

## TNT and torpex charge weight, probable causes and origin of the Port Chicago explosion.

Analysis of the craters formed by the Port Chicago explosions in the bay bottom in the vicinity of the ship loading pier elucidates the origin and progression of the explosions. A survey, by soundings, of the bay bottom in the vicinity of the pier had been made five months before the explosion. Soundings were again made between 25 July and 29 July 1944. A more precise and ingenious method of survey of the bay bottom in the vicinity of the pier was subsequently authorized by the Bureau of Yards and Docks of the Navy Department and the findings were reported 28 March 1945 by the contractor, L. Cedric Macabee, which produced “Contour Map No.1. Map of Crater on Hard Bottom.”

Army-Navy Explosives  
Safety Board Port  
Chicago explosion  
report. Contour Map  
No.1. Map of Crater on  
Hard Bottom



Contour Map No. 1 is poorly reproduced in the available copies of the Army-Navy Explosives Safety Board Port Chicago explosion report. I have added identifying text and outlined the shape of the ships *Quinault Victory* and *E. A. Bryan* and the pier. I have added text to identify isolated bay bottom craters and labeled those Craters Nos. 1, 2, 3, 4, and 5. Unfortunately most of the detailed information provided by copies of the original Contour Map No. 1 is unreadable.

All the evidence presented in the Army-Navy Explosives Safety Board Port Chicago report and the Proceedings of the Port Chicago Court of Inquiry is conclusive that the first explosion, accompanied by a brilliant flash of light, occurred either within one of the forward two cargo holds (Nos. 1 and 2) of the *E. A. Bryan*, or on the pier in the vicinity of

the Nos. 1 and 2 holds of the *E. A. Bryan*. As will be shown, the first explosion did occur on the pier rather than within in the No. 1 or No. 2 cargo hold of the *E. A. Bryan*. Because the ships *E. A. Bryan* and *Quinault Victory* were, respectively, moored inboard and outboard of the Naval Magazine pier headed west and east, the first explosion may also be said to have occurred on the pier opposite the stern cargo holds Nos. 4 and 5 of the *Quinault Victory*.

Crater No. 1 was formed directly beneath the pier at the position adjacent to the No. 2 hold of the *E. A. Bryan*, and is the crater formed by the first explosion. The widening of Crater No. 1 at the starboard (right) side of the *E. A. Bryan* shows that the force of the first explosion that formed Crater No. 1 impacted and was partly reflected by the steel hull and bulk of the ship *E. A. Bryan*. The shock and blast force of the first explosion broke the *E. A. Bryan* abaft the No. 2 hold at the position where the force of the first explosion impacted the hull and bulk of that ship. The first explosion on the pier demolished the joiner shop at 1,000 feet, broke glass in the town of Port Chicago at a mile and a half to the south, in the lighthouse 3,200 feet to the north, and in the Coast Guard Patrol boat 4,200 feet to the east of the pier. The first explosion also broke apart the stern from the *Quinault Victory* and launched the stern section of the ship's keel, with the propeller attached, into a high arc to where it fell into Suisun Bay 2,000 feet from the explosion.

The force of the first explosion that broke the *E. A. Bryan* abaft the No. 2 hold displaced the intact cargo holds Nos. 1 and 2 of the *Bryan* 90 feet to the southwest (to the port or left side of the center line of the ship) where the munitions in the No. 2 hold exploded forming Crater No. 2.

The first explosion was very powerful and a review of the varieties and weight of munitions that were on the pier in railroad cars spotted opposite the Nos. 1 and 2 holds of the *E. A. Bryan* and opposite the Nos. 4 and 5 holds of the *Quinault Victory* will define the energy of the first explosion.

Two documentary records are available that identify the 16 railroad cars that were on the pier at the time of the explosion, and those records

provide an inventory of the types of munitions contained by those cars and the cargo weight of those munitions. The two documentary records, however, do not consistently report the position of each railroad car on the pier at the time of the explosion. The two documents were assembled immediately after the Port Chicago explosion. One was prepared by personnel of the Naval Ammunition Depot Mare Island (NADMI) and was used by the Port Chicago Navy Court of Inquiry as the basis of the Court's fact-finding; the second was prepared by Los Alamos scientific staff and was used as the basis of Los Alamos analyses of the explosion.

The investigator's problem is to decide which of the two documentary records presents the true position of the railroad cars upon the pier at the time of the explosion. Because this investigation of the Port Chicago explosion is principally directed to elucidate the role of the Manhattan Project Los Alamos Laboratories in the Port Chicago explosion the records available in the Archives of Los Alamos National Laboratory that describe the position of the railroad cars on the Port Chicago Magazine pier at the time of the explosion will be taken as valid—except one important error in that Los Alamos record that will be described.

NAD No. 83044-1,  
"Explosive Material on  
Pier & on board S.S.  
Bryan prior to  
detonation on 17 July  
1944 at U.S. Naval  
Magazine, Port  
Chicago, California"



By 30 August 1944 NADMI had prepared the schematic diagram NAD No. 83044-1, "Explosive material on pier & on board S.S. 'Bryan' prior to detonation on 17 July 1944 at U.S. Naval Magazine, Port Chicago, California," with the note, "Exact arrangement of cars on center track is unknown, but presumably were spotted for thru-loading." "Thru-loading" means that munitions that arrived on the pier in railroad cars that were spotted on the pier's center track would be manually transferred by the ship loading crews from those cars on the center track through the open

side doors of emptied railroad cars spotted on the outside track. Thru-loaded munitions would be emplaced on the pier opposite the cargo holds of the ship to be loaded. From that position on the pier alongside either ship the munitions would be stacked on pallets or loaded into cargo nets and hoisted aboard by deck-mounted winches, associated booms and cables and lowered into the cargo holds where additional

ship loading personnel would stow the munitions according to a loading plan and block the munitions in place with wooden dunnage.

