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August 2, 1946

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CHARLES G. ROSS
Secretary to the President

PRELIMINARY REPORT FOLLOWING THE SECOND ATOMIC BOMB TEST

Report by the Joint Chiefs of Staff Evaluation Board for the Atomic Bomb Tests

30 July 1946

In compliance with your directive of 27 February 1946, the Evaluation Board presents a second preliminary report of the atomic bomb tests held at Bikini Atoll.

Section I

Supplement to Preliminary Report on Test "A"

In general, the observations on ship damage presented by this board in its first report were confirmed by engineering surveys. The location of the bomb burst, accurately determined from photographs, was such that only one ship was within 1,000 feet of the surface point over which the bomb exploded. There were about 20 ships within half a mile, all of which were badly damaged, many being put out of action and five sunk. It required up to 12 days to repair all of those ships left afloat sufficiently so that they could have steamed under their own power to a major base for repair.

It is now possible to make some estimate of the radiological injuries which crews would have suffered had they been aboard Test "A" target vessels. Measurements of radiation intensity and a study of animals exposed in ships show that the initial flash of principal lethal radiations, which are gamma-rays and neutrons, would have killed almost all personnel normally stationed aboard the ships centered around the air burst and many others at greater distances. Personnel protected by steel, water, or other dense materials would have been relatively safe in the outlying target vessels. The effects of radiation exposure would not have incapacitated all victims immediately, even some of the most severely affected might have remained at their stations several hours. Thus it is possible that initial efforts at damage control might have kept ships operating, but it is clear that vessels within a mile of an atomic bomb air burst would eventually become inoperative due to crew casualties.

Section II

Observations on Test "B"

The Board divided into two groups for the observation of Test "B". Four members, after surveying the target array from the air, witnessed the explosion from an airplane eight miles away at an altitude of 7500 feet. The other three members inspected the target array from a small boat the day before the test and observed the bomb's explosion from the deck of the USS HAVEN, 11 miles at sea to the east of the burst.

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The Board reassembled on the HAVEN on 26 July, and the members have since examined photographs, data on radioactivity, and reports of other phenomena, and have inspected some of the target vessels. They have also consulted with members of the Task Force Technical Staff.

As scheduled, at 0835 Bikini time on 25 July, a bomb was detonated well below the surface of the lagoon. This bomb was suspended from LSM-60, near the center of the target array. The explosion was of predicted violence and is estimated to have been at least as destructive as 20,000 tons of TNT.

To a degree which the Board finds remarkable, the visible phenomena of explosion followed the predictions made by civilian and service phenomenologists attached to Joint Task Force One. At the moment of explosion, a dome, which showed the light of incandescent material within, rose upon the surface of the lagoon. The blast was followed by an opaque cloud which rapidly enveloped about half of the target array. The cloud vanished in about two seconds to reveal, as predicted, a column of ascending water. From some of the photographs it appears that this column lifted the 26,000-ton battleship ARKANSAS for a brief interval before the vessel plunged to the bottom of the lagoon. Confirmation of this occurrence must await the analysis of high-speed photographs which are not yet available.

The diameter of the column of water was about 2200 feet, and it rose to a height of about 5500 feet. Spray rose to a much greater height. The column contained roughly ten million tons of water. For several minutes after the column reached maximum height, water fell back, forming an expanding cloud of spray which engulfed about half of the target array. Surrounding the base of the column was a wall of foaming water several hundred feet high.

Waves outside the water column, about 1000 feet from the center of explosion, were 80 to 100 feet in height. These waves rapidly diminished in size as they proceeded outward, the highest wave reaching the beach of Bikini Island being seven feet. Waves did not pass over the island, and no material damage occurred there. Measurements of the underwater shock wave are not yet available. There were no seismic phenomena of significant magnitude.

The explosion produced intense radioactivity in the waters of the lagoon. Radioactivity immediately after the burst is estimated to have been the equivalent of many hundred tons of radium. A few minutes exposure to this intense radiation at its peak would, within a brief interval, have incapacitated human beings and have resulted in their death within days or weeks.

