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SUPPRESSION OF PROPAGATION BETWEEN STACKS OF BOMBS

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ABSTRACT

Tests were conducted to determine if propagation could be prevented between stacks of MK 82 (500 pound) and MK 84 (2000 pound) bombs in storage. The effects of four variables were explored; orientation of the bombs, fuze well protection, distance between stacks of bombs, and placing material between stacks of bombs. A total of 19 tests have been conducted and conclusively prove that propagation between stacks of bombs in storage can be prevented.

BACKGROUND

Limited availability of land area for munitions storage at overseas bases, coupled with civilian encroachment, and the need to build additional facilities on available land has placed constraints on munitions storage capabilities. Many structures which can physically hold as much as 500,000 pounds of explosives are limited to 60,000 pounds or less by quantity distance constraints. One method of increasing the explosives capacity of limited structures is to place stacks of bombs in a structure in such a way that if one stack of bombs detonates the other stacks of bombs will survive. In this manner the maximum credible event (MCE) can be reduced to one stack of bombs and consequently required safety distances can be reduced.

TEST APPROACH

Two mechanisms are known to cause propagation between bombs, shock from the impact of high energy fragments and pressure/shock from blast. The easiest method of limiting pressure was to limit the size of the stacks of bombs. Consultation with Dr. Jerry Ward of the DDESB revealed that 60,000 pounds net explosives weight (NEW) was a conservative upper limit. We restricted our test to the 60,000 pound range. In order to reduce the effect of high speed fragments, material, which we will call buffer material, was placed between stacks of bombs. Buffer materials were limited to other munitions items and bomb components since they needed to be stored in the munitions areas in any case. Most fragments come from the sides of bombs, therefore the number of fragments transmitted from one stack of bombs to the next can be reduced by orienting the bombs so that the nose or tail of bombs in one stack are oriented toward the nose or tail of bombs in the other stack. Three stacks of bombs were used for each test; a center stack which we will refer to as a donor stack (in which one bomb is intentionally detonated), and two acceptor stacks which are the targets for the fragments.

MK 82 TEST SERIES

OVERVIEW

This test series was conducted in 1985. The goal was to determine if buffer material would prevent propagation between MK 82 bombs in storage.

TEST 1 (fig. 1)

The goal of this test was to determine what would happen to bombs in a normal storage configuration when one bomb in the donor stack was intentionally detonated. We were reasonably sure all bombs in the donor stack would detonate and the detonation

would propagate to the other stacks, but it was necessary to verify this before proceeding with the test series. The donor stack consisted of 108 MK 82 bombs, the acceptor stacks each consisted of 12 MK 82 bombs, and the stacks were separated by a nominal 30 inch aisle space. Bomb nose and tail fuze wells were protected only by plastic shipping covers.

All bombs detonated.

TEST 2 (fig. 2)

This was the first test using buffer material. The donor stack consisted of 108 MK 82 bombs, the buffers were one row of 20 MM TP ammunition and one row of CBU 58s. 12 MK 82s were used in each acceptor stack. Acceptor bombs were boosted and fuze as we felt this represented the most sensitive configuration for the MK 82.

The 12 bombs on the 20 MM side of the donor survived. One bomb on the CBU 58 side functioned low order, the others survived.

TEST 3 (fig.3)

This test was designed to be more representative of MK 82 bombs in storage. MK 82s were in their standard storage configuration (plastic nose and tail fuze well protectors). Two rows of 20 MM TP were used as the buffer on one side and 7 rows of MK 15 fins on the other. The acceptor stacks were 36 MK 82s.

All bombs in the acceptor stack on the MK 15 fin side survived. All bombs on the 20 MM side detonated.

We were unable to understand what caused the failure of the bombs on the side buffered by 20 MM. We had gone from the more sensitive fuze bombs and one row of buffer material to the less sensitive unfuzed bombs and two rows of buffer. We had, however, increased the size of the acceptor from 24 to 36 bombs which increased the number of targets for fragments. We decided to continue the test series using 36 bombs acceptors and see if we could determine the failure mode as the series progressed.

TEST 4 (fig. 4)

In previous tests buffer material was stacked in a standard manner and as a result an air space existed between columns of buffer material. We felt the failure mechanism might be bomb fragments coming through the spaces between columns of buffer material. In this test we staggered the buffer material horizontally to ensure that a fragment had to hit buffer material before it reached the acceptor bombs. Two rows of CBU 58s and 5 rows of MK 15 fins were used as buffers.

The bombs on the fin side survived. The bombs on the CBU 58 side detonated.

We were again faced by the dilemma of how less sensitive bombs with more buffer protection could fail. Perhaps we had erred when we considered fuze bombs more sensitive than unfuzed

bombs. Boosters and fuzes give more protection to the fuze cavities of bombs than the standard plastic shipping cap.

TEST 5 (fig. 5)

In this test we attempted to provide fuze well protection by placing plastic rods 2.75 inches in diameter by 6 inches long in the fuze wells of the bombs and covering these with the standard plastic shipping cap. We also staggered the buffer vertically in order to eliminate the possibility that fragments were transiting through the forklift holes in the pallets. The buffers were two rows of CBU 58 (which which were now staggered both vertically and horizontally) and two rows of MK 15 fins (staggered horizontally only).

All bombs detonated.

The results of our tests to this point were inconclusive. We felt we needed to go back to our successful test and proceed from there. We were convinced that fragment attack was the mechanism causing the acceptors to detonate. We also felt that staggering the buffer material both horizontally and vertically would reduce the number of fragments reaching the acceptors.

TEST 6 (fig. 6)

In addition to fuzing and boosting the acceptor bombs we oriented bombs so that the nose of the acceptors were oriented toward the noses of the donors. We felt this might reduce the effect of the fragment attack by orienting the relatively smaller flat area on the front of the acceptor bombs toward the fragment attack. The acceptor stacks were composed of 24 MK 82s and the buffers were two rows of MAU 93 fins and three rows of 20 MM TP ammunition.

All bombs survived.

We are now convinced that fuze well protection is necessary.

TEST 7 (fig. 7)

In this test we used steel tail plugs in the noses of the acceptor/donor pair and steel nose plugs in the other. We retained the nose to nose orientation of the acceptor to donor. The size of the acceptor stacks was again increased to 36 bombs. Two rows of CBU 58 were used as one buffer and three rows of CBU 58 were used for the other. The buffers were staggered both horizontally and vertically.

All bombs survived.

CONCLUSION

It is possible to prevent propagation between stacks of bombs using fuze well protection, proper bomb orientation, and sufficient buffer material.

MK 84 TEST SERIES

OVERVIEW

This series started in the spring of 1986 and is ongoing at this writing. The goals of this series are to prove that the buffered storage concept works for the MK 84 bomb, determine if nose fuze well protection alone (no buffer material) will prevent propagation, to validate additional buffer materials, and test the effect of donor stacks with a net explosive weight of up to 60,000 pounds.

TEST 1 (fig. 8)

The goal of this test was to determine if steel nose fuse well protection alone would prevent propagation between stacks of bombs. Twenty four MK 84s were used as the donor and two stacks of 12 MK 84s were used as acceptors. Bombs were oriented nose to nose and separated by 15 feet, no buffer material was used. Steel nose plugs were used in both the donor and acceptor bombs.

All acceptor bombs survived. No significant damage was noted. Steel nose plugs were slightly eroded by fragments and jets (fig. 9). High speed photography revealed what looked like an aerodynamic flow of fragments around the pointed noses of the MK 84 bombs.