Diagram NAD No. 83044-1 represents that all 16 cars on the pier at the time of the explosion were spotted between the two ships. Six of the 16 railroad cars on the pier are represented by this document to have been located in the vicinity of the Nos. 1 and 2 holds of the *E. A. Bryan*, and this diagram represents that six cars of the 16 cars on the pier were spotted on the center track.

Among the Port Chicago explosion records in the Archives of Los Alamos National Laboratory is a schematic diagram, untitled, which represents that ten cars, rather than 16, were spotted on the pier between the two ships at the time of the explosion. Six of the 16 cars

Los Alamos diagram of explosive material on pier prior to detonation on 17 July 1944



identified by the diagram made at Los Alamos are shown to have been positioned on the approach wing of the pier. The diagram made by Los Alamos represents that no cars were spotted on the center track. I have titled that Los Alamos diagram, “Los Alamos diagram of explosive material on pier prior to detonation on 17 July 1944.”

This Los Alamos diagram shows the location of 16 cars on the pier and on the approach wing of the pier, and identifies the munitions contents of each car. The manuscript notations that identify the position and contents of each car are easily legible in the original document but the outlines of the pier and ships are not, so I have clarified those. It should be noted that this Los Alamos diagram is drawn as seen from the north. The pier and ships are depicted from a perspective on Suisun Bay rather than seen from the Port Chicago shore. Seen from the perspective from Suisun Bay, the *Quinault Victory* is outboard of the pier, headed east, in the foreground.

This Los Alamos diagram represents that four railroad cars were spotted in the vicinity of the Nos. 1 and 2 holds of the *E. A. Bryan*. Spotted at the No. 1 hold of the *E. A. Bryan* is one carload of M-7 incendiary bombs. Spotted at the No. 2 hold of the *E. A. Bryan* this Los Alamos document shows one carload Mk-47 bombs—350 pound, DB AN-Mark 47 aerial depth bombs (DB) filled with torpex.

On the outboard side of the pier, spotted at the No. 4 hold of the *Quinault Victory*, this Los Alamos document shows one carload of M-33 bombs—1,000 pound, AP AN-M33 armor-piercing (AP) aerial bombs filled with TNT. This Los Alamos document also represents that one carload of M-65 bombs was spotted at the No. 5 hold of the *Quinault Victory*. The M-65 was a 1,000 pound, GP AN-M65 general purpose (GP) bomb filled with TNT.

The NAD No. 83044-1 and Los Alamos diagrams differ in their representation of the position of the two carloads of M-65 bombs that were on the pier at the time of the explosion. The document prepared by Los Alamos represents that one carload of M-65 bombs was spotted at the No. 5 hold of the *Quinault Victory* and one at the No. 3 hold of the *Quinault Victory*. But NAD No. 83044-1 represents that one carload of M-65 bombs was spotted at the No. 3 hold of the *Quinault Victory* and one at the amidships position of the *Quinault Victory*.

The NAD diagram report of the positions of those two carloads of M-65 bombs amidships and at the No. 3 hold of the *Quinault Victory* is correct. The Los Alamos diagram which represents that one carload of M-65 bombs was spotted at the No. 5 hold of the *Quinault Victory* is incorrect, as determined thus:

If one carload of M-65 bombs had been spotted at the No. 5 hold of the *Quinault Victory* the explosion of that car would have formed a discernable crater in the bay bottom beneath the position of that car, but Crater Contour Map No. 1 does not disclose a crater at that location. A distinct ellipsoidal crater, however, is revealed on Crater Contour Map No. 1 beneath the pier at the amidships position of the *Quinault Victory* and that crater extends eastward to the position beneath the pier at the ship's No. 3 cargo hold. The location of that ellipsoid crater corresponds to the position reported by NAD diagram No. 83044-1 to have been the location of two end-to-end cars loaded with M-65 bombs.

Furthermore, the bow (No. 1) and stern (No. 5) cargo holds of Liberty and Victory munitions ships were not loaded with heavy per-cubic-foot weight high explosive bombs. M-65 bombs would not have been designated as cargo to be loaded into the No. 5 hold of the *Quinault*

*Victory*. Typically the Nos. 1 and 5 cargo holds of those munitions ships were loaded with lighter per-cubic-foot cargo—gun projectiles, cartridges, and also M-7 incendiary bombs which did not have a heavy fragmentable steel or iron case. A ship heavily laden at the bow and stern does not maneuver in turns as easily as a ship relatively lighter laden at the bow and stern. A center of mass amidships also greatly increases the steadiness of a ship's floating equilibrium.

