Timetable of Mk 43 Events

8/10/55 Assistant Secretary of Defense requests Atomic Energy Commission to cooperate with Navy in feasibility study of shock-resistant implosion bomb.

8/17/55 Assistant Secretary of Defense requests Atomic Energy Commission to cooperate with the Armed Forces Special Weapons Project in the TABLELEG study.

10/6/55 The above two projects are merged into one.

12/15/55 TABLELEG Committee studies three weapon designs; Step III to be the ultimate laydown design.

(b)(1), (b)(3)

8/1/56 TABLELEG report advocates design of Step III weapon.

(b)(1), (b)(3)

Spring 1957 Drop tests prove value of nose spike for weapon impact mitigation.

6/4/57 Approved military characteristics for TX-43 Bomb released.

(b)(1), (b)(3)

Early 1958 Separate noses for laydown and air-burst options to be provided.

4/23/58 Proposed ordnance characteristics of TX-43 presented to the Special Weapons Development Board and accepted, except for concern over safing provisions.

(b)(1), (b)(3)

(b)(1), (b)(3)

3/60 Mk 43 Mod 0 released for production.

9/28/61 Mk 43 Mod 1 released for production. Early deliveries of Mod 0.

9/62 Early deliveries of Mod 1 Nose.

6/19/62 Field Command notifies Sandia that final development report has been accepted.

History of the Mk 43 Bomb

In the early 1950's, the trend in military aviation was to fly higher and faster in order to defeat enemy defenses. Air-defense techniques, however, kept pace with increases in aircraft performance, and consequently a shift was made to attacks at low altitudes, where both radar and visual observation became less effective. This resulted in a demand for a weapon that could be released at low altitudes, be rugged enough to survive impact with the target, and then detonate by delayed-action fuze after pilot and aircraft were far enough away to survive the blast.

The Navy had expressed early interest in this type of weapon, and one result was the Mk 8 Bomb that could be used to penetrate water and even concrete submarine pens. However, the Mk 8 was a gun-type device, with an inherent handicap of nuclear inefficiency. The BETTY depth-bomb application of the implosion-type Mk 7 had been produced, as well as the even more rugged design of the Mk 34/LULU. However, both these weapons could withstand only water-entry shock, not impact with harder targets.

As smaller implosion and thermonuclear designs began to appear, and as improved weapon components were developed, the subject of shock-resistant weaponry continued to be periodically raised. The Assistant Secretary of Defense, August 10, 1955, requested the United States Atomic Energy Commission to cooperate with the Navy in a feasibility study of a lightweight, shock-resistant, implosion bomb which could be dropped at high speeds and low altitudes.

The above was followed by a similar letter dated August 17, 1955, requesting the Atomic Energy Commission to cooperate with the Armed Forces Special Weapons Project and the interested Services in a feasibility study of a new family of atomic weapons not more than 18 inches in diameter. One objective of this study was to determine if a weapon with free-fall characteristics and earlier time scales than the HOTPOINT study (which resulted in the Mk 34) could be developed. This was called the TABLELEG project.[1]

On August 31, 1955, the Joint Chiefs of Staff suggested that the foregoing projects be combined into an investigation of a single weapons family, emphasizing common employment characteristics and simplifying storage, handling, transportation, delivery-vehicle compatibility, and delivery tactics.[2] Subsequently, the Assistant Secretary of Defense forwarded this suggestion to the Atomic Energy Commission October 6, 1955, noting that the new weapons family was assigned top priority.[3]

(b)(1), (b)(3)

The initial approach would be to provide a bomb not more than 1500 pounds in weight, and which could survive release at high speeds and low altitudes. This bomb would have minimum tendency to ricochet, be nonpenetrating to any degree that would degrade surface-burst effects, and function reliably when dropped into shallow water against targets such as harbors and dams. The weapon shape would have low drag to permit efficient external carriage on aircraft.

A joint committee, with members from the Atomic Energy Commission and its contractors and representatives of the Department of Defense, was formed and held its first meeting November 17, 1955. This was the TABLELEG Committee, which examined the feasibility of developing a tactical/laydown family of weapons.

In the TABLELEG Committee meeting of December 15, 1955, the Navy proposed that three weapons be developed. A Step I weapon would provide the Navy with an urgently desired laydown weapon by 1958. This bomb would have the capability of being delivered at low altitudes (50 to 200 feet) and at speeds of Mach 0.6 to 1.4. It would have a single, simple time-delay fuze which would allow escape of the slowest carrying aircraft.

(b)(1), (b)(3)

This design was called HOTPOINT, and the bomb was subsequently stockpiled as the Mk 34.

A Step II weapon would be based on the TX-28 design and it, too, would provide the Services with a tactical family of weapons by 1958. This weapon would be

to 1000-g shocks being possible along any axis perpendicular to the longitudinal. The air-burst fuze would have to resist the opening shock of the parachute, estimated to be a maximum of 100 g's for releases at aircraft speeds of Mach 0.95.

The primary power supply would be thermal batteries, activated at time of release of the bomb. Parachute deployment delay timers would also be actuated at bomb release and, after a delay of 1/2 second for externally carried bombs and 1 second for internally carried bombs, would actuate the tail eject and parachute deployment mechanism.

An integrating deceleration switch would prevent weapon arming in the event of parachute failure on retarded deliveries, as it would have to experience a velocity change of 10 g-seconds. An impact switch would operate under a force of 30 g's and initiate a pyrotechnic timer. Operation of a trajectory arm switch for free-fall deliveries would be governed by the pressure differential between the fore and aft sides of a small block on the bomb case. The switch would be designed to close at a minimum velocity of 300 feet per second. A safe-separation timer would contain a spring-powered escapement timing element to close a set of electrical contacts at the end of two preset adjustable timing intervals and a fixed 9-second time. This component would contain two independent timing channels.

(b)(3)

[redacted] It would have to be repackaged to meet the stringent space requirements of the TX-43, but its system would be similar to previous designs.