TEST 2 (fig. 10)

The goal of this test was to see if bombs with only nose and tail fuze well protection would survive if oriented so that the tail of one acceptor was exposed to the nose of the donor and if the nose of the other acceptor was exposed to the tail of the donor. The donor consisted of 24 MK 84s and the acceptors were 12 MK 84s. Bombs were placed 15 feet apart and no buffer material was used.

All bombs detonated.

TEST 3 (fig. 11)

After the failure of test 2 it was necessary to validate the results of test one to see if we should pursue testing with no buffer material. The test and results were the same as test 1.

TEST 4 (fig. 12)

This was an attempt to see what effect buffer material would have on bombs arranged with nose to tail and tail to nose

configurations. Five rows of empty 55 gallon drums were used to simulate bomb component containers. A thirty inch aisle space was maintained between the donor/acceptors and the buffer. This resulted in a distance of 13.5 feet between stacks of bombs.

One bomb in each acceptor stack reacted low order, all other bombs survived. Bomb noses and tails showed more damage than in test 1 and 3. (fig. 13, and 14).

TEST 5 (fig. 15)

Even though there was no stack to stack propagation in test 4, we wanted to prevent low order reactions if possible. In this test we added one row of drums to give us a total of six rows and increased the distance between bombs to 15 feet.

The results were identical to test 4. Based on this we decided to abandon the nose to tail and tail to nose configurations and continue the test series nose to nose orientation at 15 feet separation.

TEST 6 (fig. 16)

The DDESB had requested that we conduct this test in a simulated igloo. The igloo was simulated by a 20 x60 foot rectangular hole in the earth 10 feet deep. Three sides of the hole were lined with concrete slabs to make vertical faces and one 20 foot side was left open with a ramp sloping to ground level (fig. 17). Four rows of MK 20 cluster bombs were used as the buffer material. The MK 20 is packed 2 per metal container and has a net explosive weight of 100 pounds. Sixteen containers were used in each buffer for an explosive weight of 3200 pounds per buffer. Distance between stacks of bombs was 15 feet and the distance between the MK 20s and acceptors was 15 inches.

Acceptor bombs on the closed end of the simulated igloo detonated, MK 20s were completely consumed, and acceptors on the open end of the igloo survived with very little damage (less than that in test 1 and 3)(fig. 18).

We concluded that the detonation of the acceptor bombs at the closed end of the igloo was probably a pressure reaction caused by the relatively unyielding walls of the structure and the proximity of the MK 20s to the acceptor. Based on these results we felt that future tests should be conducted in a more realistically simulated above ground igloo.

TEST 7 (fig. 19)

The goal of this test was twofold. First to see if the donor would survive in an igloo with no buffer and to test 30 MM high explosive (HE) ammunition as a buffer. The test was conducted in a simulated igloo built above ground using concrete slabs. This igloo was 20 feet wide, 80 feet long, and 10 feet high, earth was mounded to the top on three sides, it had no roof, and a concrete slab was used for the door(fig. 20). Two rows of 30 MM HE ammunition were used as the buffer between the

donor and the acceptor at the door end of the igloo. No buffer was used between the donor and the acceptor at the rear end of the igloo, stacks of bombs were separated by 15 feet.

All acceptor bombs survived. Bombs on the closed end were damaged much like those in test 1 and 3. Some ammunition survived intact. Most cartridge cases and propellant were consumed, many projectiles appear to have reacted low order and only split the projectile case consuming most or all of the explosives inside.

From this we concluded that pressure was not a problem with a donor of 24 MK 84 bombs and that 30 MM HE ammunition was an acceptable buffer.

TEST 8 (fig. 21)

This was our first test above the 20,000 pound NEW range. The goal was to determine what effect a 48 bomb MK 84 donor would have on 24 MK 84 acceptors. The bomb fuze wells were protected with steel nose and tail plugs. Stacks of bombs were placed 15 feet apart. The test was conducted in a simulated above ground igloo. The igloo was the same dimensions as the one in test 7 but had a roof of concrete slabs. The steel superstructure used to support the roof was inside the igloo (fig. 22). A concrete slab was used as a door.

All acceptors survive. Several bombs sustained large dents in the side from collision with other bombs or the igloo (fig. 23). Many bombs had severe fragment damage to the nose, much like that seen in tests four and five.

We felt that most of the dents were caused by collisions with other bombs because there were few sharp edges that we would expect to see if the collisions were with the igloo superstructure. Several nose fuze wells had been eroded to the point that the fuze wells were visible (fig. 24).

TEST 9 (fig. 25).

Since the acceptors in test 8 had survived both the pressure and fragments from a 48 MK 84 donor we decided to increase the donor to 64 MK 84 bombs. We were concerned about the severe erosion of the nose plugs seen in test 8, so we decided to use a small quantity of buffer. Two rows of palletized MK 81 fins were used on each side. The test was conducted in a simulated above ground igloo with a roof, and a concrete slab for a door. The igloo had been redesigned so as to place the vertical support members outside of the igloo and decrease the amount of steel supporting the roof. We will call this igloo the Haymen Igloo (fig. 26).

Acceptor bombs on the door end detonated. Seven bombs from the rear stack reacted low order, many of the surviving bombs were dented and had severe nose erosion as seen in test 8.

Since the bombs at the rear of the igloo survived (these should have experienced the most pressure), we felt we could rule out pressure as the mechanism for the failure of the front stack.

We were convinced that the large quantity of fragments from 64 MK 84s simply overcame our buffer.

TEST 10 (fig. 27)

Two variables were changed in this test. The distance between stacks of bombs was increased from 15 feet to 20 feet and slightly more substantial buffers were used. The buffers were 3 rows of MK 81 fins and 3 rows of 20 MM TP ammunition. The donor was 64 MK 84s, and the acceptors 32 MK 84s. The test was conducted in a Haymen igloo.

The acceptors at the rear of the igloo (protected by the fins) detonated. The other acceptors survived in relatively good condition. Only four bombs had large dents in the sides, and one bomb had the base plate knocked off (it appeared to be a mechanical separation caused by impact with another metal object). Only two bombs had fragment damage to the nose.

A clear impression of a bomb base plate on the side of a bomb gave credence to our belief that many dents were caused by bomb to bomb collisions. We felt strongly that the failure was caused by fragment attack rather than pressure because the acceptor at the rear of the igloo had survived a 64 MK 84 attack with less buffer and less distance to the donor.

TEST 11 (fig. 28)

Since three rows of 20 MM TP ammunition had been a sufficient buffer we decided to try another fairly massive buffer. Three rows of CBU 58s were used for both buffers. The bombs were separated by 20 feet, and the test was conducted in a Haymen igloo.

All acceptors survived. Very little fragment damage was observed but several bombs were dented.

TEST 12 (fig. 29)

The success with CBU 58s led us to believe that MK 20s would work. Three rows of MK 20s were used in each buffer, the stacks of bombs were 20 feet apart, and the test was conducted in a Haymen igloo.

One acceptor bomb from the top row of each stack functioned low order, all other bombs survived. Again very little fragment damage was observed and several bombs were dented.

In this test the tops of the donor, buffer, and acceptor stacks were at virtually the same height and we believe the low order reactions were caused by fragments coming through the thin top of the buffer.

