

# Why the USS SCORPION (SSN 589) Was Lost 50 years Ago

## A technical assessment based on metalurgical analysis of recovered wreckage and analyses of acoustic detections of the event

*The author was the lead acoustic analyst at the Office of Naval Intelligence for 42 years, testified before the THRESHER Court of Inquiry in April 1963, published major assessments of the losses of THRESHER and SCORPION (royalties declined) and has contributed pro bono to numerous books and articles on the losses of Soviet submarines including the GOLF Class SSB K-129. For access to more than 100 additional discussions of submarine-related subjects, search the Internet for Commentaries Bruce Rule.*

## Summary Assessment

The US nuclear submarine SCORPION (SSN 589) was lost on 22 May 1968 because the explosion at 18:20:44 Greenwich Mean Time (GMT) of hydrogen out-gassed by the TLX-53-A main battery created over-pressures within the battery well that were more than several times the 100-percent fatal level and at lower but still fatal levels throughout the submarine if the bulkheads were not watertight (sealed). That explosion did not breach the pressure-hull.

Over the following 21m, 50s, SCORPION sank vertically to collapse (implode) at 18:42:34 GMT at a depth of 466m (1530-feet) in 37milliseconds (ms), 1/27<sup>th</sup> of a second with an energy release equal to the explosion of 6000 kg (13,200 lbs) of TNT, the almost instantaneous (less than 0.001s) conversion of potential energy ((sea pressure of 46.3 bars (680 psi)) to kinetic energy, the motion of the water-ram which entered the SCORPION pressure-hull with a velocity of about 900 m/s (2000 mph). The time of the battery explosion and the position of the wreckage indicate that - when lost - SCORPION was on the planned course of 290 and about 35 nautical miles (nm) behind the Projected Intended Movement (PIM) based on a planned speed-of-advance (SOA) of 18 knots and the position reported by SCORPION at 212354Z, 18 hours and 27 minutes earlier. All times are onboard event times.

## Analyses of Physical Evidence

Ten months after the USS SCORPION (SSN 589) was lost in the east central Atlantic on 22 May 1968, the US Naval Ships Command issued a change to NAVSHIPS Technical Manual, Section 9623.718, March 1969 Edition.

That Section - which discussed "Submarine Storage Batteries" - stated the following: "Do not enter the battery well of ships having open tank ventilation systems while a charge is in progress." The Section further stated that "Experience has shown that all individual (battery) cell explosions have occurred while personnel were working in the battery tank during charge."

Based on microscopic, spectrographic and X-ray diffraction analyses of SCORPION battery components - recovered by the US submersible TRIESTE - by the Portsmouth Naval Shipyard Analysis Group, Section 7.1.3, page 72 of the SCORPION Structural Analysis Group (SAG) Report of 29 June 1970 stated: "...the general battery damage is violent. The high velocity intrusion of pieces of the flash arrestor into both the inside and outside surfaces of the retrieved plastisol (battery) cover attest to violence in the SCORPION battery well. Battery cell debris is in evidence over the entire SCORPION debris field."

The SAG included the Navy's leading experts in submarine design, submarine structures, and the effect of underwater explosions: Peter Palermo, CAPT Harry Jackson and Robert Price.

Page 7.8 of the SAG Report notes that the estimated over-pressure in the SCORPION battery well from the explosion (of hydrogen) was 10.2-13.6 bars (150-200 psi), multiple times the 100-percent fatal value. discussed by reference (1).

Further, Section 5.3.6, page 5.17 of the SAG Report states: "...the available evidence indicates the battery probably exploded at some time before flooding of the battery well occurred. A review of Figure 5-13 indicates that the threads on the terminal posts were sheered off and there are no cover seal nuts remaining. The covers were completely blown off. Had the pressure been applied on the outside of the covers, the cover support flange on the terminal posts would have held pieces of the cover and it is expected that the cover seal nuts would have remained in place in at least some instances."

And finally, Section 5.3.6e, page 5.18 of the SAG Report states; "Some 20 equally small (nearly sub-visible) fragments of material were imbedded at high velocity in both the inside and outside of the (battery) sample. The trajectories of the fragments were essentially random, ranging from grazing to vertical incidence. Metallurgical analyses revealed these fragments are identical in composition and structure to the alumina flash arrestors used on the batteries in SCORPION."

**Collectively, these findings confirm the explosion of hydrogen out-gassed by the SCORPION battery was the initiating event responsible for the loss of SCORPION 50 years ago.** That event may have occurred because activities by a member of the crew in the battery well created a static electricity spark that ignited hydrogen already present at explosive levels.

## Analyses of Acoustic Evidence

In 2008, Dan McMillin (1929-2015), an electrical and mechanical engineer who was part of the Bell Telephone Laboratory "brain-trust" integrally involved in the development of the Sound Surveillance System (SOSUS), and who also was deeply involved in the initial analysis of the Canary Island acoustic sensor (bottom-mounted hydrophone) detections of the loss of the USS SCORPION, provided the writer with a copy of a tape recording and graphic displays of the acoustic signals associated with the event.

