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H1626 Insert Kit Design and Fabrication for the H1501B Transportation Accident Resistant Container (TARC)

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H1626 INSERT KIT DESIGN AND FABRICATION FOR THE H1501B TRANSPORTATION ACCIDENT RESISTANT CONTAINER (TARC)

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ABSTRACT

An Insert Kit, made primarily of rigid polyurethane foam, was designed for use with the H1501B Container. The Insert Kit was designed to retain a B61 Center Bomb Subassembly (CBS), inside the H1501B. Concurrent engineering was utilized to design and manufacture the H1626 on a very tight schedule.

* M. P. Spencer is an Allied-Signal employee on contract to Sandia National Laboratories

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H1626 INSERT KIT DESIGN AND FABRICATION FOR THE H1501B TRANSPORTATION ACCIDENT RESISTANT CONTAINER (TARC)

Introduction

This report documents the design of H1626 Insert Kit (part no. 214244) for use with the H1501B (TARC) and B61 Programs. Design parameters, constraints and the design evolution will be described. Particular emphasis on how concurrent engineering played a key role in the design and manufacture will be highlighted.

The H1501B (TARC) is third in a family of containers starting with the H1501 and including the H1501A. TARC stands for Transportation Accident Resistant Container. The TARC's consist of an aluminum inner container surrounded with redwood. The redwood is encased in an outer shell of stainless steel. An aluminum bolster is attached to the outer shell for handling purposes (Fig. 1). The purpose of TARC's is to mitigate and insulate nuclear weapons or nuclear explosives from the impact and fire of an air transportation accident, thus reducing the probability of plutonium dispersal.

In order to fit a B61 inside a H1501B, the B61 nose and tail sections must be removed. A lifting adapter and strongback were designed to lift the B61 Center Bomb Subassembly (CBS) from the bomb dolly and insert it in the H1501B (Fig. 5). The H1626 Insert Kit provides the interface between the B61 CBS and the H1501B (Fig. 3). Once the B61 CBS had been removed from the bomb dolly, a Dummy Center Bomb Subassembly (DCBS) is placed on the bomb dolly. The B61 nose and tail sections are then reassembled to the DCBS for shipment.

The H1626 Insert Kit consists of a polyurethane foam Forward Support, two foam Mid Supports, a foam Aft Support Assembly, an aluminum Lifting Adapter, a Dummy Center Bomb Subassembly and fourteen Flat Head Machine Screws (Fig. 2).

Design Task

The goal of the project was to design an Insert Kit to support the B61 Center Bomb Subassembly (CBS) in the H1501B (TARC) in a uniform and predictable method during an accident. This goal had to be accomplished quickly to fulfill an accelerated delivery schedule.

Design Constraints Identified

We identified the design constraints as follows:

- Due to the limited time available, and the desire to minimize cost and complexity, the design had to be easy to procure or manufacture. The design was started in March, 1992 with first delivery scheduled for August, 1992.
- The Insert Kit had to be able to support a B61 CBS inside a H1501B and provide protection to the CBS against severe crash environments. Sharp transitions in density that could puncture the bomb on impact were not permissible.
- A method of shipping the remaining B61 nose and Rear Subassembly had to be addressed.
- An easy method for installing the B61 CBS into H1501B/H1626 Insert Kit had to be devised.

Design Concept

Material Selection

Preliminary analysis showed that an Insert which supported the B61 at the two ends would result in case failure due to bending at high velocity lateral impacts. It was decided that a full area contact support of rigid polyurethane foam (28 pounds per cubic foot) would be used. A lighter density foam would yield at low velocities and not efficiently utilize the mitigation capability of the H1501B and also might allow sufficient case flexing to again result in failure. A heavier density foam would not begin to crush until acceleration levels are reached that exceed the capabilities of the H1501B. Also, the B61, a lay-down bomb, can survive relatively high lateral accelerations so that a foam is not required to mitigate loads to low levels. Since the foam behavior is nearly elastic-perfectly plastic, the foam will not yield at low impact velocities. It was decided to design the foam insert to begin yielding at an impact velocity of the H1501B of 225 feet per second (fps) onto a hard concrete target with H1501B bolster side up. Since the mitigation capability of the TARC is small above velocities of 225 fps, the foam then provides an additional mitigation mechanism for the B61 and thus increases the overall system effectiveness.

Using full area contact foam design also eliminated sharp transitions which could puncture the B61 Case.

Foam Parts Description

The Insert Kit contains the following (Fig 2):

1. Four foam parts (a Forward Support, two Mid Supports and an Aft Support Assembly).
2. One aluminum part (a Lifting Adapter).

The decision to make the foam inserts out of four parts was based on information from Allied Signal about their foam equipment's pouring capacity and the size capacity of the press used to strip parts from the mold. This manufacturing information was incorporated concurrently into the design. The outer dimensions of these parts were designed similar to the W70 Insert Kit foam parts used with the H1501A TARC. The diameter of the H1501B is the same as the H1501A but the H1501B is 12 inches longer. This enabled the manufacturer (Allied-Signal) to utilize the barrels (outer portion of the molds) from the W70 Insert Kit development order, thus saving time and money.