OVERALL TEST RESULTS

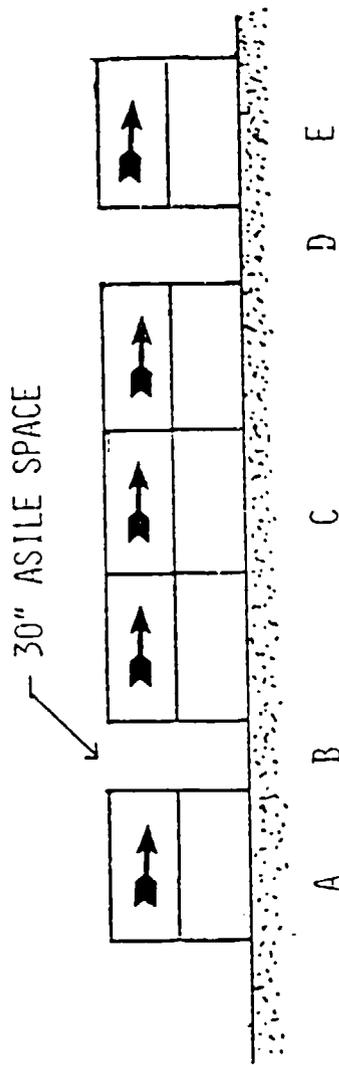
When stacks of bombs were arranged so the noses of the bombs in one stack were oriented toward the noses of bombs in the other stacks and steel nose and tail fuze well protectors were used, propagation between stacks could be prevented. Acceptor bombs survived the attack of pressure and fragments of up to 48 MK 84 bombs (45,360 pounds NEW) at 15 feet separation without using buffer material. Acceptor bombs also survived the attack of pressure and fragments from stacks of 64 MK 84 bombs (60,480 pounds NEW), even when coupled with the detonation of 96 MK 20s used as a buffer (9,600 pounds NEW) when stacks were separated by 20 feet and a proper buffer material was used.

CONCLUSION

Propagation can be prevented between stacks of MK 82 and MK 84 bombs when they are properly oriented, separated, steel nose and tail fuze well protection is provided, and buffer material proven adequate in this test series is used.

TEST NUMBER: 1

CONFIGURATION:



- A. ACCEPTOR: 12 MK 82 with plastic nose and tail plugs
- B. BUFFER: None. 30 inches between bombs
- C. DONOR: 108 MK 82
- D. BUFFER: None. 30 inches between bombs
- E. ACCEPTOR: 12 MK 82 with plastic nose and tail plugs

RESULTS: All bombs detonate.

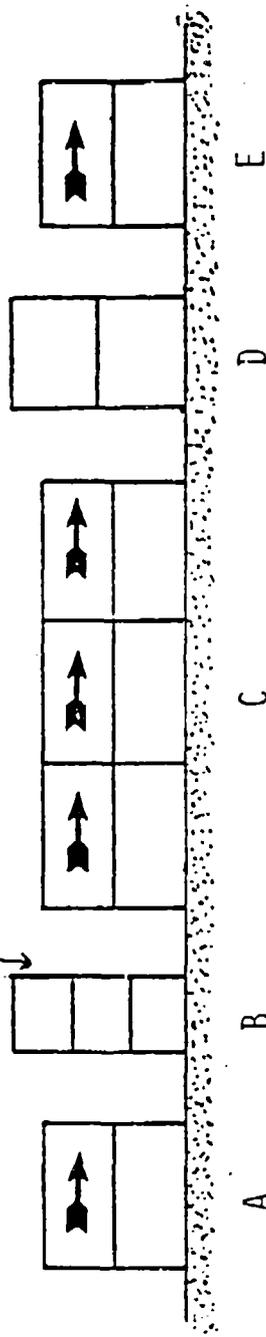
CONCLUSIONS: All bombs in a stack of MK 82s will detonate if one bomb is initiated. Bombs in adjacent stacks will propagate.

FIGURE 1

TEST NUMBER: 2

CONFIGURATION:

30" ASILE SPACE



- A. ACCEPTOR: 12 MK 82 boosted and fuzed with 904 and 905 fuzes
- B. BUFFER: One row of CBU 58
- C. DONOR: 108 MK 82
- D. BUFFER: One row of palletized 20 mm TP ammunition.
- E. ACCEPTOR: 12 MK 82 boosted and fuzed with 904 and 904 fuzes

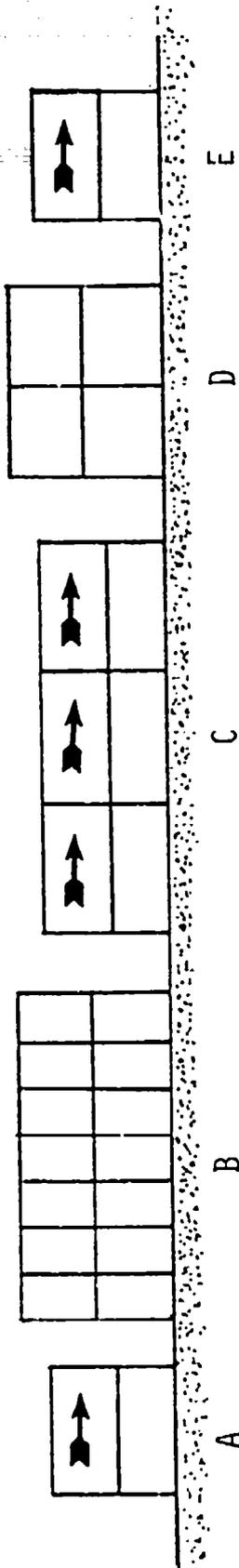
RESULTS: One bomb on CBU side functioned low order, all others survive.

CONCLUSION: Boosted and fuzed bombs do not propagate when properly protected by buffer materials.

FIGURE 2

TEST NUMBER: 3

CONFIGURATION:



- A. ACCEPTOR: 36 MK 82 with plastic nose and tail plugs
- B. BUFFER: 7 rows of MK 15 bomb fins
- C. DONOR: 108 MK 82
- D. BUFFER: 2 rows 20 MM TP
- E. ACCEPTOR: 36 MK 82 with plastic nose and tail plugs

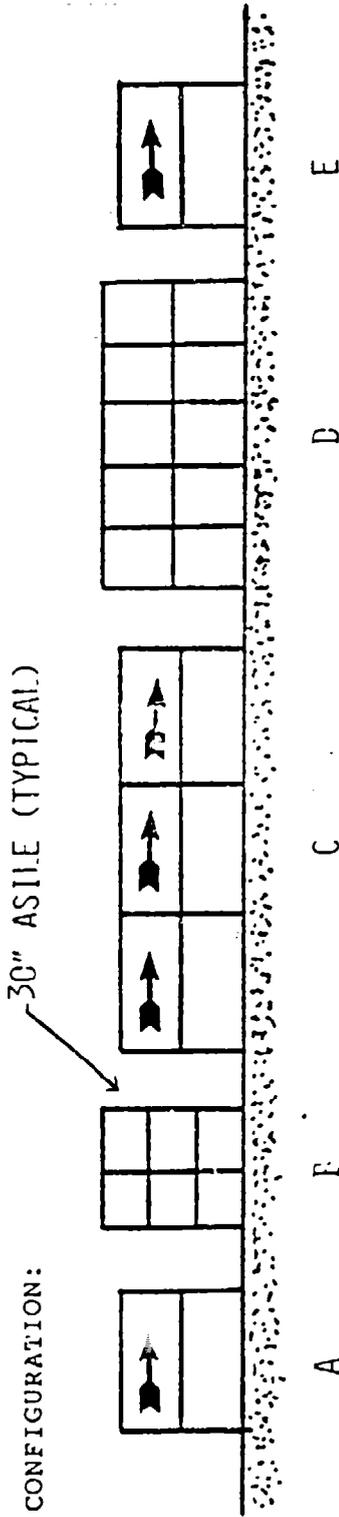
RESULTS: Bombs on fin side survive, bombs on 20 MM side detonate.

CONCLUSIONS: None. Why did less sensitive bombs fail when more of the same buffer was used? Did the change from 24 acceptors to 36 increase the probability of a lethal fragment? Continue testing with 36 acceptors. Stagger the rows of buffer horizontally so no line of sight exists between columns of acceptors.