In 2011, the writer published a detailed technical analysis of those signals (2). That analysis - the first reanalysis of the SCORPION acoustic data in 40 years - confirmed the SCORPION SAG conclusions in 1970 that:

(1) The acoustic event that occurred onboard SCORPION at 18:20:44 GMT was produced by a battery-related explosion. In January 2003, Peter Palermo, the Chairman of the SAG and the Head of all Ship's Structures at the Naval Sea Systems Command from the late 1960's to the 1980's stated that "An acoustic signal detected from SCORPION 20-plus minutes before the initial breaking up sounds had all the characteristics of a small internal event. This was felt to be a battery cell."

(2) The acoustic event that occurred onboard SCORPION at 18:42:34 GMT was produced by the collapse of the pressure-hull which produced a strong bubble-pulse frequency of 4.46 Hz. The duration of the collapse phase was 37 milliseconds (ms),  $1/27^{\text{th}}$  of a second. The minimum human cognitive reaction time is 80-100 ms. (Note: the reaction time of Usain Bolt to the starting gun during the finals of the 100m sprint event in the 2016 Olympics was 155ms.)

Based on the empiric relationship that exists between the volume of an air-filled structure and the number of times in one second that the pressure differential created by collapse (implosion) of that structure initially cycles from compression to expansion back to compression – the bubble pulse frequency – can be used to determine the depth of the collapse event. The derived depth value can then be used to determine the energy required to produce the acoustically-detected bubble-pulse frequency at the derived depth. In the case of SCORPION, the measured bubble-pulse frequency of 4.46 Hz indicated collapse occurred at a depth of 466m (1530-feet) (2.2 time test-depth) with an energy release equal to the explosion of 6000 kg (13,200 lbs) of TNT at that depth. The formula for this derivation is provided on page C4 of the following document: USS SCORPION (SSN 589) RESULTS OF NOL ANALYSIS (U) NOL LTR SER 69-160 of 20 January 1970, Robert Price and Ermine Christian.

## **Disproven Conjectures**

### **SCORPION Reversed Course to Deactivate a Torpedo**

In 1968, Dr. John Craven (1925-2015) conjectured SCORPION had reversed course to disarm a Mk-37 torpedo that had become active in its launch tube. That conjecture was based on an estimated change of two seconds in the delay of signal detection times between acoustic sensors located to the east and to the west of the loss position over a 111.6s period. If valid, that change in the relative detection times of signals detected over that period would have required a course reversal by SCORPION from a course of 290 to an easterly heading for a distance of about 4900-feet in 111.6 seconds for an average speed of 26 knots.

To address that conjecture, Dan McMillin analyzed magnetic tape recorded from the Canary Island acoustic sensor located to the east of the SCORPION wreck site to achieve signal detection timing accuracies of 0.01s and high-time resolution VisiCorder displays to achieve a timing accuracy of 0.1s for the signals detected by a sensor system located to the west of the SCORPION wreck site: Sound Surveillance System (SOSUS) hydrophone array 3131

McMillin's analysis - of the same data reviewed by Craven - established that the change in detection times was only 0.04s which equated to a speed of 0.5 knots, not Craven's values of 2.0s and 26 knots. McMillin's original data/calculation sheet is reproduced on the last page of Chapter 1 of reference (2). This sheet includes a note that McMillin called Craven at 2130 ETD on 18 July 1968 to inform him of the more accurate measurement.

Note: SCORPION was not capable - from a propulsion capability standpoint - of reversing course and achieving an average speed of 26 knots during a maneuver with a duration of 111.6s.

The writer's reanalysis of these SCORPION signals in 2008 confirmed McMillin's event timing values and also confirmed the SAG assessment that the signal at the start of the 111.6s period was produced by the collapse of the SCORPION pressure-hull. Additionally, it was determined in 2008 that collapse occurred at a depth of 466m (1530-feet) and that two of three other signals that occurred during the 111.6s period were produced by the collapse of two of the six SCORPION torpedo tubes at depths near 1027m (3370-feet) and 1143m (3750-feet).

In summary, during the 111.6s period conjectured by Craven to have involved a high-speed course reversal, the SCORPION wreckage was sinking vertically at a speed of 10-13 knots with a horizontal displacement of less than 15m (50-feet) over a vertical distance of about 670m (2200-feet) which is consistent with the conclusion that the third signal was also produced within the bow section of the wreckage.

It is only an apparent anomaly that time-difference localization (acoustic triangulation) of an event can - at best - achieve a position accuracy of one nm in the broad ocean area while relative accuracies (one position relative to another) can - if detected in temporal proximity - provide accuracies of less than 10m (33-feet). This is possible because the sensors - both bottom-mounted hydrophones in the SCORPION case - did not move during the measurement period and because the sound energy produced during that 111.6s period would have followed almost exactly the same transmission path and consequently have had the same sound-travel time.