The rotary chopper would be a single-channel, motor-driven unit with an integral radio-interference filter. The device would convert battery voltage of 28 volts direct current into alternating voltage of the same magnitude and approximately rectangular waveform. The resultant power pulses would then be applied to a transformer-converter assembly, creating an output of 2400 volts direct current to charge the X-unit capacitor and provide a signal to the external initiators.

The X-unit would have one capacitor, with either a 4-probe gap or puncture switch connected to the central capacitor terminal. If a gap switch was used, four pulse

were expected with the latter application. Since wind-tunnel tests of the release and separation characteristics of internally carried streamlined shapes similar to the TX-43 had not been satisfactory in the past under high-speed conditions, it was essential that the separation problem be investigated as soon as possible.[13]

Field Command replied June 6, 1957, noting that B-47 compatibility could not be achieved without changing the existing design. However, if laydown option only would be acceptable, an internally carried version of the bomb could be provided by removing the air-burst fuze, thus reducing the length of the bomb 15 inches. The bomb could be made compatible with the F-105 by minor relocation of the bomb suspension rack.

Field Command noted that proposed drafts of the military characteristics for the TX-43 had virtually excluded the possibility of internal carriage of the bomb in the B-47, since a minimum length of 153 inches had been specified. It was felt that insistence on including the B-47 as a carrier might jeopardize the existing bomb design or result in a different design for internal carriage. Field Command noted that the design could not be provided with a turnaround design, similar to that of the TX-28, since the spike and parachute had to be at opposite ends of the weapon.[14]

The approved military characteristics for a tactical/laydown family of atomic weapons were meanwhile approved by the Military Liaison Committee June 4, 1957.[15]

(b)(1), (b)(3)

The bomb would be capable of delivery at high speeds and low altitudes with high accuracy and delivery safety. It would be capable of remaining in a completely assembled condition, ready for immediate use and without loss of functional reliability, for a period of at least 6 months.

The maximum diameter would be 18 inches. The length would be compatible with the designated carriers, but would not exceed 170 inches, and the maximum weight would be 1500 pounds.

(b)(1), (b)(3)

(b)(1), (b)(3)

The weapon would be capable of inflight selection of laydown burst, free-fall air burst, or retarded air burst. Four selectable burst heights would be provided, and the fireball was not to touch the ground. Releases at altitudes as low as 200 feet and speeds as high as Mach 0.95 were required, with releases down to 50 feet being desirable. For high-altitude releases, the bomb would be capable of delivery at 60,000 feet and a speed of Mach 2.1.[17]

Wind-tunnel tests had meanwhile been proceeding, and had proved that the fin span, as limited by carrier aircraft, would not provide proper ballistic stability. The span could have been increased by use of a folding-fin mechanism, but this was undesirable, from the standpoints of increased weight and decreased reliability.

(b)(1), (b)(3)

This made it possible to reduce the external diameter of the bomb to 16-1/2 inches, and this diameter, when coupled with the largest fixed fin span permissible, gave marginally acceptable aerodynamic performance.

(b)(1), (b)(3)

Los Alamos and Sandia commented on the tactical/laydown military characteristics in a letter to the Division of Military Application September 10, 1957. It was pointed out that a host of new and sometimes conflicting requirements had been added, and that the weapon design requested was infeasible.

The extensive list of weapon carriers included a wide range of aircraft types, and required the TX-43 to be capable of delivery at velocities ranging from

yield, and the weight was accordingly increased to 1900 pounds. It was agreed that the premature-probability figure of 1 in 10,000 could be reduced to 1 in 1,000.

(b)(1), (b)(3)

The above information was forwarded to Albuquerque Operations Office by the Division of Military Application November 25, 1957. It was requested that a laydown design, compatible with B-47 and F-105, be design-released in July 1959, with production occurring a year later. This would be called the TX-43. A variation of this design, called TX-43-X1, would add an air-burst capability. The TX-43-X1 would be design-released in February 1960, with production starting in February 1961.[21]

The increased weight of the bomb required a larger parachute, and a 16-foot ribbon design was selected. After some trajectories had been computed for this new combination, it was found that the weight-to-drag ratio was essentially unchanged, and that the new trajectories were similar to the original ones. After optimizing the spike design, it was theorized that sticking characteristics might be improved if a hole could be made in the target for seating of the spike. A small shaped charge, detonating on contact, was mounted on the tip of the spike. This charge successfully punched a hole in the target concrete, but produced an adverse reaction on the weapon, and the idea was abandoned.[11]

Revised military characteristics for the tactical/laydown family of atomic weapons were approved by the Military Liaison Committee January 14. 1958.

(b)(1), (b)(3)

If a high-voltage power source was provided, provision would be made for its separation from the bomb with a minimum of disassembly.

There would be three fuzing options: Free-fall air burst, retarded air burst, and laydown ground burst. In the free-fall air-burst option, safety would be provided by velocity sensing and arm/safe switches. The retarded air-burst option would have the same safing features as the laydown fuze. Retarded or free-fall air burst would be selected before takeoff, but ground burst or pre-selected air burst could be chosen in flight.[25]

Sandia sent a teletype to the Division of Military Application April 21, 1958, noting that the proposed ordnance characteristics for the TX-43 would be submitted to the Special Weapons Development Board.

(b)(1), (b)(3)

Reliability requirements would be satisfied by use of dual circuits. Diameter and fin span of the bomb would prevent carriage by the F-104.[26]

Report SC4093(TR), Proposed Ordnance Characteristics of the TX-43 Bomb, was presented to the April 23, 1958 meeting of the Special Weapons Development Board. The report was generally acceptable, although the Navy and the Air Force held differing opinions in regard to safety. The design incorporated a low-voltage thermal battery and a chopper-converter for charging the firing set, and these components were not readily removable. Sandia had designed a battery-isolating plug that could be removed, and felt that this met the safety intent of the military characteristics.[27]

The Navy stated that the battery itself should be removable, but the Air Force thought this undesirable. Eventually, the Board accepted the report for forwarding to Washington, with the understanding that the difference in opinion would be settled at the Military Liaison Committee level.