The NAD and Los Alamos documents that diagram the position of the cars on the pier agree that two carloads of M-7 incendiary bombs were on the pier at the time of the explosion. Both documents identify the M-7 bomb to have been an incendiary “cluster” bomb. In the World War II military literature available to me I have been unable to find any reference to the M-7 (Mark 7, Mk-7, M7, or M-7) incendiary cluster bomb. I have found reference to two U.S. World War II incendiary cluster bombs used in the Pacific Theater of War, the 500-pound M-17 which was a cluster of 110 4-pound M-50 magnesium incendiary bombs, and the 220-pound M-19 which was a cluster of 36 6-pound jellied oil M-69 bombs. The otherwise unidentified M-7 is, however, mentioned by the Port Chicago Navy Court of Inquiry as a consideration in the Court's endeavor to establish probable causes of the explosion:

“52. That the initial explosion occurred in the vicinity of the inboard end of the pier near the bow of the *E. A. BRYAN*, probably among components being handled on the pier or being loaded into No. 1 or 2 holds. The sharp distinct sound and the brilliant white flash lead to the belief that the initial detonation was that of an M-7 cluster or Mark 47 depth bomb. . . .”

The NAD and Los Alamos documents agree that one of the two cars of M-7 incendiary cluster bombs on the pier was spotted on the outside track at the No. 1 hold of the *E. A. Bryan*. But the two diagrams differ in their representation of the position of the second carload of M-7 bombs. The diagram prepared by Los Alamos represents that the second of those two cars was positioned on the approach wing of the pier, but NAD diagram No. 83044-1 represents that the second car of

M-7 bombs was spotted on the center track opposite the *Bryan's* No. 1 hold.

NAD diagram No. 83044-1 can be shown to have erroneously reported the position of the second carload of M-7 incendiary bombs. The second carload of M-7 bombs was not located on the center track opposite the *Bryan's* No. 1 hold but was, as represented by the diagram prepared by Los Alamos, located on the approach wing of the pier. That error of NAD diagram No. 83044-1 is proven thus:

Two railroad cars of ammunition reported by NAD diagram No. 83044-1 to have been spotted on the pier between the two ships at the time of the explosion were later found by salvage divers intact on the mud bottom, below the destroyed portion of the western approach wing of the pier. Both cars were full and the dunnage had not been removed as the first preparation to unload the cars' munitions contents. One of the two cars found intact on the mud bottom contained M-7 incendiary bombs; the second contained Mk-47 aerial depth bombs.

In March 1947 an officer of the staff of the Army-Navy Explosives Safety Board interviewed the senior member of the salvage company who was in charge of the actual salvage operations at the pier and according to his description of the contents of the cars, "the officer reported that one car must have contained incendiary clusters and the other air depth bombs. The cars were found just beyond the trestle of the undestroyed western approach portion of the pier. One was lying upright and the other in a slightly tilted position as if they had rolled off the tracks." [Reference: "The Port Chicago Ship Explosion of 17 July 1944," Army-Navy Explosives Safety Board, VIII Appendix. D. Origin and Number of Explosions; footnote, page 4.] The two cars "were blown into the bay without exploding and subsequently were raised and buried on Ryer Island." [Reference: "The Port Chicago Ship Explosion of 17 July 1944," Army-Navy Explosives Safety Board, Section III. Structural Damage; footnote, page 11.]

As one measure of the inaccuracies of NAD diagram No. 83044-1 those two cars later recovered intact and fully laden from the mud bottom are erroneously represented to have been spotted between the two ships opposite the Nos. 1 and 2 holds of the *E. A. Bryan*: "MK-7

CLSTR” bombs at the No. 1 hold and “350# DEPTH TORPEX” at the No. 2 hold. In consequence of that error the munitions contents of those two railroad cars were incorrectly assumed by the Navy Court of Inquiry to have contributed to the explosion and incorrectly assumed by the Court to have been probable origins of the explosion.

Having now noticed that one error of several in NAD diagram No. 83044-1, which errors led the Court of Inquiry to several mistaken findings, we turn to discussion of the railroad cars and their munitions contents that were on the pier at the time of the explosion.

We are able to refer to another Los Alamos document to establish important information about each of the railroad cars that was on the pier. That document is, “The following cars were on the pier during the explosion.” From this document we may learn which of the two ships was to receive the contents of each railroad car on the pier at the time of the explosion, the railroad company that owned each car on the pier, the railroad company’s identifying number for each car, the munitions

Los Alamos  
National Laboratory:  
The following cars  
were on the pier during  
the explosion



contents of each car, the cargo weight of the munitions in each car, and the point of origin of each car. Manuscript notes made upon this document, as received from Los Alamos Archives, are legible and define if the contents of each car would detonate high order, low order or would make no contribution to the energy of the Port Chicago explosion.

We have shown that one carload of M-7 incendiary bombs was spotted on the outside track at the No. 1 hold of the *E. A. Bryan*. From Los Alamos document, “The following cars were on the pier during the explosion,” we learn that car was either DRGW (Denver & Rio Grand Western) car No. 68697 or C&O (Cincinnati & Ohio Railroad) car No. 10645. Both were designated to be loaded aboard the *E. A. Bryan* (PC# 80); both contained 30 tons of M-7 incendiary cluster bombs; both originated at the Hawthorne, Nevada, Navy Ammunition Depot, now the Hawthorne Army Depot.

However, in the aggregate load of munitions on the pier and loaded as cargo aboard the *E. A. Bryan* the M-7 incendiary cluster bombs would have held an insufficient charge of TNT to have contributed

significantly to the TNT charge weight of the Port Chicago explosion, and that would also have been true for any type of incendiary bomb. A very small TNT charge is sufficient to effectively disperse the bomb's incendiary material.