### **SCORPION Was Lost Because of the Explosion of a "Large Charge Weight External to the Pressure-Hull."**

John Craven also conjectured that acoustic energy produced by the collapse of a submarine pressure-hull at great depth could be "swallowed" within the collapsing structure and not be acoustically detected. Based on that assertion, the SCORPION Court of Inquiry (COI) concluded that the exceptionally strong signal that occurred at 18:42:34 GMT on 22 May 1968 was the "explosion of a large charge weight

external to the SCORPION pressure-hull," an assessment not accepted by the SAG who maintained the signal was produced by collapse of the SCORPION pressure hull.

Craven's conclusion is not in consonance with the known dynamic characteristics of collapse events. Any SCORPION structure that might have "swallowed" (contained) the acoustic signal produced by collapse of the pressure-hull was destroyed during the compression phase of the event. The highest levels of acoustic energy associated with a collapse event are produced during the expansion phase of the event when there would not have been any still intact structure that could have "swallowed" the signal. (Note that the SCORPION hydrogen explosion – which was contained within the pressure hull – was acoustically detected at a range of 821 nm. (2)

Neither Craven nor members of the SCORPION COI appear to have researched the acoustic detectability of the collapse of the USS THRESHER (SSN 593) pressure-hull at 09:18:24R on 10 April 1963 at a depth of 730m (2400-feet) ((73 bars (1070 psi)) with an energy yield equal to the explosion of 10,230 kg (22,500 lbs) of TNT at that depth. (3) **The failure of the SCORPION COI to research the THRESHER data was a critical mistake.**

That THRESHER-associated signal – the bubble-pulse frequency of 3.4 Hz – was detected by 14 SOSUS hydrophone arrays in the western Atlantic with signal-to-noise ratios sufficient to have been detected at ranges greater than the circumference of the earth had there been an unobstructed deep-water transmission path, i.e., no bathymetric occlusion. Reflections (echoes) of the collapse event signal from the Mid-Atlantic Ridge were detected by SOSUS. Basically, the THRESHER collapse (implosion) signal briefly "insonified" the entire western North Atlantic Basin.

The SCORPION collapse event signal was detected at a range of 821 nm to the east and at a range of 1021 nm to the west; hence, this signal was not "swallowed."

**These assessments - based on analyses of acoustic data - invalidate the COI conclusion that SCORPION was lost because of the explosion of a "large charge weight external to the pressure-hull."**

### **Involvement of Hostile Forces in the Loss of SCORPION.**

At 2354 GMT on 21 May 1968, SCORPION sent a last message that reported a position of 31-21N, 27-36W, an intended course of 290 and a planned speed of advance (SOA) of 18 knots for the remaining five day transit to Norfolk, Virginia, with an arrival time of 1700 GMT on 27 May.

At 18:20:44 GMT on 22 May, a battery-related explosion killed or functionally disabled the crew and caused extensive internal structural damage. SCORPION sank vertically until the pressure-hull collapsed (imploded) at a depth of 466m (1530-feet) at 18:42:34 GMT. The wreckage then continued to sink vertically.

The position of the SCORPION wreckage - first identified on 28 October 1968 - is 32-55N, 33-09W. That position lies 297 nautical miles (nm), bearing 290 from the position SCORPION reported 18 hours and 27 minutes before the time of the battery explosion.

The SOA required to transit that distance in that time is 16.1 knots which placed SCORPION about 35 nm behind her PIM (Projected Intended Movement) at the time of the battery explosion, well within the moving position "box" established for the transit to avoid interference with other US submarine operations.

Thus, SCORPION was on course and only slightly behind her PIM when lost because of battery-related explosion contained within the pressure-hull. Interactions with hostile forces - as conjectured by conspiracy theorists - could not have occurred.

## **Why the Loss of SCORPION is NOT a Mystery**

The headline of an Internet posting of 22 May 2018 ((reference (4) below)) reads; "NORFOLK, Va. (WVEC) -- A Navy admiral called it 'one of the greatest unsolved sea mysteries of our era.'"

**That assertion is simply wrong.**

As discussed in the first section of this assessment, the Navy's own experts, the SCORPION Structural Analysis Group (SAG), concluded in 1970 that -- as supported by metalurgical analysis of a recovered battery fragment -- **SCORPION was lost because the main battery exploded at 18:20:34 GMT on 22 May 1968.**

That event would have produced a flame-front/pressure-pulse that either instantly killed or functionally incapacitated the SCORPION crew. They would not have been aware of the event.

**Although the SCORPION Court of Inquiry did not accept the SAG assessments -- primarily because of the above described misinformation provided by John Craven -- the evidence derived from the metalurgical analysis made it indisputable in 1970 -- and still indisputable in 2018 - that a battery explosion was the event responsible for the loss of SCORPION 50 years ago.**

So -- no mystery but instead the perpetuation for nearly 50 years of erroneous SCORPION COI conclusions that the Navy should acknowledge to have been in error, and correct.

References:

- (1) Glasstone and DOLAN, 1977; TM 5-1300, 199
- (2) WHY THE USS SCORPION (SSN 589) WAS LOST, Nimble Books, 31 October 2011
- (3) WHY THE USS THRESHER (SSN 593) WAS LOST, Nimble Books, 31 December 2017
- (4) <https://www.13newsnow.com/article/news/military/50-years-later-questions-remain-about-the-uss-scorpions-sinking/291-556797190>