. No one realized that placing the valve at a slight angle to the weapon's longitudinal axis would cause a corresponding change in how the valve reacted in determining depth control. The flow of water across the tapered aft area of a faster moving torpedo such as the Mark 14, created a lower pressure region in the area of the depth control pressure sensor. This low pressure caused the depth control mechanism to send the torpedo to a greater depth than was set on the depth index wheel to achieve the pressure that the device had been calibrated for.

Further complicating the depth control problem, it would later be found that the depth recording instrument used by the bureau to check the accuracy of all hydrostatic valves was improperly calibrated. Late in the war, technicians discovered that the recording instrument and the misplaced pressure sensors erred in the same direction and by the same amount. Two completely different devices, each responsible for checking the other, deviated identically for vastly different reasons. This coincidence explains the bureau's initial testing results and its rejection of Lockwood's evidence. Earlier improvements to the torpedo by Commander King, though well-intentioned, added to the depth control problem. The higher density TNT that King had developed to increase the warhead capacity by 115 pounds had caused the warheads to further deviate from the test warheads. The Bureau of Ordnance was using one version of the Mark 14 for testing and issuing quite a different version for combat.

The problem of designing identical torpedo heads for testing was solved by using Lockwood's calcium chloride solution which correctly matched the warhead in size and density. The hydrostatic valve problem was alleviated when a new re-calibrated depth control valve was designed and installed on all Mark 14 torpedoes. Once these improvements brought the Mark 14 up to the correct depth, the torpedoes Mark 6 - Mod 1 exploder with its dual mode magnetic influence / contact inertia detonator presented additional problems.

Development of the Mark 6 exploder began in 1922 at a time when the U.S. Navy still believed that submarines would be playing a tactical role in naval combat in support of capital warships. In this role, a submarine would need to be able to cripple or sink heavy cruisers and battleships however the thick side armor on these ships made this impossible with anything but a perfect pattern of 4 or more torpedoes. If a torpedo could be made to detonate under the ship, near its keel where the armor is thin or non-existent, one or two torpedoes would be capable of sinking these ships. This was the impetus for the development of the magnetic influence detonation feature on the Mark 6 exploder. All development work on the Mark 6 exploder was carried out under the tightest of security at the Naval Torpedo Station on Goat Island near Newport, Rhode Island. If potential future enemies knew of its existence, they could re-design their warships to be resistant to such an attack. By late 1925, a number of these exploders had been produced and were ready for testing. The Navy allowed just two live test firings of the new and highly complex exploder and these were mounted into the warhead of the Navy's standard torpedo of the time, the Mark 10. In 1926, two firings were conducted off the eastern coast of the U.S. under heavy security. The 2 torpedoes would be fired at the hulk of an obsolete submarine with the depth set to pass under the target ship's keel. The first shot at the target passed under the submarine without detonating, the second torpedo detonated under the sub and sank it, with a 50% success rate, the Naval Torpedo Station declared the test a success and ordered 1,500 of the exploders which were placed in storage and not issued until the summer of 1941. These exploders cost $1,500 each in 1941 dollars which was more than the cost of an entire torpedo used by any of the axis powers during the coming world war.

Below, **Figure 3**: Aerial view of the first of only two test firings of the Mark 6 magnetic influence exploder, this first test shot was a failure, the second was successful. Both were fired on a slower Mark 10 torpedo with reliable depth control.



At 22:2 ... s in Micronesia, roughly 300 mi ... Tunny, made radar contact with an ... engine speed to maneuver into p ... course putting the Tunny in a posit ... n to decks awash to avoid detectio ... r, Commander James Scott, cou ... rcraft carrier and to port, two escor ... ven this perfect setup, he maneuv ... rgets, but her plans were disrupted when three small ... pedo boats appeared only three hundred yards off her port bow. Tunny qu... dove to 40 feet, her periscope depth, turned right ninety degrees and launched four torpedoes from her stern tubes at one of the escort carriers from a distance of 880