The document, "Los Alamos diagram of explosive material on pier prior to detonation on 17 July 1944," and NAD diagram No. 83044-1 agree that one carload of Mk-47 bombs was spotted on the outside track at the No. 2 hold of the *E. A. Bryan*. The Mk-47 bomb was a 350 pound, torpex-filled aerial depth bomb. This carload of Mk-47 bombs was either NJI&I (New Jersey, Indiana & Illinois Railroad) car No. 4149 or ATSF (Atchison, Topeka & Santa Fe Railroad) car No. 143756. Both cars were designated to be loaded aboard the *E. A. Bryan* (PC# 80); both contained 54 tons of Mk-47 bombs; both originated at the Hawthorne Navy Ammunition Depot. One of those two cars containing Mk-47 was found intact and fully laden on the mud bottom just beyond the trestle of the undestroyed portion of the pier; that carload of Mk-47 bombs was not consumed in the explosion.

Immediately opposite the No. 4 hold of the *Quinault Victory* was one car which contained M-33 bombs—1,000 pound, TNT-filled AP AN-M33 armor-piercing (AP) aerial bombs. This was either ATSF car No. 147190 or SAL (Seaboard Air Line Railroad) car No. 19442. Both cars were designated to be loaded aboard the *Quinault Victory* (PC# 79); both contained 53 tons of M-33 bombs; both originated at the Indian Island, Washington, Naval Magazine, now the Naval Magazine Indian Island.

The location of the railroad cars on the Port Chicago ship loading pier, as reported by NAD diagram No. 83044-1, suggests that the carload of M-33 bombs spotted on the outside track at the No. 4 hold of the *Quinault Victory* was to have been loaded into the No. 4 hold. Following that transfer the emptied car would have been moved off the pier to the west and the next car eastward on the pier, spotted at the amidships position, would have been moved westward to be opposite the No. 4 hold and that carload of M-65 bombs loaded into the No. 4 hold. The M-65 bombs held by the next car eastward on the pier's

outside track, spotted at the No. 3 hold, would have been loaded into the No. 3 hold.

In summary, according to Los Alamos records corrected to show that no railroad car was spotted at the No. 5 hold of the *Quinault Victory*, three bomb-laden railroad cars were on the pier between the Nos. 1 and 2 holds of the *E. A. Bryan* and the Nos. 4 and 5 holds of the *Quinault Victory*. Manuscript notes on the Los Alamos document, "The following cars were on the pier during the explosion," provide the TNT and torpex charge weight of the munitions loaded in each of those three cars.

Car spotted at:

*E. A. Bryan*, No. 1 hold.

M-7 incendiary cluster bombs.

Cargo weight: 30 tons;

TNT charge weight: effectively none.

*E. A. Bryan*, No. 2 hold.

Mk-47 aerial depth bombs.

Cargo weight: 54 tons;

Torpex charge weight: 39 tons (73 % of the cargo weight).

*Quinault Victory*, No. 5 hold

No munitions at this position.

*Quinault Victory*, No. 4 hold.

M-33 AP aerial bombs.

Cargo weight: 53 tons;

TNT charge weight: 8 tons (15% of the cargo weight).

The total amount of explosives available to the first explosion on the pier in the vicinity of the inboard end of the pier between the bow of the *E. A. Bryan* and stern of the *Quinault Victory* is thus determined to have been 137 tons cargo weight containing 47 tons of TNT and torpex.

The detonation of 47 tons of TNT and torpex on the pier between the bow of the *E. A. Bryan* and the stern of the *Quinault Victory* certainly generated a sufficiently energetic shock wave to break the *E. A. Bryan* abaft the No. 2 hold and to displace the broken forward portion of the ship—the bow and cargo holds Nos. 1 and 2—to the position 90 feet southwest of the pier where Crater No. 2 demonstrates that the munitions cargo of the No. 2 hold of the *E. A. Bryan* detonated. The force of the first explosion was also certainly sufficient to break the stern apart from the unloaded, high-riding *Quinault Victory* and to have been the impetus that impelled the stern section of the ship's keel, with the propeller attached, in a high arc through the air to the position 2,000 feet to the north of the pier.

The first Port Chicago explosion indisputably occurred on the pier between the Nos. 1 and 2 cargo holds of the *E. A. Bryan* and the Nos. 4 and 5 cargo holds of the *Quinault Victory* where three munitions-laden railroad cars were positioned. The second, massive explosion that followed the first explosion on the pier by several seconds included the essentially simultaneous detonation of the cargo of bombs that had been loaded into Nos. 2, 3 and 4 cargo holds of the *E. A. Bryan*, as well as the unexploded munitions remaining on the pier. The cargo within the ship's Nos. 1 and 5 holds (projectiles, cartridges and M-7 incendiary bombs) did not contribute significant energy to the explosion because that cargo burned or detonated low order.

Los Alamos  
document  
"S.S. E.A. Bryan"



Los Alamos document "S.S. E. A. Bryan" inventories the munitions cargo loaded into the *E. A. Bryan* prior to the explosion. The total TNT and torpex charge weight of the ship's cargo was initially calculated by Los Alamos to have been 1,552 tons. That total of 1,552 tons TNT was reported in Capt. Parsons' memorandum to Adm. Purnell dated 24 July 1944, "Port Chicago Disaster: Preliminary Data."

That 1,552 tons total represented an erroneously calculated TNT charge weight for the M-64 bombs loaded into the ship's No. 2 hold—erroneously calculated to have been 142 tons. Los Alamos personnel subsequently correctly recalculated the TNT charge weight of the M-64 bombs in hold No. 2 to have been 167 tons, rather than 142 tons. Captain Parsons reported a recalculated total of 1,577 tons to Adm. Purnell in his memorandum dated 4 August 1944, "Port Chicago Disaster: Second Preliminary Report." The total TNT and torpex charge weight of the ship's cargo, initially reported as 1,552 tons, was increased by 25 tons of TNT to 1,577 tons.