(b)(1), (b)(3)

Steps had meanwhile been taken to secure a suitable target for the final laydown test drops. Tactical airfields were considered one of the primary targets for the TX-43, and studies of existing runways in Europe and Asia had indicated that runway thicknesses varied between 6 and 12 inches of unreinforced concrete.[31] Some XW-34 drops had been made on an airstrip at Melfa, Virginia, but the field did not have adequate security protection. Steps were taken to construct a target at the Tonopah Test Range, but it was apparent that this would not be available in time for the early tests. Consequently, an abandoned concrete apron near Dalhart, Texas, was leased for some drops in August 1958, even though the concrete was only 7 inches thick.[32] The parachute deployment system was initiated by a pullout switch connected by a 5-foot lanyard to the carrying aircraft. Closure of this pullout switch fired powder-actuated squibs that blew off the tail cone, which in turn extracted a 3-foot-diameter pilot chute. This pilot chute pulled out the main bag and canopy, and the opening shock of the main parachute released the nose cap of the bomb, thus exposing the spike.[33]

An amendment to the military characteristics was issued by the Division of Military Application December 22, 1958.[34] The Navy VA-X was replaced by the A2F, and compatibility of the air-burst bomb with B-47 and B-52 was required. Compatibility of this version with F-105 was desired.

To ensure internal-carriage compatibility with B-47, B-52 and F-105, and external carriage with F-104, it was noted that a modified version without air-burst capability would be acceptable. Where the same carriers were involved, compatibility with the Mk 28 Bomb suspension system was required.

(b)(1), (b)(3)

Production authorization was released in February 1959, and Sandia proposed production nomenclature in a letter to Albuquerque Operations Office March 11, 1959. The Mk 43 Mod 0 Bomb would be identified as the B43-0, and the Mk 43 Mod 0 Nose would be called the N43-0. The Mk 43 Mod 1 Nose would be named the N43-1. The complete identification would specify both bomb and nose. This proposal was approved by the Albuquerque Operations Office April 17, 1959.[36]

Sandia notified the Air Force Special Weapons Center June 16, 1959, that preliminary results from the first four releases at Dalhart indicated that the 16-foot-diameter ribbon parachute was inadequate. Wright Air Development Center had proposed three alternatives: An 18-foot unreefed, an 18-foot reefed, and a 12-foot, 3-cluster system. It was doubtful whether the 18-foot unreefed design would fit into the allowable space, but a reefed system was undesirable due to the short time of fall of the weapon. The 3-cluster system would require considerable development. Since the release date of the TX-43 was imminent, Sandia preferred to use the 16-foot system, even with its limitations, since it appeared to be functional. However, development work was begun on a replacement high-speed release system.[37]

Sandia wrote to the Naval Air Special Weapons Facility September 14, 1959, referring to carriage of TX-43 and TX-43-X1 in Navy AD aircraft. Both bomb designs contained trajectory recognition devices to prevent weapon arming caused by accidents during handling and loading operations, and to provide a measure of safety during aircraft takeoff and landing. A minimum release speed of 285 knots was required for operation of the devices, and this was greater than the maximum speed of the AD aircraft.

It did not appear feasible to alter the operating characteristics of the trajectory devices without seriously compromising the safety of both bomb designs. The safety devices could be bypassed, and this operation would require only a relatively minor field operation that would only compromise the safety of bombs modified for carriage in AD aircraft. However, the parallel operation on the TX-43-X1 would require a weapon redesign that would affect the safety of all TX-43-X1's.

Laydown times of 30 and 60 seconds had been provided for both weapon modifications.

(b)(1), (b)(3)

designs, Mod 0 and Mod 1, had been accepted by the Services as meeting the requirement for a single weapon including both laydown and air-burst capabilities.

It was recognized that the high shock requirements of a laydown design would not allow shipboard removal or insertion of the nuclear assembly. The 200-foot release altitude satisfied the military characteristics, but it was hoped that work would continue toward attainment of a 50-foot capability as soon as possible.[40]

(b)(1), (b)(3)

The fuze switch pack was a potted unit containing printed-circuit boards, various explosive switches, diodes and cables. A 28-volt thermal battery was connected to a ready-safe switch operated electrically by the aircraft pilot. An inertial switch formed a safety device to prevent bomb arming in the event of accidental bomb release below minimum delivery speed, or in the event of parachute failure. A minimum force of 3 g's was required to activate this inertial switch, with a minimum of 8 g-seconds needed for complete operation.

A rotary chopper inverter transformed the battery output of 28 volts direct current into an alternating 28-volt rectangular waveform that was stepped up and rectified to provide high-voltage direct current for charging the capacitors of the X-unit and the external initiators (neutron generators). The capacitor in the neutron generators was charged to a potential of 2200 to 2600 volts.

(b)(1), (b)(3)

Firing of this gap resulted in an arc discharge between two titanium tritide conductors in the source tube, thus producing tritium ions.

Firing of the spark gap allowed an energy storage capacitor to discharge the primary winding of a high-voltage pulse transformer.