FIGURE 3

TEST NUMBER: 4

CONFIGURATION:



- A. ACCEPTOR: 36 MK 82 with plastic nose and tail plugs
- B. BUFFER: 2 rows of CBU 58s, staggered
- C. DONOR: 108 MK 82
- D. BUFFER: 5 ROWS MK 15 bomb fins, staggered

RESULTS: Bombs on CBU side detonate, bombs on fin side survive.

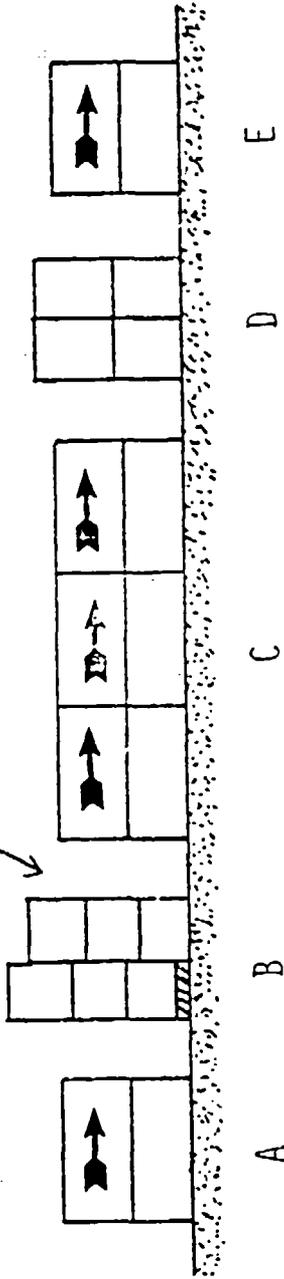
CONCLUSION: MK 15 fins are an acceptable buffer. Since test 2 was successful with the bombs boosted and fuze, perhaps fuze well protection will increase survival.
Try the next test with fuze well protection.

FIGURE 4

TEST NUMBER: 5

CONFIGURATION:

30" ASILE (TYPICAL)



- A. ACCEPTOR: 36 MK 82 with 2.5" diameter 6" long plastic rods in fuze wells.
- B. BUFFER: 2 rows CBU 58, staggered both horizontally and vertically
- C. DONOR: 108 MK 82
- D. BUFFER: 2 rows MK 15 fins, staggered horizontally

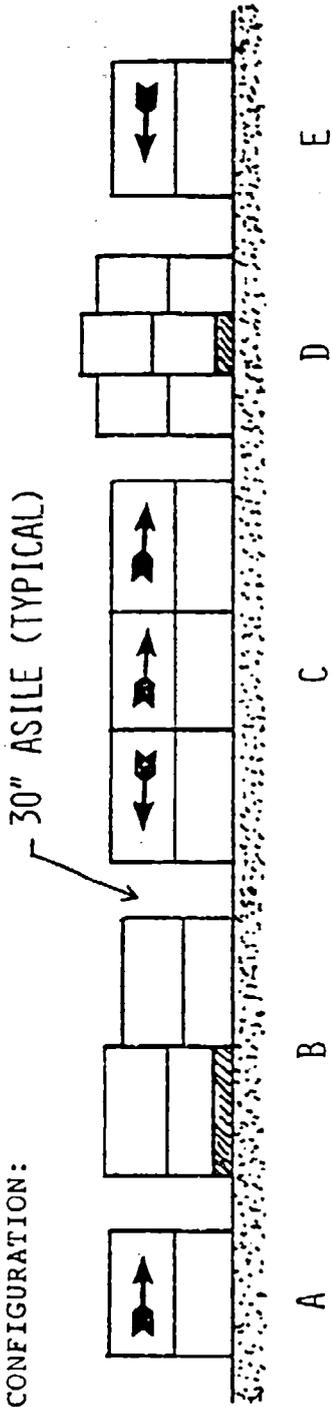
RESULTS: All bombs functioned high order.

CONCLUSIONS: Plastic rods were not sufficient nose fuze protection.

Try fuzes and boosters again. Reduce acceptor stack to 24 bombs. Orient bombs so noses of the acceptors are exposed to noses of the donors.

TEST NUMBER: 6

CONFIGURATION:



- A. ACCEPTOR: 24 MK 82 boosted and fuzed with 904 and 905 fuzes
- B. BUFFER: 2 rows palletized MAU 93 fins, staggered horizontally and vertically
- C. DONOR: 108 MK 82
- D. BUFFER: 3 rows 20 MM ammunition, staggered horizontally and vertically.
- E. ACCEPTOR: 24 MK 82 boosted and fuzed with 904 and 905 fuzes

RESULTS: All bombs survive.

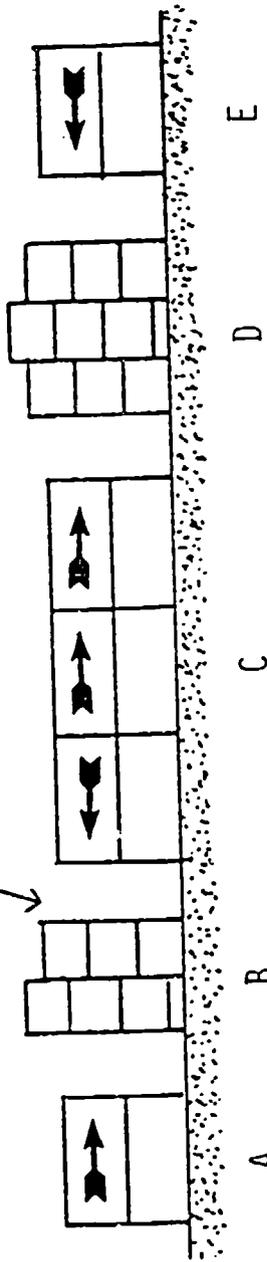
CONCLUSIONS: Fuze well protection works. Buffer stacks must be staggered to prevent a free path for fragments. Nose to nose orientation appears to work.

FIGURE 6

TEST NUMBER: 7

CONFIGURATION:

30" ASILE TYPICAL



A. ACCEPTOR: 36 MK 82 with steel tail plugs in nose fuze wells.

B. BUFFER: 2 rows of CBU 58, staggered

C. DONOR: 108 MK 82, steel tail plugs in noses of bombs facing acceptor with plugs in nose, steel nose plugs in noses of bombs facing acceptor with steel nose plugs.

D. BUFFER: Three rows of CBU 58, staggered

E. ACCEPTOR: 36 MK 82 with steel nose plugs in noses of bombs.

RESULTS: All bombs survive.

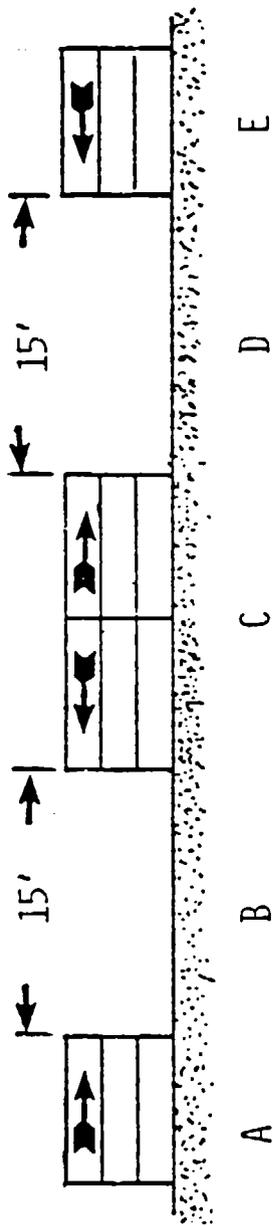
CONCLUSIONS: Propagation between stacks of bombs can be prevented. A combination of fuze well protection, and adequate buffers is necessary.