Port Chicago Naval Magazine, California, PC #80 – S.S. A.E. [sic] Bryan. Approximate load at 2330 – 17 July 1944.



Corresponding information prepared by Naval Magazine Port Chicago to document the munitions that had been loaded into the cargo holds of the *E. A. Bryan* is reproduced by the document, "Port Chicago Naval Magazine, California, PC #80 – S.S. A. E. [sic] Bryan. Approximate load at 2330 – 17 July 1944."

I have made a compilation of the information provided by the three documents presented here to summarize the cargo weight of the munitions loaded into the holds of the *Bryan*, the TNT or torpex charge weight of those munitions, and to show if those munitions burned, exploded low order or high order. Those documents are: "S.S. E. A. Bryan," "Port Chicago Naval Magazine, California, PC #80 – S.S. A. E. [sic] Bryan. Approximate load at 2330 – 17 July 1944," and the compilation I have given the title, "Approximate munitions load aboard the *E. A. Bryan* at 2330, 17 July 1944."

"Approximate munitions load aboard the *E.A. Bryan* at 2330, 17 July 1944."



To ascertain the origin of the first explosion the problem for the investigator is to determine which of the three railroad cars on the pier in the vicinity of the Nos. 1 and 2 holds of the *E. A. Bryan* was the first to explode and thereby initiated the second, massive explosion.

I exclude the possibility of an accidental detonation in or about the car spotted opposite the No. 4 hold of the *Quinault Victory*, which car contained M-33 bombs. Although the hatch of the No. 4 hold of the *Quinault Victory* had been opened before to the explosion, the transfer of cargo from that car or any car on the pier into the *Quinault Victory*

had not commenced prior to the explosion. The contents of the car opposite the No. 4 hold of the *Quinault Victory* were most probably undisturbed. The findings of the Navy Port Chicago explosion Court of Inquiry state: “Loading [of the *Quinault Victory*] should have started by midnight. Dunnage and loaded cars were spotted on the pier for this purpose.” The 1948 Army-Navy Explosives Safety Board report on the explosion states, “Port Chicago Naval Magazine personnel were rigging the ship [*Quinault Victory*] for loading and all hatches except the No. 5 were about ready to load at the time of the explosion.”

I minimize as a possibility that the accidental detonation of one or several M-7 incendiary cluster bombs opposite the No. 1 hold of the *E. A. Bryan* would have produced a sufficient shock to sympathetically detonate nearby high explosive munitions. The accidental detonation of one or several M-7 incendiary bombs in or about the car laden with M-7 incendiary bombs would have dispersed incendiary material and ignited extensive areas of the wooden pier that, aflame, eventually would have caused nearby high explosive munitions to burn or explode, but that process would have required minutes rather than seconds.

An explosion in or about the car of Mk-47 bombs spotted at the No. 2 hold of the *E. A. Bryan* is the only presumptively effectual origin of the first explosion on the pier in the vicinity of the Nos. 1 and 2 holds. That first explosion on the pier initiated the second and larger explosion that, as defined by the Court of Inquiry, “consisted of the detonation – substantially simultaneously – of the ammunition in ten holds of the *E. A. BRYAN*. That this was initiated by the detonation of a component or group of components, or hot fragments from the first explosion which entered the holds either through the ship's side or through the open hatches.”

Liberty and Victory ships were constructed with five large openings in the deck, the hatches leading to the ships' five cargo holds. Each of the five cargo holds was divided into upper and lower holds; therefore the Court of Inquiry mentions ten holds. The heaviest cargo—bombs, in the case of a munitions ship—was loaded into the lower holds to establish the ship's center of gravity well below the waterline to

mitigate the possibility of capsize in rough seas and during fast, full-rudder turns. Lighter-weight more bulky cargo was loaded into the upper holds. At the time of the explosion only the five lower holds of the *E. A. Bryan* had been loaded.

Accidental detonation of a torpex-filled Mk-47 bomb on the pier is frequently cited by commentators on the Port Chicago explosion to have been the cause of the explosion. The 1944 Navy Court of Inquiry proposed as the first in the order of probable causes the “presence of a supersensitive element which was detonated in the course of handling.” In definition of a supersensitive element the court specified:

“a. One wherein a thin film of high explosives is present because of defects in the manufacture of the case or faulty filling of that particular component. (This condition could have occurred in the Mark 47 and the Mark 54 depth bombs.)

“b. One which has become prematurely armed by reason of damage to the safety features either in transit to the magazine or in the handling after arrival. (This condition could have occurred in the M-7 incendiary bomb clusters.)”

The court’s reference to a defective Mark 54 depth bomb as a probable cause of the explosion is not plausible; 315 tons of torpex-filled Mark 54 depth bombs had been loaded into the No. 4 hold of the *E. A. Bryan* the day preceding the explosion but could not have been a cause of the first explosion on the pier. Mark 54 bombs were not anywhere on the pier at the time of the explosion.

It has been noted that the Navy Court of Investigation that inquired into the cause of the 10 November 1944 explosion of the USS *Mount Hood* in Seeadler Harbor, Manus Island, reported “Torpex filled depth bombs were apparently coming on board.”