(b)(3)

The weapon was provided with four fins, each having a frangible area at the outboard trailing edge. The unreefed ribbon parachute, developed by Wright Air Development Center, was 16 feet in diameter.[41]

Full-scale tests included drops onto a concrete target, at impact velocities of 46 to 117 feet per second, and at angles of 22 to 75 degrees to the horizontal target. Some test vehicles contained high explosives, and others held fuzing and firing components. Two tests were made at a temperature of -55°F. There were three fractures reported, all of which occurred when the weapon spike did not stick in the concrete. The high explosive did not detonate at impact, and the low-temperature units operated normally. Airdrops were started at the Salton Sea Test Base and continued at the Tonopah Test Range, where a 12-inch-thick concrete target became available in late 1960.[43,44]

Tests of the early designs of inertial latching switches showed that an excessively high minimum release speed was required and, for releases below an altitude of 300 feet, closure and lock-in were not accomplished with desired reliability.[45] The switch was redesigned for better operation and, due to a delay in the Mk 43 production schedule, it became possible to supply this new switch in time to meet first Mk 43 Mod 0 Bomb production in April 1961.[46,47,48]

The military characteristics were again amended April 11, 1961. The Air Force F-105 was added for external carriage of the Mk 43, together with the Navy A3J, F4H and AD5. The P6M was deleted, with the Navy thus being interested only in the externally carried version of the bomb.[49]

Sandia wrote to Albuquerque Operations Office May 31, 1961, noting that a larger parachute would have to be provided for releases from AD aircraft and subsequently, the Air Force Special Weapons Center was requested to supply this parachute design. Release speeds between 230 and 275 knots were specified, at altitudes from 50 to 200 feet above the target. The laydown option only would be used.[50]

Meanwhile, tests had been conducted on the 12-inch-thick concrete target at the Tonopah Test Range. These tests were more severe than any that had been undertaken previously, and it was found that slapdown caused failure of the neutron generators.[51]

Suggestions were made that the Mk 43 Mod 0 be externally carried on the B-58 Bomber, and wind-tunnel tests showed that the combination of weapon and aircraft had an adequate margin of stability in the speed range from Mach 0.3 to 3.0.[52] Thus, plans were formalized for external carriage of four bombs on pylons, and compatibility was authorized by the Division of Military Application in an amendment to the military characteristics dated July 19, 1961.[53]

The Air Force Special Weapons Center wrote to Sandia August 2, 1961, noting that the retardation system used with the AD aircraft was being designed by the Aeronautical Systems Division of the Air Force. Recent developments in reefing-cutter timers had produced faster disreefing action, thus making the use of reefed chutes practicable for short times of fall. Studies had indicated that a 32-foot-diameter ribbon parachute, reefed to an area of 140 square feet for a period of 1 second and extracted by a 4-foot-diameter pilot chute, would satisfy the operational requirements, and it was felt that the minimum release altitude might be less than 100 feet above the terrain.[54]

The addition of the B-58 aircraft to the list of carriers was discussed in a letter from Sandia to the Division of Military Application August 24, 1961. Current

Subsequently, Sandia wrote to the Air Force Special Weapons Center November 21, 1961, noting that the delay in developing the Air Force's 20-foot reefed parachute was preventing stockpiling of the Mk 43 in a configuration capable of release at altitudes down to 200 feet. The Wright Air Development Division design was undergoing testing, but there had been only one success out of six tests, while the Sandia design had demonstrated two successful tests. It was felt that the Sandia design should be certified for use with the Mk 43, or work on it stopped.[61]

The Center replied to the above, December 29, 1961, pointing out that the 16-foot parachute currently being provided for the Mk 43 was capable of successfully retarding the bomb when released 200 feet above the target. The requirement for performance on hardened targets was not felt to be a restriction of the parachute system. It was noted that the Air Force parachute design had been completed several months prior to testing the Mk 43 on the extremely hard Tonopah target.

Recognizing the desirability of improving the effectiveness of the parachute above and beyond the requirements of the military characteristics, the Center had started, in early 1961, to develop a 20-foot reefed system, and theoretical curves of this system appeared encouraging. This system was reefed to a drag area of 70 square feet for 3/4 second after initial deployment, and would be tested with the Mk 43, if it could be packaged in the limited volume available in this bomb.[62]

The Air Force Special Weapons Center notified Sandia February 2, 1962 that development of two larger retardation systems for the Mk 43 were being considered. One was a 23-foot-diameter chute reefed to a drag area of 70 square feet for 3/4 second. This had been successfully tested at 125 percent of the design dynamic pressure, and it was proposed that field tests with the Mk 43 be made. The other was an even larger parachute to be used for releases from AD aircraft. This had a diameter of 32 feet and had experienced a successful test in which simulated release at 230 knots airspeed had latched all the inertial switches. An overtest, however, had not been successful, and the parachute was being strengthened.[63]

Meanwhile, the desirability of providing a lower-drag configuration had been discussed.[64] It was pointed out that, originally, compatibility with various carriers had required that the fin span be held to a minimum. This resulted in dynamic stability that was not quite high enough to be entirely satisfactory. Extendible fins had been considered, but their operational reliability was felt to be low.[65]

Eventually, it was decided that large fins would be assembled to the weapon and a set of small fins and spoiler bands placed in Base Spares.[66] The small fins would be used with F-104 and AD aircraft, due to lack of clearance between bomb and carrier. Subsequent tests of the low-drag configuration showed this to be aerodynamically superior in almost every respect to the original configuration.

(b)(1), (b)(3)

Field Command notified Sandia June 19, 1962 that Report SC4471(WD), Final Development Report for the Mk 43 Bomb with a Mk 43 Mod 0 Nose, had been reviewed in coordination with representatives of the interested Services.

(b)(3)

The 2060-pound weight exceeded the allowable 2000 pounds, but this had been accepted.

(b)(1), (b)(3)

The bomb possessed some degree of vulnerability to electromagnetic radiation, but the extent had not been defined. Laydown reliability had not been met, and expected reliability when impacting in vertical masonry and targets having hardness greater than 12 inches of concrete, had not been defined. Successful laydown delivery from altitudes up to 5000 feet above the terrain had not been met in the case of fighter delivery. This had been accepted as not imposing any very serious operational restrictions, but failure to meet a requirement for a minimum laydown delivery from 200 feet above the terrain against hard targets did impose a serious operational limitation and was accepted only on an interim basis. Release at altitudes down to 50 feet remained a desired capability. Thus unconditional acceptance of the design was withheld, pending action on these points.[68]

Meanwhile, compatibility tests with B-58 aircraft showed that the weapon would successfully withstand 3 hours of maximum afterburner environment, and acoustic, wind-tunnel, firing-range and aerodynamic tests were successfully conducted.[69] Drop and low-level separation tests were also satisfactory, and engineering release of the TX-43-X1 with the B-58 was authorized in May 1962.