The foam parts were molded to finished size and shape. This had several advantages over a machined foam part. The molded skin is tougher and more resistant to handling damage, has a smoother surface, and is easier to install in the H1501B. Also, it eliminates foam dust found on machined parts. The foam dust can be an eye hazard when installing the foam parts in the confined space of a H1501B. The dust can be blown into the eyes by air escaping from around the foam parts as they are inserted into the H1501B.

The Insert Kit was designed with a .080" nominal gap between it and the H1501B inner container. This is the same fit as the W70 Insert Kit in the H1501A. A smaller gap of .055" between the B61 CBS and the Insert Kit was selected, because the B61 CBS diameter tolerance is much tighter than the H1501B inner diameter. This gap is large enough to allow trapped air to escape when inserting the B61 CBS and allows for slight swelling of the foam in high humidity conditions.

The Forward Support (part no. 249458) was designed to mitigate shock in the longitudinal, lateral and vertical axes. The Forward Support was designed to engage the 6.500" spherical radius on the nose of B61 CBS (See Figures 3 & 4). A clearance hole is provided for the forward connector. This provides maximum surface contact for longitudinal impact mitigation. The FWD Support weighs approximately 55 lb. Hand holes are molded in place for easy installation and removal by two persons.

The Mid Supports (part no. 249457) were designed to support the CBS in the vertical and lateral axes. The Mid Supports weigh 38 lb. each and have molded in hand holes for easy handling.

The Aft Support Assembly (part no. 249456), the last part of the Insert Kit, is installed after inserting the B61 CBS (Fig. 4). It consists of a compression pad made of neoprene rubber sponge bonded to a molded rigid polyurethane foam part. The compression pad compensates for the tolerance stack up in the

longitudinal axis between the Fwd Support, B61 CBS/Lifting Adapter Assembly, and Aft Support Assembly. The Aft Support Assembly is designed so that it will always contact the B61 CBS/Lifting Adapter Assembly prior to contacting the mid supports. The Aft Support Assembly mitigates impacts in all three axes. It weighs 35 lb. and also has hand holes for easy installation and removal. The Aft Support Assembly also provides anti-rotation features. It has slots molded on the O. D. to engage pins on the H1501B inner door and two holes to engage pins on the B61 CBS/Lifting Adapter Assembly. Alignment marks are molded in the Aft Support to facilitate assembly.

Loading Method

Previous Insert Kits for the H1501 and H1501A had built in rollers and separate loading trays. The weapon was installed in the Insert Kit and placed on a loading tray. The Insert Kit/weapon was rolled into the TARC.

Due to the weight and length of the B61 another loading method was selected. A strongback design, H1627, was selected for installing both the B57 and B61 CBS's into TARC's (Fig. 5). The strongback concept is more compact and versatile than the loading tray. The strongback has the added capability of being able to lift the H1501B inner and outer doors.

A lifting adapter was designed to interface between the strongback and the weapon. It attaches to the B61 CBS with ten screws and is attached to the strongback with three 5/8" bolts. The lifting adapter is made of aluminum 6061-T6 plate and weighs approximately 17 lbs. The Lifting Adapter (part no. 249460) and fourteen screws (part no. 249459), of which four are spares, are part of the Insert Kit, the H1627 is not.

Shipping Method For Remaining Parts

Once the B61 Nose and Rear Subassembly have been removed, the B61 CBS can be removed from the bomb dolly using the H1627 Strongback and H1626 Lifting Adapter. The B61 CBS can now be installed in the H1501B.

Once the B61 CBS has been installed in the H1501B the remaining components can be dealt with. A Dummy Center Bomb Subassembly (DCBS) was designed to be mated to the B61 Nose and Rear Subassembly. The DCBS is fabricated from retired B61 CBS's. After the B61 DCBS has been installed on the bomb dolly the Nose and Rear Subassembly can be re-assembled to the DCBS (Fig. 6). The DCBS enables the military to use existing procedures and equipment to safely ship the B61 Nose and Rear Subassembly.

Design Evolution

Design of the Insert Kit evolved concurrently with the manufacture of the kit. Tooling was started based on preliminary sketches. Design changes were incorporated as the tooling was being fabricated.

The original design had the centerline of each of the Insert Kit parts perfectly aligned when installed in the H1501B. However, gravity would cause the centerline of the 450 lb. B61 CBS to be misaligned with the centerline of the 6.500" spherical radius on the FWD Support. The misalignment was due to a .055" nominal gap between the foam support I. D. and the CBS O. D..

In order to overcome the misalignment, the O. D. of the Mid Support was increased by .060" and the Fwd Support was reduced by .050". These changes were incorporated in the tooling prior to production of product.

Once production had commenced, inspection data was evaluated. From this evaluation, design changes were incorporated concurrently with the production (see Appendix A, Tolerance Study). Most changes were to non-critical dimensions and will not be addressed in the report.

Changes to critical dimension were evaluated and accepted. They are as follows:

- Changes that affected circumferential clearances (ref. ACO 921909KC rev. 5) were made to the Fwd Support and Mid Support resulting in a .020" nominal misalignment between the B61 CBS and the Fwd Support centerline. Although this was not a desirable condition it was considerably better than the original design misalignment of .055".
- Changes on the Fwd Support and Aft Support that affected the longitudinal stack-up had the net effect of .005" more compression on the AFT Compression Pad when evaluated together.