### RDX and Torpex.

Following World War I, TNT replaced wet gun cotton as the explosive utilized as the main charge filler for underwater bombs and torpedoes. In 1920 the chemical compound cyclonite, actually cyclotrimethylene

trinitramine, was identified in Germany. It is more powerful than TNT and the British renamed it RDX for Research Department Explosive. It is the primary ingredient in plastic explosives.

RDX provided the basis for a new class of explosives particularly suited to underwater military uses. RDX is a white crystalline solid, has a high degree of stability in storage, and is considered the most powerful and brisant of the military high explosives. It has a very plastic, dough-like consistency and RDX explosive charges can be shaped for special detonation effects. RDX forms the base of the current military explosives Composition A, Composition B, Composition C, HBX, and H-6, and is sometimes referred to as hexogen (Russian). Apart from its explosive hazard, breathing RDX dust can cause epilepsy and amnesia.

On at least one occasion Osama bin Laden's associates in Al Qaeda terrorist network were reported to have used RDX, and the U.S. Federal Bureau of Investigation (FBI) determined that RDX was the explosive used in the attack on the *Arleigh Burke* class guided missile destroyer USS *Cole* (DDG-67), 12 October 2000 in the Yemen port of Aden. Seventeen sailors were confirmed or presumed dead in that attack. RDX is the explosive most frequently utilized by terrorists worldwide.

RDX is at least 50% more effective than TNT as an underwater explosive against ships. During World War II, RDX was difficult to make safely and therefore, compared to TNT, considerably more expensive to produce in large quantities. During the war U.S. explosives researchers compounded a mixture of TNT (37-41%), RDX (41-45%) and 18% aluminum that was known as torpex. The addition of aluminum to the mixture of RDX and TNT was found to accomplish a prolongation of the pressure wave. The process of converting torpedo warheads and depth charge loadings from TNT to torpex began with an order for 20 million pounds of torpex in early 1942. The first torpex filled antisubmarine torpedo warheads followed late the same year. Torpex-filled aerial depth- bombs, for example the Mk-47, appear to have been introduced in late 1943.

During World War II, after about January 1944, as the manufacture of torpex in the U.S. provided that material in quantities sufficient for application to its optimal military purposes (aerial depth bombs, depth charges and torpedoes), the use of torpex by the Navy increased. Torpex provided a higher explosive energy and higher detonation velocity (24,600 feet per second) than RDX (22,700 to 23,700 feet per second) or TNT (21,800 to 22,400 feet per second).

In 1945 torpex was replaced by HBX, in the 1960s by H-6, and in the 1970s by PBX. Although commonly used today without the admixture of TNT, sometimes RDX and TNT are mixed in what is called Cyclotol or C-6 (Composition 6), but RDX alone is more commonly used as C-4 (Composition 4). Prior to the 1945 introduction of HBX, which included a stabilizing wax component, experimental testing with torpex indicated that torpex had a greater sensitivity to heat and shock than TNT, but in no instance is the accidental detonation of a World War II torpex-filled torpedo, aerial bomb or depth charge documented.

The aluminum component of torpex-filled ordnance did produce an intense flash of white light in explosion. One carload of Mk-47 bombs exploded on the pier in the first explosion (39 tons of torpex) and certainly produced a brief flash of intense white light in the immediate area of the pier. The second, massive explosion included the detonation of 54 cargo tons of Mk-47 bombs in the No. 2 hold (39 tons of torpex) and 315 cargo tons of Mk-54 bombs in the No. 4 hold (225 tons of torpex). The torpex contribution to the second explosion was 264 tons.

Newspaper accounts of the explosion reported that at the city of Napa, a distance of 30 miles across flat terrain and a few low hills, the landscape was illuminated as if by the noonday sun. Whether the detonation of 264 tons of torpex could have produced a flash of white light of sufficient lux to so brilliantly illuminate the landscape at that distance can not be ascertained from the available literature. Certainly the brilliant flash of white light produced by the detonation of 264 tons of torpex and the simultaneous explosion of “blinding” white light produced by the detonation of the Mark II weapon were sufficient to produce full daylight illumination at Napa 30 miles away.

The accidental detonation of a torpex-filled Mk-47 bomb was suspect as a possible cause of the Port Chicago explosion and torpex-filled munitions are mentioned as cargo being handled at the time of the explosion of the USS *Mount Hood*. But since there is no known documented instance of an accidental torpex munitions explosion during World War II munitions handling operations, improperly filled or otherwise, the probability of an accidental detonation of a Mk-47 torpex aerial depth bomb on the pier at Port Chicago must be considered in that context.

News media documentary accounts done in recent years of the Port Chicago mutiny have touched peripherally on the cause of the explosion and settled on the accidental shock-induced detonation of a Mk-47 bomb to have been cause. In 1944 the Navy Court of Inquiry listed the accidental detonation of a Mk-47 bomb first in the rank of probable causes; that expert opinion satisfied the purposes of those news media inquiries, which chiefly portrayed the circumstances of the mutiny. In fact, the likelihood of an accidental shock-induced detonation of a Mk-47 bomb at Port Chicago was negligible.

A World War II torpex aerial depth bomb was not shock sensitive and none is documented to have accidentally exploded in handling operations. Released from an airplane the Mk-47 depth bomb struck the water surface with a very considerable force of impact. If torpex were remarkably sensitive to shock-induced detonation those bombs would have had been essentially wasted ordnance because they would frequently have detonated on impact with the water surface rather than sinking intact to a subsurface depth at which the detonation of those bombs might disable the target of those bombs, an enemy submarine.