(b)(3)

Sandia wrote to Field Command October 10, 1962, noting that the externally carried Mk 43, when handled in accordance with authorized procedures, provided adequate protection against electromagnetic radiation. For internal carriage, or when standard handling procedures could not be followed, the radio-frequency energy delivered to the bomb could be reduced to an acceptable level through use of electromagnetic shields. However, this could not be accomplished on the F-104, since the shallow pylon of this aircraft physically prevented making electrical connections after the bomb was attached to the pylon.[70]

It had been suggested that a coded permissive device be incorporated in the Mk 43 to provide an additional measure of command control and to delay an unauthorized individual attempting to arm or detonate the bomb, and an amendment to the military characteristics was approved by the Military Liaison Committee February 26, 1963.[71]

(b)(3)

The device would be enabled or disenabled by both aircraft and ground-support controls. The latter capability would be retained up to the time of taxi or launch of the aircraft, and the time required for the enabling operation after receipt of the code would not exceed 1 minute.[72]

A subsequent amendment to the military characteristics, approved by the Military Liaison Committee March 19, 1963, called for a 4-digit, 10,000-combination device to permit recoding as two distinct and separate insertions of two digits by different men, such that each insertion would be unobservable by the other.[73]

Report SC4725(WD), Final Development Report for the Mk 43 Basic Assembly with a Mk 43 Mod 1 Nose and Shape Components, was forwarded by Sandia to the Division of Military Application. The report described the status of the design at the time of first production. It had been presented to and accepted by the Design Review and Acceptance Group March 13, 1963.[74] The term "Shape Components" referred to tail assemblies used for installation with various carrying aircraft.[75]

It was noted that the Mk 43 Bomb did not meet the military characteristics in that it was about 120 pounds overweight, which was caused by reinforcing the center case to improve the low-level delivery capability, also that the desired capability of release at an altitude of 200 feet had been achieved only for dirt and water targets.

(b)(1), (b)(3)

Fuzing for surface burst was made by selecting GRD on the aircraft monitor and control equipment. After takeoff, but before release of the weapon, power was applied to the inflight monitor and control system. This action monitored the position of the ready-safe switch and indicated any incompatibility between the position of the option-selector switch in the aircraft and the position of the ready-safe switch. When the selector switch was rotated from the SAFE to the AIR or GROUND position, the ready-safe switch operated to the ready position, completing the circuit from the weapon power supply to the fuzing system.

(b)(3)

(b)(3)

For the retarded air burst, before takeoff the RETARD option and either GROUND BACKUP or PRECLUDE were selected by means of switches, and safe-separation times TA and TB set by means of dials located in the Mod 1 Nose and accessible through a panel. The radar range was automatically selected by the range plug attached to the Mod 0 Bomb Assembly.

After takeoff and before weapon release, aircraft power was applied to the monitor and control system and AIR option selected to apply power to the break-away pulse connector assembly and to operate the ready-safe switch to the READY position.

(b)(1), (b)(3)

A suggestion was made that the Mk 43 be provided with a nose parachute to more effectively slow the rate of fall of the bomb, but it was found that this feature decreased the efficiency of the tail parachute by blocking the air flow. Sandia experimented with a 21-foot-diameter parachute having 70 percent more drag than the existing 16-foot-diameter parachute, and a successful release was made at an altitude of 185 feet above the Tonopah concrete target. A 30-foot Sandia design for use with AD aircraft demonstrated successful delivery from an altitude of 124 feet.[78]

Sandia wrote to Field Command April 15, 1963, noting that the parachute used by the Navy for Mk 43 Bomb releases from AD aircraft was a 32-foot-diameter design produced by the Air Force. Release altitude was limited to 350 feet above the target, due to the fact that a trim angle of about 10 degrees prevented spiking impact and resulted in slapdown. The Air Force was developing a permanent reefing feature, and tests indicated that a sticking impact would result from releases at 200 feet, but showed that the design was marginal at minimum dynamic-pressure release conditions. The Sandia 30-foot design was not satisfactory under these conditions, and resulted in unacceptable slapdown caused, in part, by a large trim angle between weapon axis and trajectory.

Sandia developed a 21-foot-diameter parachute reefed to 70 square feet of area. This demonstrated consistent reefing times and maximum deployment shocks of 40 g's, but spiking was marginal when the bomb was released from an altitude of 200 feet onto a target of 12 inches of concrete. Reefing to 90 square feet would be tested, to produce higher impact angles and a sharper impact shock to improve the operation of the inertial switch. Sandia felt that possibly the addition of an aluminum-honeycomb support might allow laydown releases from 200 feet.[79]

Sandia discussed the parachute problem in a letter to the Division of Military Application July 1, 1963. Drop tests of the Air Force's permanently reefed 32-foot chute and Sandia's 30-foot chute had demonstrated some improvement, but not enough for consistent sticking conditions below a release altitude of 350 feet.

Tower tests had been made using external shock-mitigating devices, such as honeycomb soft noses, shock-mitigating rings, and explosive noses, but these had not noticeably improved laydown characteristics. It was pointed out that several failures of the spike-to-case joint had been experienced early in the drop-test program. The joint had been strengthened and the case contour changed to a conical section. This had apparently moved the failure point, and steps were taken to identify all Mk 43 Bombs with a conical case and restrict these for laydown use against soft targets.[80]

Sandia wrote to Field Command April 22, 1964, noting that a design release, April 7, 1964, authorized a minimum release altitude of 275 feet for the Mk 43 Mod 0 Basic Assembly when used with a 23-foot-diameter parachute. Sandia hoped that this minimum altitude might be improved when the Mods 1 and 2 Basic Assemblies became available, as foam support provided for these items should improve the shock resistance.