FIGURE 7

TEST NUMBER: 1

DATE: 1 April 86

CONFIGURATION:



- A. ACCEPTOR: 12 MK 84 with steel nose plugs
- B. BUFFER: 15' AIR
- C. DONOR: 24 MK 84 with steel nose plugs
- D. BUFFER: 15' AIR
- E. ACCEPTOR: 12 MK 84 with steel nose plugs

RESULTS: All acceptors survive. Noses of bombs show erosion from fragments and jets.

CONCLUSIONS: MK 84 bombs can survive attack by 24 MK 84 bombs without buffers at a distance of 15 feet, when oriented nose to nose and steel nose plugs are inserted in the nose fuze wells.
Try nose to tail and tail to nose exposures.

FIGURE 8



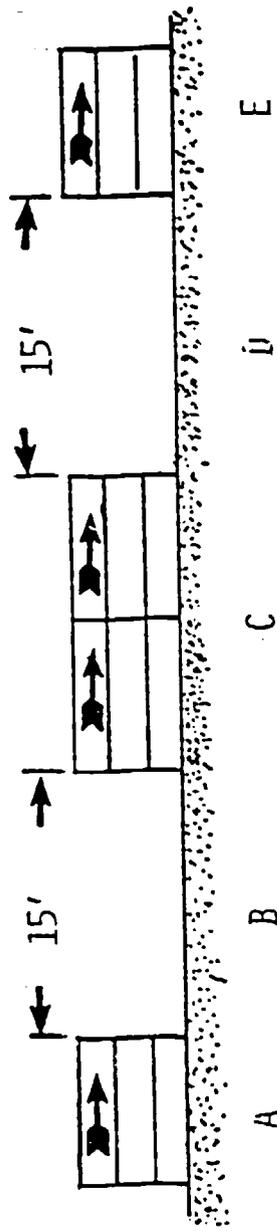
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FIGURE 9

TEST NUMBER: 2

DATE: 4 April 86

CONFIGURATION:



- A. ACCEPTOR: 12 MK 84 with steel nose plugs
- B. BUFFER: 15' Air
- C. DONOR: 24 MK 84 with steel nose and tail plugs
- D. BUFFER: 15' Air
- E. ACCEPTOR: 12 MK 84 with steel tail plugs

RESULTS: All acceptors detonate.

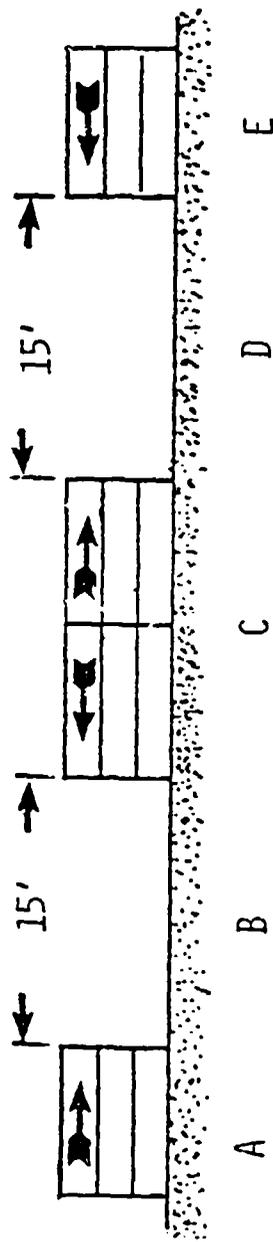
CONCLUSIONS: This is not an acceptable orientation. Were we just lucky with test one?
Reaccomplish test one.

FIGURE 10

TEST NUMBER: 3

DATE: 8 April 86

CONFIGURATION:



- A. ACCEPTOR: 12 MK 84 with steel nose plugs
- B. BUFFER: 15' AIR
- C. DONOR: 24 MK 84 with steel nose plugs
- D. BUFFER: 15' AIR
- E. ACCEPTOR: 12 MK 84 with steel nose plugs

RESULTS: All acceptors survive. Nose plugs show erosion from fragment attack.

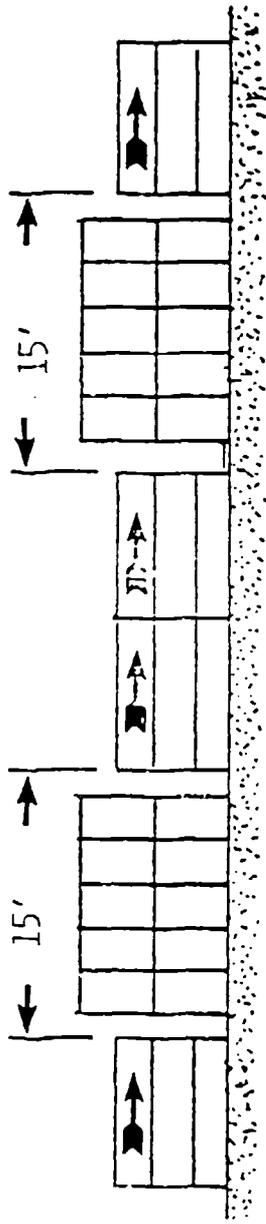
CONCLUSION: Nose to nose orientations are effective. Try orientations used in test two with buffer.

FIGURE 11

TEST NUMBER: 4

DATE: 10 April 86

CONFIGURATION:



A B C D E

- A. ACCEPTOR: 12 MK 84 with steel nose plugs
- B. BUFFER: 5 rows of 55 gallon drums.
- C. DONOR: 24 MK 84 with steel nose and tail plugs
- D. BUFFER: 5 rows of 55 gallon drums.
- E. ACCEPTOR: 12 MK 84 with steel tail plugs

RESULTS: One low order explosion in each acceptor stack. Many acceptor bombs show severe fragment damage.

CONCLUSION: This configuration could be successful with more buffer material. Try again with more buffer.

FIGURE 12



1259

FIGURE 13



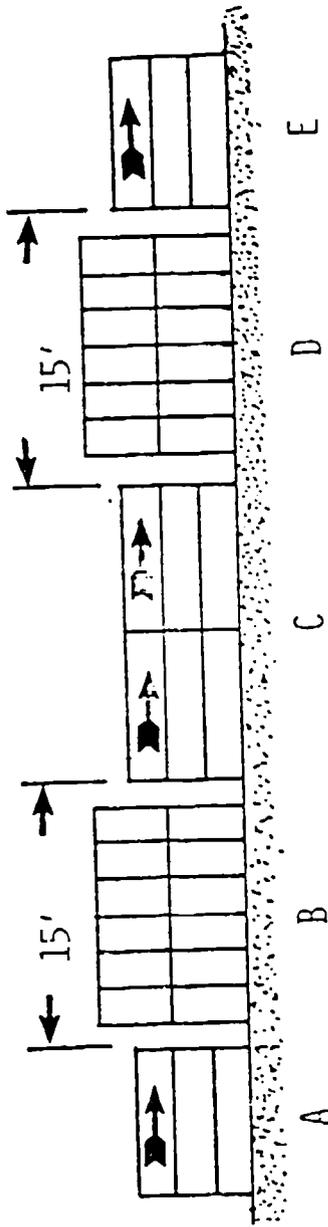
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FIGURE 14

TEST NUMBER: 5

DATE: 15 April 86

CONFIGURATION:



- A. ACCEPTOR: 12 MK 84 with steel nose plugs
- B. BUFFER: 6 rows of 55 gallon drums
- C. DONOR: 24 MK 84 with steel nose and tail plugs
- D. BUFFER: 6 rows of 55 gallon drums
- E. ACCEPTOR: 12 MK 84 with steel tail plugs

RESULTS: One low order in each acceptor stack. Severe fragment damage to many survivors.