Crater Contour Map No. 1 shows that the entire carload of Mk-47 bombs spotted at the No. 2 hold of the *E. A. Bryan* detonated instantaneously in the first explosion. The Court of Inquiry, however, assumed that an accidental detonation of a single explosive element on the pier had been necessary to cause the detonation of that carload of Mk-47 bombs, but no conclusive evidence of that presumed first detonation of a single explosive element was offered in testimony. Despite

the absence of testimony that could identify the precipitating detonation of a single explosion element the court found:

“That the initial explosion occurred in the vicinity of the inboard end of the pier near the bow of the E. A. BRYAN, probably among components being handled on the pier or being loaded into No. 1 or 2 holds.”

Section 51 of the court’s “Finding of Facts, Opinion and Recommendations” provides the court’s ranked order of probable causes of the explosion:

“a. Presence of a supersensitive element which was detonated in the course of handling.

“b. Rough handling by an individual or individuals. This may have occurred at any stage of the loading process from the breaking out of the cars to final stowage in the holds.

“c. Failure of handling gear, such as the falling of a boom, failure of a block or hook, parting of a whip, etc.

“d. Collision of the switch engine [operating on the pier] with an explosive loaded car, possibly in the process of unloading.

e. An accident incident to the carrying away of the mooring lines of the QUINAULT VICTORY or the bollards to which the QUINAULT VICTORY was moored, resulting in damage to an explosive component.

“f. The result of an act of sabotage. Although there is no evidence to support sabotage as a probable cause, it cannot be ignored as a possibility.”

For the text of the Court’s “Finding of Facts, Opinion and Recommendations,” see:

<http://www.history.navy.mil/faqs/faq80-4n.htm>

The court ranked sabotage last in the order of probable causes of the explosion. Sabotage is an act which damages property or obstructs productivity or normal functioning, such as committed by enemy agents against a nation in war. Deliberate detonation of the carload of Mk-47 bombs spotted at the No. 2 cargo hold of the *E. A. Bryan* with the purpose to effect the detonation the Mark II fission bomb and to conceal the detonation of that bomb within the larger explosion of the *E. A. Bryan*'s massive cargo of TNT and torpex munitions was not sabotage. But that is the means I impute as the origin of the Port Chicago explosion. The Mark II weapon was concealed among the cargo of crated aerial bomb tail vanes loaded 16 July 1944 into the No. 3 hold of the *E. A. Bryan* and was set with aerial depth bomb or depth charge hydrostatic pressure-activated fuses to detonate the Mark II at a pressure of 3-4 atmospheres in excess of sea level ambient atmospheric pressure; that necessary pressure above the ambient was propagated by the detonation of the carload of Mk-47 bombs.

The proof detonation of the Mark II at Port Chicago was conducted pursuant to determination by the nation's top civilian and military authorities that the resultant deaths and injury of civilians and military personnel, the destruction of private and Government property and war materiel, and the temporary obstruction of normal functioning at the Port Chicago magazine would be justified by the unwelcome proof that large scale nuclear fission weapons were in fact feasible. In July 1944 those weapons, if proven feasible, were expected to provide a sure means to successfully end World War II and, in the Pacific Theater, to avoid the more than 100,000 U.S. military casualties anticipated if U.S. forces would be required to force the Japanese surrender by invasion of the Japanese home islands. The death of 320 men at Port Chicago was a small fraction of the 100,000 U.S. casualties that would certainly have resulted if an invasion of Japan by U.S. forces had been necessary to defeat the Empire. But of more continuing significance, the 1944 U.S. military and scientific forecast of postwar reality recognized that if nuclear fission weapons were in fact proven every future enemy of the United States would eventually acquire a capability to attack the United States or the nation's interests anywhere in the world with nuclear weapons.

The reader should well ask why the proof of nuclear fission weapons was conducted in circumstances that would result in the death and injury of U.S. civilians and military personnel, the destruction of private and Government property and military materiel, and the temporary disruption of normal operation of the Port Chicago Naval Magazine. Several reasons provided the logical imperative for that decision. Military secrecy was one of those reasons.

The proof detonation of the Mark II weapon was effectively concealed from notice by the artifacts of the massive explosion of conventional munitions that were in place at Port Chicago. It was important in July 1944 that Germany, Japan and Russia should not know that the U.S. had proven the feasibility of nuclear fission weapons and consequently could be expected to have a near-term nuclear weapon combat capability. If the Mark II had been proof fired anywhere in an isolated area which did not provide an apparent and plausible cause for that explosion, firm speculation or actual discovery that a fission weapon had been detonated would quickly have passed through the existing foreign espionage networks. The typical fireball and column of flame produced by an isolated nuclear fission weapon explosion would have been clear evidence of a nuclear explosion to scientists, U.S. and foreign, working on the development of fission weapons.

Even though the proof of the Mark II uranium hydride bomb had been concealed by the Port Chicago ship explosion and that proof was known only to a few U.S. military officers, top civilian officials and Los Alamos scientists, by 16 March 1945 Professor Igor Kurchatov in Russia had received sufficient information about development of the U.S. uranium hydride bomb through the espionage network that he considered it possible “the [uranium hydride] atomic bomb has already been executed and that uranium 235 has been separated in major quantities.” How much the Russians had learned about the Mark II uranium hydride bomb and how the Russians obtained that information will be taken up more extensively in a later chapter that will recount development of the Mark II weapon. Igor Kurchatov directed the Soviet Union's nuclear weapons program from its inception in February 1943 until his death in 1960.