Sandia noted that Field Command had requested information concerning the capabilities of the bomb against irregular and exceptionally hard targets May 14, 1962. At that time it had been agreed that the bomb could not be tested against every conceivable type of target, but that it would be desirable to know more about the capability of the bomb on other than horizontal targets. Negotiations were accordingly made with the Naval Ordnance Test Station, China Lake, California, and 13 units were tested in the period from October to December 1962.

The China Lake targets were 120 feet long, 60 feet apart, 20 feet high, and varied from 10 feet thick in the middle to 1 foot thick at the ends. The targets were of concrete, reinforced with 1/2- and 5/8-inch-diameter steel bars. Weapons were tested at impact velocities between 163 and 307 feet per second. The unit remained in the spiked attitude seven times, and neutron generators were subsequently operable in six tests. The seventh unit ricocheted off the top of the wall and the assembly shattered. The tests showed that there was some capability for impacts against hard vertical targets, but that an extensive and expensive program would be required to define and prove-out the exact limits of this capability.[81]

In the fall of 1963, Sandia was informed that Mk 43 Bombs in military custody were developing excessive internal pressure. This was found to be caused by evolution of hydrogen gas, produced by interaction of airborne moisture with the weapon uranium. Humidity-controlled areas were established in the production lines, and special packaging methods used to prevent moisture from entering the internal portions of the bomb.[82]

Sandia issued a Mod 1 change to the Mk 43 Mod 0 Basic Assembly (the weapon central section) and a Mod kit was produced in August 1964. This change increased the shock-mitigation capability of the bomb through use of foam supports, provided electromagnetic radiation shielding, and blocked unnecessary aircraft power from the aft continuity loops. The modified items included a new firing set and foam support, new neutron generators, pulse connector with radio-frequency filters and blocking diodes, inertial switch with positive locking features, and shielded pullout cables. A Mod 2 kit was produced in December 1964, when prescribed-action-link assemblies became available.

Various so-called Shape Components, or tail assemblies, were produced. The Mod 0 incorporated a 16-foot-diameter parachute and small fins. The Mod 1 had a 32-foot-diameter parachute, and was for use with the A-1H, J aircraft only. The Mod 2 had a 16-foot-diameter parachute and a set of large fins. The Mod 3 had a 23-foot-diameter parachute and small fins, and the Mod 4 had a 23-foot-diameter parachute and large fins.

(b)(1), (b)(3)

Sandia wrote to the Division of Military Application October 27, 1964, replying to a request to provide Mk 43 compatibility with F-4 and F-111 aircraft.

(b)(1), (b)(3)

Sandia noted that compatibility with the F-4 aircraft required that supersonic delivery and thermal compatibility be checked. It was felt that the existing retardation system would be suitable for the aircraft's maximum delivery speed of Mach 1.09 at sea level, and suitable testing was in progress. Thermal analysis had been made and there were felt to be two potential trouble areas. One of these was the bimetallic center case assembly, which was an aluminum case with a shrink-fitted steel sleeve. The strength of this joint was unknown under the temperatures encountered during high-speed flight, and tests were being made. The other problem area was the parachute deployment device. This component was being redesigned to incorporate an explosive with higher temperature capability.

It was felt that there would be only minor problems in providing compatibility of the Mk 43 Bomb with the F-111 aircraft. This airplane, as used by the Tactical Air Command, had a bomb bay cooled to a temperature of 150°F. The plane, as used by the Navy, might not be cooled, but its operating temperature of 210°F was much less severe than external carriage of the Mk 43.[84]

Subsequent tests showed that the center-case-assembly joint could withstand a parachute load of 160,000 pounds applied at an angle of 7 degrees, and would have a factor of safety of 1.25 at temperatures up to 270°F. This was well above any predicted temperatures for the carriers concerned with the Mk 43.[85]

(b)(1), (b)(3)

It was not possible, however, to provide an explosive for the parachute deployment device that would withstand the heating created by the high-speed profile of the F-111. A somewhat more heat-resistant design was created, and this changed the Mods 1, 3, and 4 Shape Components to Mods 5, 6, and 7, respectively.[86]

Glossary of Mk 43 Terms

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

Albuquerque Operations Office -- The local office of the Atomic Energy Commission (AEC) concerned with the operations of Sandia Corporation.

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions related to atomic weapons.

Assistant Secretary of Defense -- Created by Department of Defense directive, June 30, 1953, as part of DOD reorganization. Handles research and development activities of the DOD.

Boosting Gas -- Deuterium-tritium gas introduced into the implosion process to increase the fission activity and thus the yield of the device.

(b)(1), (b)(3)

Defense Atomic Support Agency -- An interdepartmental agency formed to handle military functions related to atomic weapons. Originally called the Armed Forces Special Weapons Project.

Department of Defense -- The Armed Forces, i.e., the Army, Navy and Air Force.

Depth Charge -- An explosive charge that detonates after sinking to a prescribed depth in water.

Design Review and Acceptance Group -- A Military committee that absorbed some of the functions of the Special Weapons Development Board (which see).

Deuterium -- The hydrogen isotope of mass number 2.

Division of Military Application -- An AEC office that functions as liaison between the Military and weapons designers and producers.

(b)(1), (b)(3)

Field Command -- The local office of the Armed Forces Special Weapons Project (Defense Atomic Support Agency), located on Sandia Base, Albuquerque, New Mexico.

Firing System -- The electrical system of the weapon that produces and applies a high-voltage current to the detonators.

Free-Fall Bomb -- A bomb that falls under the forces of gravity and the impetus given at time of release.

Fuze -- A combination of the arming and firing devices of a weapon.

(b)(1), (b)(3)

Hardtack -- A nuclear series of 72 tests. Hardtack I was held at the Pacific Proving Grounds from April 28 to August 18, 1958. The decision to declare a moratorium on testing resulted in Hardtack II, held at the Nevada Test Site between September 12 and October 30, 1958.

High-Explosive Sphere -- The ball of high explosive that surrounds the nuclear primary and is designed to produce the implosion effect when detonated.