Qualification

Drop and vibration tests were being conducted concurrently with H1501B. The results are included in H1501B report.

Lessons Learned

The Lifting Adapter could of been more user friendly if handling features had been designed into the Lifting Adapter. Currently two 5/8" bolts are installed to use as handles. After the Lifting Adapter has been attached to the CBS or DCBS the bolts must be removed. Also the Lifting Adapter/CBS attachment points should be located such that they can be reached from the side or above.

Figure 1. H1501B Transportation Accident Resistant Container

H1626 INSERT KIT
214244-00

FIGURE 2

FIGURE 3

B61/H1501B INSERT KIT

FIGURE 4

H1627
STRONGBACK

FIGURE 5

Figure 6

Appendix A

Date: September 11, 1992

To: John Liebenberg, 5365

From: Mack Spencer, 5365

Subject: TOLERANCE STUDY H1626

The purpose of this study is to determine the amount of compression on the Aft Pad along the x-axis and the gaps in the z-axis between the H1626 foam inserts and B61 Center Bomb Subassembly (CBS) and H1501B Inner Container.

The tolerance stack-up along the x-axis will be evaluated first. The amount of compression on the Aft Pad is controlled by the thickness of the Forward Support, dimension A, the length of the CBS, dimension B, thickness of the Lifting Adapter, dimension C, and the thickness of the Aft Support Assembly, dimension D. (see fig. 1)

Since the Forward Support and Aft Support are molded parts, produced in a controlled process, there will be very little dimensional variation from part to part. Therefore, inspection data will be used to determine dimensions A & D. Dimension A is found by subtracting 9.36 and 6.244 basic dim.'s and 6.500 spherical radius from 27.00 spherical radius. (ref. dwg. ay249458 issue A) Dimension D is found by subtracting 14.02 basic dim. and 8.69 dim. from 27.00 spherical radius. (ref. dwg ay249455 issue A) The inspection data for each part will be averaged and the maximum variation determined. (see table 1)

Fig. 1
X-Axis Clearances

When determining the clearances in z-axis, the same approach that was used above on molded foam dimensions will be used here too. Table 2 below contains the average diameters for the molded foam parts. From the data in table 2 the average wall thickness can be calculated and used to determine the z-axis clearances between the foam insert parts and the B61-CBS and the foam insert parts and the H1501B inner container.

Table 2
Inspection Results of Insert Parts

Part Name	Control No.	O.D. Dim.	I.D. Dim.
Fwd. Support	108	19.758+.015/-.013	13.391+.006/-.005
Fwd. Support	X1	19.752+.011/-.012	13.390+.007/-.011
Fwd. Support	104	19.748+.014/-.015	13.388+.007/-.009
Average Diameter & Range		19.753+.020/-.020	13.390+.007/-.011
Mid Support	101	19.878+.015/-.008	13.399+.010/-.006
Mid Support	102	19.878+.017/-.008	13.404+.011/-.012
Mid Support	103	19.877+.015/-.007	13.400+.010/-.005
Mid Support	104-1	19.880+.015/-.009	13.402+.010/-.006
Average Diameter & Range		19.878+.017/-.008	13.401+.014/-.008
Aft Support	105	19.767+.004/-.006	13.390+.006/-.005
Aft Support	103	19.767+.007/-.003	13.391+.007/-.004
Aft Support	104	19.768+.008/-.005	13.391+.003/-.003
Aft Support	101	19.770+.003/0.07	13.396+.007/-.003
Average Diameter & Range		19.768+.008/-.007	13.392+.011/-.007

The clearances in the z-axis were determined in a gravity environment with zero gaps at the bottom. (see fig. 2)

Fig. 2
Z-Axis Clearances

B61 CBS diameter=13.300+/-0.0025
H1501B Inner Liner ID= 20.000+/-0.030

$E = (19.878 - 13.401) / 2 - (19.753 - 13.390) / 2 = .057 + .037 / -.028$
 $F = (19.878 - 13.401) / 2 - (19.768 - 13.392) / 2 = .051 + .025 / -.015$
 $G = 13.390 - 13.300 - .057 = .033 + .0245 / -.0285$
 $H = 13.401 - 13.300 = .101 + .0165 / -.0105$
 $I = 13.392 - 13.300 - .051 = .041 + .0285 / -.0345$
 $J = 20.000 - 19.753 = .247 + .050 / -.050$
 $K = 20.000 - 19.878 = .122 + .038 / -.047$
 $L = 20.000 - 19.768 = .238 + .041 / -.037$

In summary , most of the variation in clearances in both the x-axis and y-axis are attributable to the machined parts, Lifting Adapter, B61 CBS, and H1501B Inner Liner. In the z-axis, the H1501B Inner Liner accounts for over 50% of the tolerance stack-up. In the z-axis, it accounts for over 60% of the tolerance in dimensions J, K, L. If more data was available , a more valid statistical analysis could be performed.

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