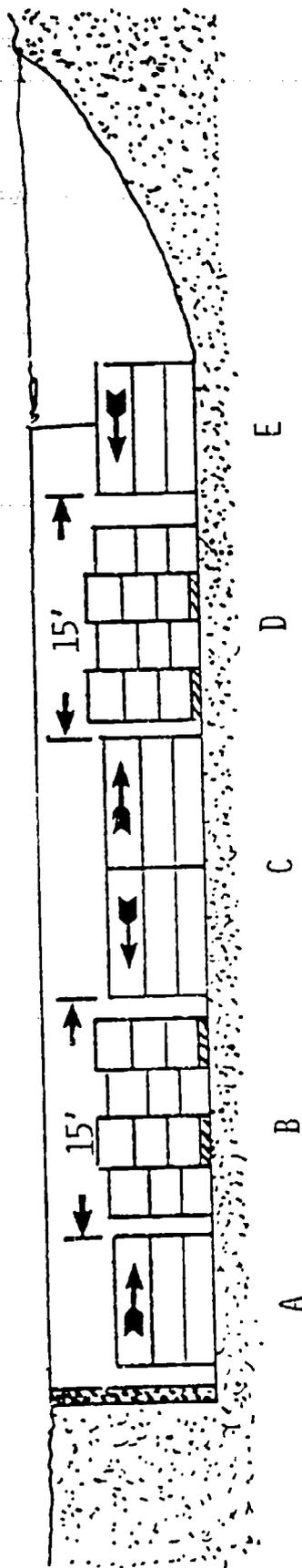
CONCLUSIONS: Since bombs oriented nose to nose survive with very little damage and no low orders abandon this configuration and continue the tests with nose to nose orientation and 15' separation.

FIGURE 15

TEST NUMBER: 6

DATE: 21 April 86

CONFIGURATION:



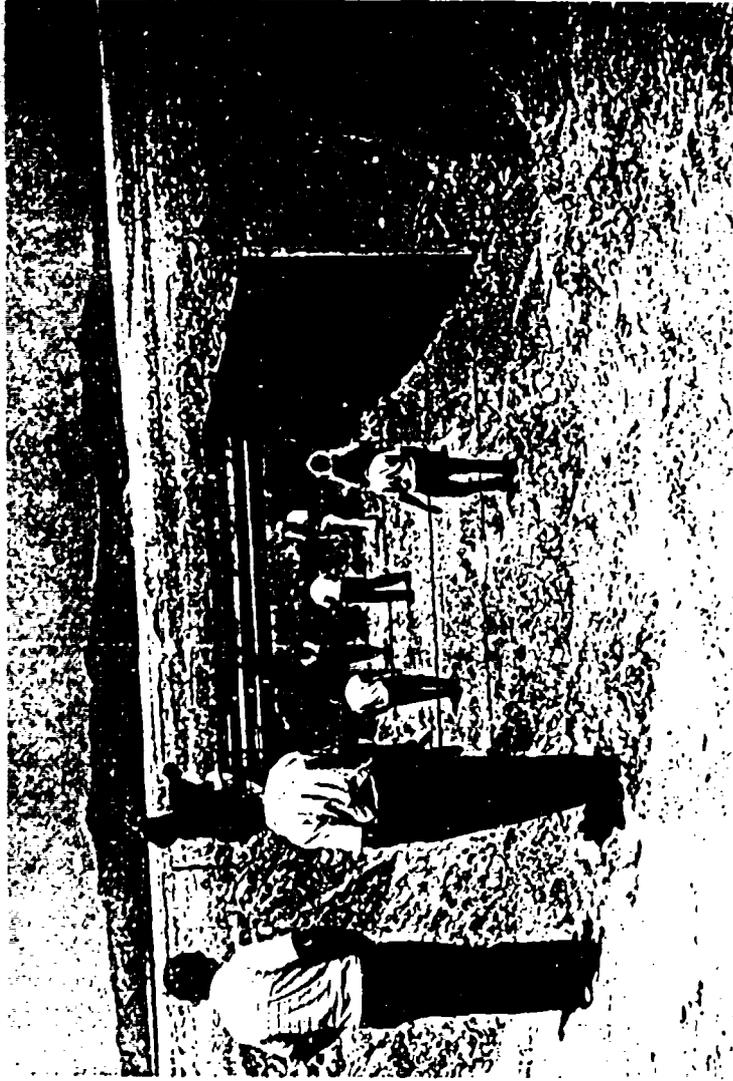
- A. ACCEPTOR: 12 MK 84 with steel nose and tail plugs
- B. BUFFER: 4 rows MK 20, a total of 16 containers with 2 MK 20 per container. NEW of one MK 20 is 100 pounds.
- C. DONOR: 24 MK 84 with steel nose and tail plugs
- D. BUFFER: 4 rows MK 20
- E. ACCEPTOR: 12 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in a simulated igloo. This igloo was constructed by digging a pit in the ground 10 feet deep, 20 feet wide and 60 feet long. The two long sides and one end was lined with concrete slabs to provide vertical walls. The remaining end was open with a ramp sloping to ground level.

RESULTS: Acceptors at closed end detonated. Acceptors at open end survived in very good condition. MK 20s appear to have mass detonated, there were a few intact metal components of the M118 bomblets but no unreacted explosives.

CONCLUSION: Acceptor bombs at closed end reacted due to pressures created by the combined MK 84 donor and the MK 20 acceptor. This pressure was not allowed to relieve due to the construction of the igloo. The lack of fragment damage to surviving bombs tends to rule out fragment attack as a mechanism. Try next test in a simulated igloo built above ground.

FIGURE 16



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FIGURE 17



1264

FIGURE 17





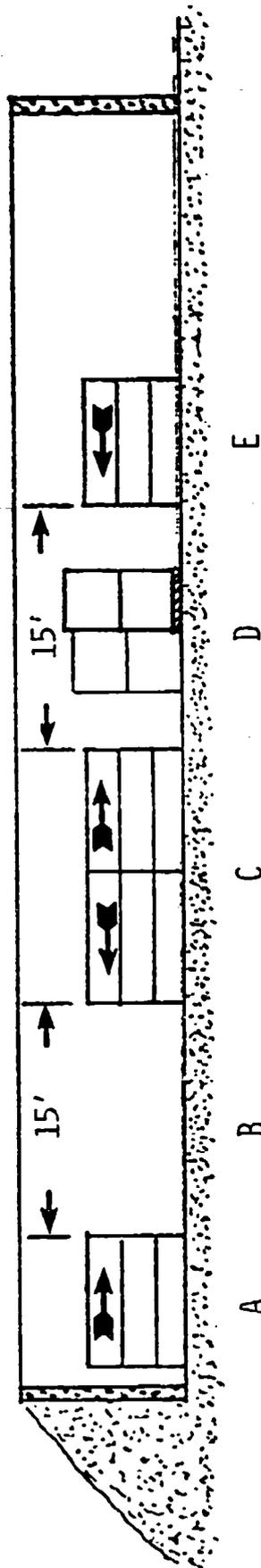
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FIGURE 18

TEST NUMBER: 7

DATE: 7 May 86

CONFIGURATION:



- A. ACCEPTOR: 12 MK 84 with steel nose and tail plugs
- B. BUFFER: 15' Air
- C. DONOR: 24 MK 84 with steel nose and tail plugs
- D. BUFFER: Two rows 30 mm HE
- E. ACCEPTOR: 12 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in simulated igloo built above ground using concrete slabs. Size 10 feet high, 20 feet wide, and 80 feet long. Earth is mounded against three sides and a concrete slab is used for the door. The structure has no roof.