Implosion -- The effect created when a sphere of high explosive is detonated on its exterior surface. If suitable lens charges are provided to invert the explosion, the force of the shock wave is directed largely toward the center of the sphere.

Inertial Switch -- A switch containing a small weight and a spring. When subjected to an external force of acceleration or deceleration, the weight compresses the spring. Generally, a metering device is added to measure the length of time the external force is applied.

Ionizing -- To render a device conductive by formation of ions or electrically charged atoms.

Joint Chiefs of Staff -- A group composed of the Chiefs of Staff of the Army, Navy and Air Force, to determine policy and develop joint strategic objectives of the Armed Forces.

Kiloton -- A means of measuring the yield of an atomic device by comparing its output with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the detonation effect of 1000 tons of high explosive.

Knot -- A naval unit of speed, equivalent to 1 nautical mile or 6076 feet per hour.

Laydown Device -- A bomb capable of being dropped on a relatively hard target or surface and surviving in a condition to later detonate.

Los Alamos Scientific Laboratory -- A nuclear design organization located at Los Alamos, New Mexico.

Mach -- A measure of speed. Mach 1.0 is the speed of sound, or 738 miles per hour at sea level.

Megaton -- A measure of yield of a large weapon. One megaton is the equivalent of 1,000,000 tons of high explosive.

Military Characteristics -- The attributes of a weapon that are desired by the Military.

Military Liaison Committee -- A Department of Defense committee established by the Atomic Energy Act to advise and consult with the AEC on all matters relating to military applications of atomic energy.

(b)(1), (b)(3)

One-Point Safety Test -- A test in which the high-explosive sphere is detonated at one detonator or point. If the device is one-point safe, no nuclear yield is produced.

Operation Hardtack -- See Hardtack.

Operation Plumbbob -- See Plumbbob.

Operation Redwing -- See Redwing.

(b)(1), (b)(3)

Uranium-235 -- A radioactive element, an isotope of uranium-238.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent uranium-238; the rest is uranium-235.

X-Unit -- A device used to provide high voltage to the weapon detonators.

37. CRD Ltr, RS 1220/210, Sandia Corporation to Air Force Special Weapons Center, dtd 6/16/59, subject, TX-43 Parachute Performance. SC Central Technical Files, 43 Program, 3-, March through July 1959.

38. SRD Ltr, RS 1200/3580, Sandia Corporation to United States Naval Air Special Weapons Facility, dtd 9/14/59, subject, AD Aircraft/TX-43, TX-43-X1 Compatibility. SC Central Technical Files, 43 Program, 4-, 1959-60.

39.

(b)(3)

40. SRD Ltr, RS 3466/92778, Field Command to Sandia Corporation, dtd 1/25/60, subject, Description and Status at Design Release of the TX-43 Bomb, SC-4366(TR). SC Central Technical Files, 43 Program, 7-, 8-.

41.

(b)(3)

42.

43. SRD Ltr, RS 5231/73, Division 5231 to Division 1222, Sandia Corporation, dtd 8/4/60, subject, Preliminary Test Report of 43-68. SC Central Technical Files, TX-43, 3-, June through December 1960.

44. SRD Ltr, RS 7231/1275, Division 7231 to 7122, Sandia Corporation, dtd 9/23/60, subject, Preliminary Test Report of 43-80. SC Central Technical Files, TX-43, 3-, June through December 1960.

45. CRD Ltr, RS 1200/3772, Sandia Corporation to Field Command, dtd 6/1/60, subject, Minimum Release Velocity for Delivery of Mk 43 Weapons. SC Central Technical Files, 43 Program, 2-, 1959-60.

46. SRD Ltr, RS 2532/221, Division 2532 to Division 2331, Sandia Corporation, dtd 2/24/61, subject, Product Change Proposal No. 1353. SC Central Technical Files, 43 Program, 6-, 1959-61.

47. SRD Ltr, RS 100/100, Sandia Corporation to Albuquerque Operations Office, dtd 3/31/61, subject, First Production Unit, Mk 43 Mod 0. SC Central Technical Files, 43 Program, 1-, 1961.

48. SRD Ltr, RS 3466/148153, Albuquerque Operations Office to Sandia Corporation, dtd 4/12/61, subject, First Production Unit for War Reserve, Mk 43 Mod 0. SC Central Technical Files, 43 Program, -2, 1961.

49. CRD Ltr, Military Liaison Committee to Distribution, dtd 4/11/61, subject, Amendment No. 5 to the Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

50. CRD Ltr, Sandia Corporation to Albuquerque Operations Office, dtd 5/31/61, subject, Mk 43 Military Characteristics Amendment No. 5. SC Central Technical Files, 43 Program, 1-6.

51. SRD Ltr, RS 7122/2, Division 7122 to Department 7120, Sandia Corporation, dtd 6/8/61, subject, Mk 43 Drop Test Program to Investigate 200 Foot Delivery Capability. SC Central Technical Files, 43 Program, 3-, 1961.

52. CRD Ltr, Sandia Corporation to Air Force Special Weapons Center, dtd 3/30/61, subject, TX-43 Weapon Redesign. SC Central Technical Files, 43 Program, 2-, 1961.

53. SRD Ltr, RS 3446/41219, Division of Military Application to Albuquerque Operations Office, dtd 7/19/61, subject, Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

54. CRD Ltr, Air Force Special Weapons Center to Sandia Corporation, dtd 8/2/61, subject, Status of Development of the Retardation System for the Mk 43/AD Airplane. SC Central Technical Files, 43 Program, 1-, 1961.

55. SRD Ltr, RS 7000/193, Sandia Corporation to Division of Military Application, dtd 8/24/61, subject, Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

56. SRD TWX, RS 1/1326, Sandia Corporation to Albuquerque Operations Office, dtd 8/30/61, subject, TX-43 Bomb Program. SC Central Technical Files, 43 Program, 1-, 1961.

57. CRD Ltr, Sandia Corporation to Division of Military Application, dtd 9/28/61, subject, Forwarding Letter for SC4487(WD). SC Central Technical Files, 43 Program, 7-, 8-.