Great quantities of radioactive water descended upon the ships from the column or were thrown over them by waves. This highly lethal radioactive water constituted such a hazard that after four days it was still unsafe for inspection parties, operating within a well-established safety margin, to spend any useful length of time at the center of the target area or to board ships anchored there.

As in Test "A", the array of target ships for Test "B" did not represent a normal anchorage but was designed instead to obtain the maximum data from a single explosion. Of the 84 ships and small craft in the array, 40 were anchored within one mile and 20 within about one-half mile. Two major ships were sunk, the battleship ARKANSAS immediately and the heavy-hulled aircraft carrier SARATOGA after 7½ hours. A landing ship, a landing craft, and an oiler also sank immediately. The destroyer HUGHES, in sinking condition, and the transport FALCON, badly listing, were later beached. The submerged submarine APOGON was sent to the bottom emitting air bubbles and fuel oil, and one to three other submerged submarines are believed to have sunk. Five days after the burst, the badly damaged Japanese battleship NAGATO sank. It was found impossible immediately to assess damage to hulls, power plants and machinery of the target

ships because of radioactive contamination. Full appraisal of damage will have to await detailed survey by engineer teams. External observation from a safe distance would indicate that a few additional ships near the target center may have suffered some hull damage. There was no obvious damage to ships more than one-half mile from the burst.

Section III

Observations and Conclusions, Both Tests

The operations of Joint Task Force One in conducting the tests have set a pattern for close, effective cooperation of the Armed Services and civilian scientists in the planning and execution of this highly technical operation. Moreover, the tests have provided valuable training of personnel in joint operations requiring great precision and coordination of effort.

It is impossible to evaluate an atomic burst in terms of conventional explosives. As to detonation and blast effects, where the largest bomb of the past was effective within a radius of a few hundred feet, the atomic bomb's effectiveness can be measured in thousands of feet. However, the radiological effects have no parallel in conventional weapons. It is necessary that a conventional bomb score a direct hit or a near miss of not more than a few feet to cause significant damage to a battleship. At Bikini the second bomb, bursting under water, sank a battleship immediately at a distance of well over 500 feet. It damaged an aircraft carrier so that it sank in a few hours, while another battleship sank after five days. The first bomb, bursting in air, did great harm to the superstructures of major ships within a half-mile radius, but did only minor damage to their hulls. No ship within a mile of either burst could have escaped without some damage to itself and serious injury to a large number of its crew.

Although lethal results might have been more or less equivalent, the radiological phenomena accompanying the two bursts were markedly different. In the case of the air-burst bomb, it seems certain that unprotected personnel within one mile would have suffered high casualties by intense neutron and gamma radiation as well as by blast and heat. These surviving immediate effects would not have been menaced by radioactivity persisting after the burst.

In the case of the underwater explosion, the air-burst wave was far less intense and there was no heat wave of significance. Moreover, because of the absorption of neutrons and gamma rays by water, the lethal quality of the first flash of radiation was not of high order. But the second bomb threw large masses of highly radioactive water onto the decks and into the hulls of vessels. These contaminated ships became radioactive stoves, and would have burned all living things aboard them with invisible and painless but deadly radiation.

It is too soon to attempt an analysis of all of the implications of the Bikini tests. But it is not too soon to point to the necessity for immediate and intensive research into several unique problems posed by the atomic bomb. The poisoning of large volumes of water presents such a problem. Study must be given to procedures for protecting not only ships' crews but also the populations of cities against such radiological effects as were demonstrated in Bikini lagoon.

Observations during the two tests have established the general types and range of effectiveness of air and shallow underwater atomic-bomb bursts on naval vessels, army material, including a wide variety of Quartermaster stores, and personnel. From these observations and from instrumental data it will now be possible to outline such changes, not only in military and naval design but also in strategy and tactics, as future events may indicate.

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