RESULTS: All acceptor bombs survive. Bombs which were protected by 30 mm buffer suffer very little damage. Bombs on closed end are damaged much like those in tests 1 and 3. Some 30 mm rounds survived intact. Most cartridge cases and propellant were consumed. Many projectiles appear to have reacted low order and only split the projectile case and consumed most or all of the explosives inside.

CONCLUSIONS: Pressure is not a problem with 24 MK 84 bombs. 30 mm HEI is an effective buffer. Continue to test in above ground igloo and start increasing donor toward a goal of 64 MK 84.

FIGURE 19



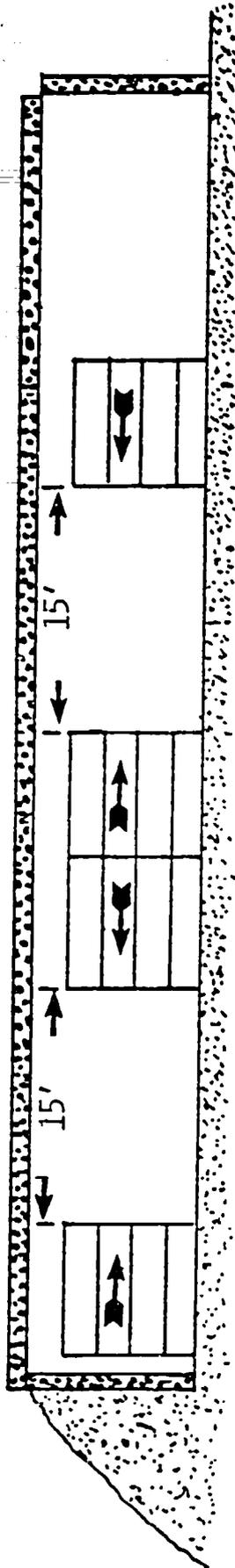
1267

FIGURE 20

TEST NUMBER: 8

DATE: 21 May 86

CONFIGURATION:



- A ACCEPTOR: 24 MK 84 with steel nose and tail plugs
B BUFFER: 15' Air
C DONOR: 48 MK 84 with steel nose and tail plugs
D BUFFER: 15' Air
E ACCEPTOR: 24 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in simulated igloo. Construction similar to that in test 7, however, this igloo has a steel structure inside to support roof.

RESULTS. All acceptors survive, numerous large dents in sides of bombs which appear to be caused by interaction of bombs with the steel structure in the igloo or with other bombs. Many bombs have severe fragment damage similar to that seen in tests 4 and 5.

CONCLUSIONS: Most of the large dents were caused by bombs colliding with other bombs, very few sharp edged dents that one would expect from collisions with the steel structure. The severe fragment damage leads us to believe that we are near propagation caused by high energy fragments and must now use buffer. Pressure created by the donor bombs is not yet a problem. Continue tests in above ground igloo with roof, increase donor to 64 bombs, and use buffer material.

FIGURE 21



1269

FIGURE 22



1270

FIGURE 23



FIGURE 24



1272

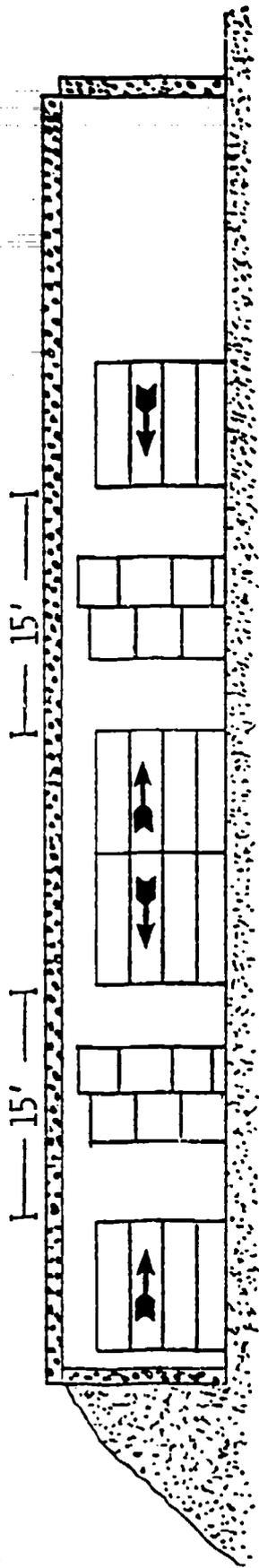
FIGURE 24



TEST NUMBER: 9

DATE: 11 June 86

CONFIGURATION:



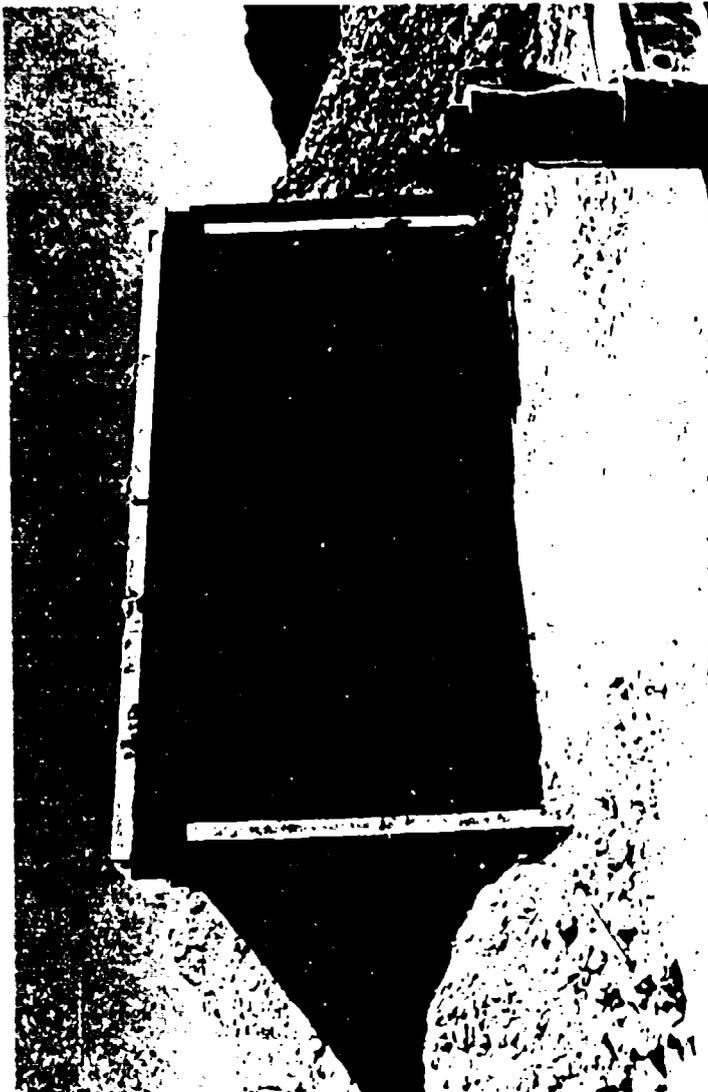
- A. ACCEPTOR: 32 MK 84 with steel nose and tail plugs
- B. BUFFER: 2 rows palletized MK 81 fins
- C. DONOR: 64 MK 84 with steel nose and tail plugs
- D. BUFFER: 2 rows palletized MK 81 fins
- E. ACCEPTOR: 32 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in a simulated igloo of the same dimensions as that in test 8. This igloo has the vertical metal superstructure used to support the roof beams outside the igloo. We will now call this igloo a Haymen igloo.