Not less important than the military need to conceal the proof of the Mark II was the military need to learn as much as possible, from that very expensive proof in terms of fissionable material, about the potential military effects of large scale fission weapon explosions, and especially the effects of a nuclear weapon detonated in an enemy port or harbor facility which, in 1944, was the only feasible combat application for the atomic bomb. Prior to 17 July 1944 no explosion of energy yield greater than 1,000 tons of TNT had been sufficiently well documented to provide absolute baseline data on the effects of large explosions. Every measured destructive and damaging effect of the Port Chicago explosion could be, and was, utilized by Los Alamos scientists to confirm the mathematically calculated effects of multi-kiloton explosions. The measured destruction and damage that resulted from the Port Chicago explosion included a comprehensive range of equivalent military and civilian target elements: harbor installations, a variety of ships at different ranges, airplanes in flight at different altitudes and distances, typical military structures and munitions storage facilities, civilian residential and business structures close-in and distant, automobiles, a passenger train, above and below ground utility installations. The earth shock and air wave at a variety of distances near and far were precisely taken by recording seismographs and barometers . . . the list of measured effects was very extensive and included, significantly, the effect of such a large explosion on the morale of surviving military personnel. Most of the surviving military personnel at the base rallied quickly.

Tragic and bitterly sorrowful as the Port Chicago proof of the Mark II was for those persons injured in the proof and for those who suffered the death of family in that proof that cost of human suffering was the nation's first payment required to assure that the nation would be prepared for the age of nuclear weapons. Title II of Public Law 102-562, the "Port Chicago National Memorial Act of 1992," established the Port Chicago Naval Magazine National Memorial to recognize those who served at the facility, to honor the memory of those who gave their lives and were injured in the explosion, and to commemorate "the critical role Port Chicago played in the Second World War and the historic importance of the explosion."

It is now necessary to show that sufficient fissionable  $U^{235}$  had been produced by the Manhattan Project to permit the detonation of one Mark II weapon on 17 July 1944. The amounts of  $U^{235}$  produced by the Manhattan Project for each of the years 1943, 1944 and 1945 were, during the war, protected from disclosure by a Top Secret classification. The  $U^{235}$  production data for the years 1943 through 1949 today are still protected from disclosure by a Top Secret/Not Declassifiable designation.  $U^{235}$  production data for the years 1943 through 1949 have not yet been administratively released by the U.S. Department of Energy, but on 5 December 1980 I obtained the  $U^{235}$  production data for the years 1943 through 1949 from two offices of the U.S. Department of Energy. Those data show that, by the end of 1943, the Manhattan Project had produced sufficient  $U^{235}$  to permit the detonation of eight of the Mark II weapon each utilizing 9 kg  $U^{235}$ . During 1943, 74 kilograms  $U^{235}$  were produced by the Manhattan Project.

## Photographs and illustrations credits.

“Crater Contour Map No.1. Map of Crater on Hard Bottom.” Source: “The Port Chicago, California, Ship Explosion of 17 July 1944,” VIII Appendix, C. Suisun Bay Crater. Army-Navy Explosives Safety Board: Washington D.C., 1948. Original detail enhanced by author, January 2002.

“Explosive material on pier and on board S.S. ‘Bryan’ prior to detonation on 17 July 1944 at U.S. Naval Magazine, Port Chicago, California.” Source: Prepared by Naval Ammunition Depot, Mare Island (document: NAD No. 83044-1) reproduced in, “Port Chicago Naval Magazine Explosion on 17 July 1944: Court of Inquiry Convened at the U.S. Naval Magazine, Port Chicago, California, 21 July 1944.” [U.S. National Archives, Pacific Sierra Region, Record Group 181, 12th Naval District Commandant's Office, General Correspondence Series, 1946.] Available online at:

<http://www.history.navy.mil/faqs/faq80-4b3.jpg>.

“Los Alamos diagram of explosive material on pier prior to detonation on 17 July 1944.” Source: Los Alamos National Laboratory Archives, Collection A-84-019, Series 5, 319.1, “Port Chicago Loading Schedules, 7/17/44 - 7/18/44” (Folder 29-2) [Formerly Folder 37-7].

“The following cars were on the pier during the explosion.” Source: Los Alamos National Laboratory Archives, Collection A-84-019, Series 5, 319.1, “Port Chicago Loading Schedules, 7/17/44 - 7/18/44” (Folder 29-2) [Formerly Folder 37-7].

“S.S. E. A. Bryan.” Source: Los Alamos National Laboratory Archives, Collection A-84-019, Series 5, 319.1, “Port Chicago Loading Schedules, 7/17/44 - 7/18/44” (Folder 29-2) [Formerly Folder 37-7].

“PC #80 – S.S. A. E. [sic] Bryan.” Approximate load at 2330 – 17 July 1944. Source: Los Alamos National Laboratory Archives, Collection A-84-019, Series 5, 319.1, “Port Chicago Loading Schedules, 7/17/44 - 7/18/44” (Folder 29-2) [Formerly Folder 37-7].

“Approximate munitions load aboard the *E. A. Bryan* at 2330, 17 July 1944.” Source: Compiled by author from Los Alamos document, “S.S. E. A. Bryan,” and Port Chicago Naval Magazine document “PC #80 – S.S. A. E. [sic] Bryan. Approximate load at 2330 – 17 July 1944.”