58. CRD Ltr, Department 5140 to Department 1220, Sandia Corporation, dtd 4/6/60, subject, Sandia-Designed Parachute for the TX-43. SC Central Technical Files, 43 Program, 1959-60.

59. CRD Ltr, RS 1220/289, Department 1220 to Department 5140, Sandia Corporation, dtd 5/23/60, subject, Sandia-Designed Parachute for TX-43. SC Central Technical Files, 43 Program, 1959-60.

60. CRD Ltr, Department 7120 to Department 7130, Sandia Corporation, dtd 4/18/61, subject, Feasibility Study, Design and Development of a Parachute for Mk 43 Mod 0. SC Central Technical Files, 43 Program, 1-, 1961.

61. CRD Ltr, Sandia Corporation to Air Force Special Weapons Center, dtd 11/21/61, subject, Development of 20-Foot Reefed Parachute for Mk 43. SC Central Technical Files, 43 Program, 2-, 1961.

62. SRD Ltr, RS 3446/46504, Air Force Special Weapons Center to Sandia Corporation, dtd 12/29/61, subject, 20-Foot Retardation System. SC Central Technical Files, 43 Program, 1-, 1961.

63. SRD Ltr, RS 3446/47307, Air Force Special Weapons Center to Sandia Corporation, dtd 2/2/62, subject, Status of Development of Retardation Systems for the TX-43 Bomb. SC Central Technical Files, 43 Program, 1-, 1962.

64. CRD Ltr, Sandia Corporation to Albuquerque Operations Office, dtd 7/10/61, subject, B43-0/N43-1, Freefall Airburst Capability for F104. SC Central Technical Files, 43 Program, 2-, 1961.

65. CRD Ltr, RS 7100/1300, Sandia Corporation to Field Command, dtd 4/8/62, subject, Low-Drag Configuration of the Mk 43. SC Central Technical Files, 43 Program, 2-, 1961.

66. CRD Ltr, Field Command to Sandia Corporation, dtd 7/9/62, subject, Low-Drag Configuration of the Mk 43. SC Central Technical Files, 43 Program, 7/62 through 12/62.

67.

(b)(3)

68. SRD Ltr, RS 3446/51892, Field Command to Sandia Corporation, dtd 6/19/62, subject, Final Development Report for the Mk 43 Bomb with the Mk 43 Mod 0 Nose, SC4471(WD). SC Central Technical Files, 43 Program, 2-, 1961.

69. CRD Ltr, Sandia Corporation to Division of Military Application, dtd 6/11/62, subject, Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 2-, 1961.

70. SRD Ltr, RS 7000/267, Sandia Corporation to Field Command, dtd 10/10/62, subject, Status of the TX-43-X1 Bomb. SC Central Technical Files, 43 Program, 7/62 through 12/62.

71. SRD Ltr, RS 3446/54991, Military Liaison Committee to Distribution, dtd 6/15/52, subject, Amendment No. 9 to the Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

72. SRD Ltr, RS 3446/59621, Military Liaison Committee to Distribution, dtd 2/26/63, subject, Amendment No. 10 to the Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

73. SRD Ltr, RS 3446/61182, Military Liaison Committee to Distribution, dtd 3/19/63, subject, Amendment No. 11 to the Military Characteristics for a Tactical/Laydown Family of Atomic Weapons. SC Central Technical Files, 43 Program, 1-6.

74. Unc Ltr, Sandia Corporation to Division of Military Application, dtd 5/7/63, subject, Forwarding Letter for SC4725(WD). SC Central Technical Files, 43 Program, 7-, 8-.

75. CRD Ltr, Sandia Corporation to Albuquerque Operations Office, dtd 6/29/61, subject, Nomenclature Changes, TX-43 Program. SC Central Technical Files, 43 Program, 1-, 1961.

76.

(b)(3)

77.

78. CRD Ltr, Section 7134-1 to Section 1443-2, Sandia Corporation, dtd 1/9/63, subject, Suggestion for Improving Laydown of the Mk 43. SC Central Technical Files, 43 Program, 3-, January through May 1963.

79. SRD Ltr, RS 7100/1583, Sandia Corporation to Field Command, dtd 4/15/63, subject, Mk 43 Laydown Capability. SC Central Technical Files, 43 Program, 1-, 1963-4.

80. SRD Ltr, RS 1500/1063, Sandia Corporation to Division of Military Application, dtd 7/1/63, subject, Progress on Mk 43/32-Foot Diameter Chute/AD Capability. SC Central Technical Files, 43 Program, 1-, 1963-4.

81. SRD Ltr, RS 1500/1200, Sandia Corporation to Field Command, dtd 4/22/64, subject, Status of Mk 43 Bomb. SC Central Technical Files, 43 Program, 2-, 1964-5.

82. CRD Ltr, Sandia Corporation to Albuquerque Operations Office, dtd 4/22/64, subject, Humidity Control for Mk 43 Manufacturing Areas. SC Central Technical Files, 43 Program, 3-, March and April 1964.

83. (b)(3)

84. SRD Ltr, RS 1/1503, Sandia Corporation to Division of Military Application, dtd 10/27/64, subject, Mk 43 and Mk 57 Weapon Programs. SC Central Technical Files, 43 Program, 1-, 1963-4.

85. CRD Ltr, Division 1542 to Division 1525, Sandia Corporation, dtd 2/11/66, subject, Structural Compatibility of the Mk-43 with All MC-Required Carriers with the Exception of the F-111 Series of Aircraft. SC Central Technical Files, 43 Program, 2-1.

86. CRD Ltr, Sandia Corporation to Distribution, dtd 6/23/66, subject, Final Product Change Proposal No. 1-66. SC Central Technical Files, Mk 43, 6-1.

~~SECRET~~
~~RESTRICTED DATA~~

UNCLASSIFIED

~~SECRET~~
~~RESTRICTED DATA~~

UNCLASSIFIED