RESULTS: Acceptor bombs on the door end detonate. 7 bombs on the closed end sustain low order detonations (5 of which are on top row), 7 bombs have large dents in sides, still have fragment damage.

CONCLUSION: The large quantity of fragments generated by 64 MK 84 bombs overcame the buffer. Pressure was not a factor or we would have expected the donor at the closed end to mass detonate. Repeat the test using more substantial buffer.

FIGURE 25



1274

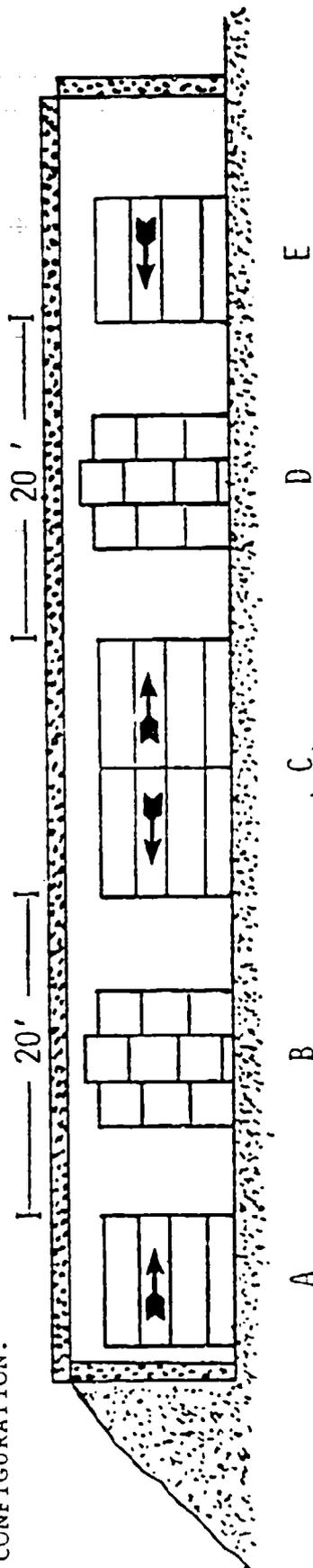
FIGURE 26



TEST NUMBER: 10

DATE: 27 June 86

CONFIGURATION:



- A. ACCEPTOR: 32 MK 84 with steel nose and tail plugs
- B. BUFFER: 3 rows palletized MK 81 fins
- C. DONOR: 64 MK 84 with steel nose and tail plugs
- D. BUFFER: 3 rows palletized 20 mm TP
- E. ACCEPTOR: 32 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in a Haymen igloo.

RESULTS: Acceptors at closed end of igloo detonated. Acceptors at door end were in relatively good condition, 4 had dents in the side, 2 had fragment damage on noses, one had a fragment hole in the side, and one had the base plate knocked off by impact with another bomb or with the steel roof beams. Evidence of bomb to bomb interaction was indicated by the clear impression of a base plate on the side of one of the surviving bombs. A considerable amount of the 20 mm ammunition was unreacted. A few cans, with contents, survived virtually intact and were crushed by the pressure.

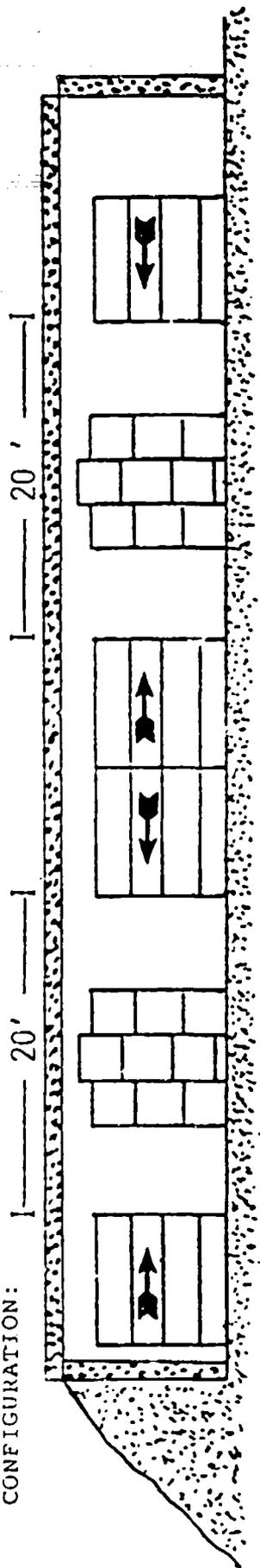
CONCLUSIONS: Three rows of palletized bomb fins are not a substantial enough buffer to prevent propagation. The mass provided by the 20 mm buffer was substantial enough to prevent propagation. Continue tests in igloo, use a more substantial buffer.

FIGURE 27

TEST NUMBER: 11

DATE: 17 JULY 86

CONFIGURATION:



- A. ACCEPTOR: 32 MK 84 with steel nose and tail plugs
B. BUFFER: 3 rows CBU 58s packed in metal shipping containers, two CBUs per container, NEW of each CBU 85 pounds. 24 total containers for a NEW of 4,080 pounds per buffer.
C. DONOR: 64 MK 84 with steel nose and tail plugs
D. BUFFER: 3 rows CBU 58
E. ACCEPTOR: 32 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in Haymen igloo.

RESULTS: All acceptors survive. Very little fragment damage occurred but several bombs sustained dents in the sides.

CONCLUSIONS: Substantial buffers will prevent propagation and also prevent fragment damage to bombs.
Since the 1.2 CBU 58 worked try the 1.1 MK 20

FIGURE 28

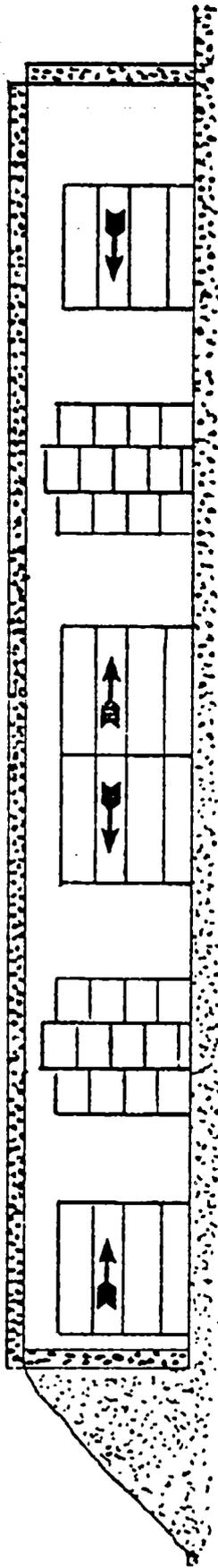
TEST NUMBER 12

DATE: 7 August 86

← 20' →

← 20' →

CONFIGURATION:



A

B

C

D

E

- A. ACCEPTOR: 32 MK 84 with steel nose and tail plugs
- B. BUFFER: 3 rows MK 20
- C. DONOR: 64 MK 84 with steel nose and tail plugs
- D. BUFFER: 3 rows MK 20
- E. ACCEPTOR: 32 MK 84 with steel nose and tail plugs

SPECIAL CONDITIONS: Conducted in Haymen igloo.

RESULTS: One bomb from the top row of each acceptor detonated low order. All other bombs survive with very little fragment damage. Several acceptors have dents in sides.

CONCLUSIONS: Three rows of MK 20s are an effective buffer. In this test the tops of the donor, buffer, and acceptor stacks were at virtually the same height. Only one row of buffer material(the one staggered vertically) was at the same height as the acceptors. We feel the low order was caused by a fragment that passed through the one stack of buffer material.

FIGURE 29