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Quality Improvement Program for the B83 Bomb Hand Truck

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Quality Improvement Program for the B83 Bomb Hand Truck

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Abstract

This report describes the problems, issues, and history of the H1347 bomb hand truck for the B83 bomb after the bomb was put into stockpile in the mid-1980s. Major issues that were reported in Unsatisfactory Reports (URs) were cracking problems on stacking fixture welds, cracked welds on the caster bracket receptacles on the cradle, cracked caster mounting brackets, casters unlocking from the swivel lock position, and caster tires rubbing and binding on the stacking frame. Resolution of these and other problems is described.

The introduction of the H695B storage-only bomb hand truck to alleviate a shortage of bomb hand trucks in the mid-1990s is described. The development and qualification of the H1347A bomb hand truck as a replacement for the H695B is covered. The results from load test evaluations on the stacking fixture, cradle, and casters for the H1347 are described along with towing results on one and two-high stack configurations of B83 bombs in bomb hand trucks. New towing and truck/trailer transport procedures are described. Development, evaluation, and production recommendations for a stronger caster mounting bracket are described.

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Acknowledgments

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Quality Improvement Program for the B83 Bomb Hand Truck

Introduction

The B83 Modern Strategic Bomb with full fuzing option and lay-down capability went into production in 1983 for use by the Air Force. This bomb is 18 inches in diameter and weighs 2465 pounds. The original bomb hand truck used for storage and transportation of the B83 was the H1347 (Figure 1). The loaded bomb hand trucks can be in one-high or two-high stacks (Figure 2).

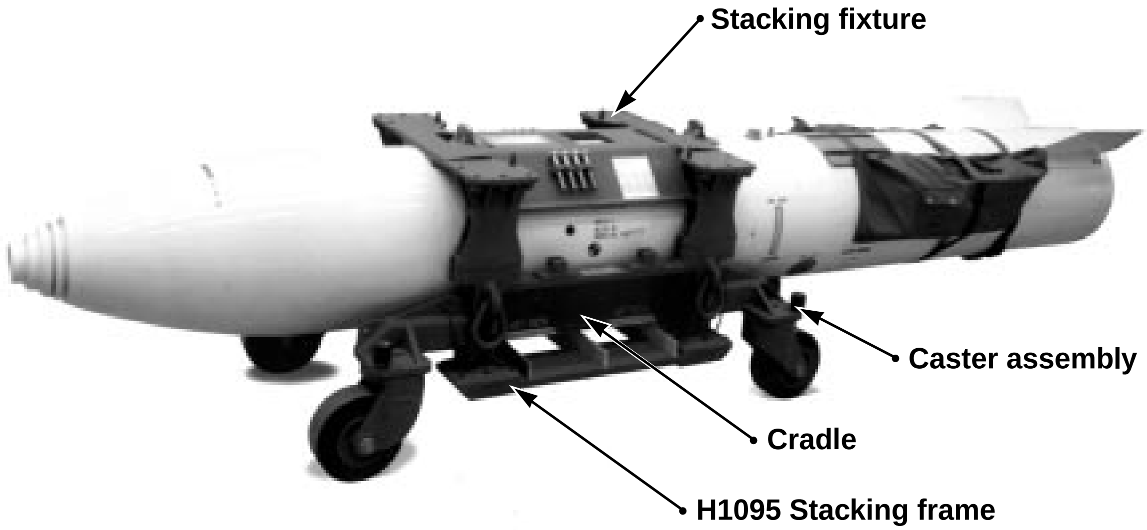

Figure 1. B83 bomb in H1347 bomb hand truck.

The H1347 was reprocessed from the H695A, the bomb hand truck previously used for the now retired B43 bomb (which had the same diameter but weighed 2100 pounds). The manufacturing history of the H695A bomb hand truck dates back to the early 1960s when more than 1,000 were built. Approximately 580 of these were converted to H1347s in the mid-1980s by fabricating a new stacking fixture. The cradle assemblies, H1095 stacking frames, and other parts were reused from the H695A program. Approximately 685 new caster assemblies were fabricated for the H1347, but the majority of caster assemblies were reused from the H695A.

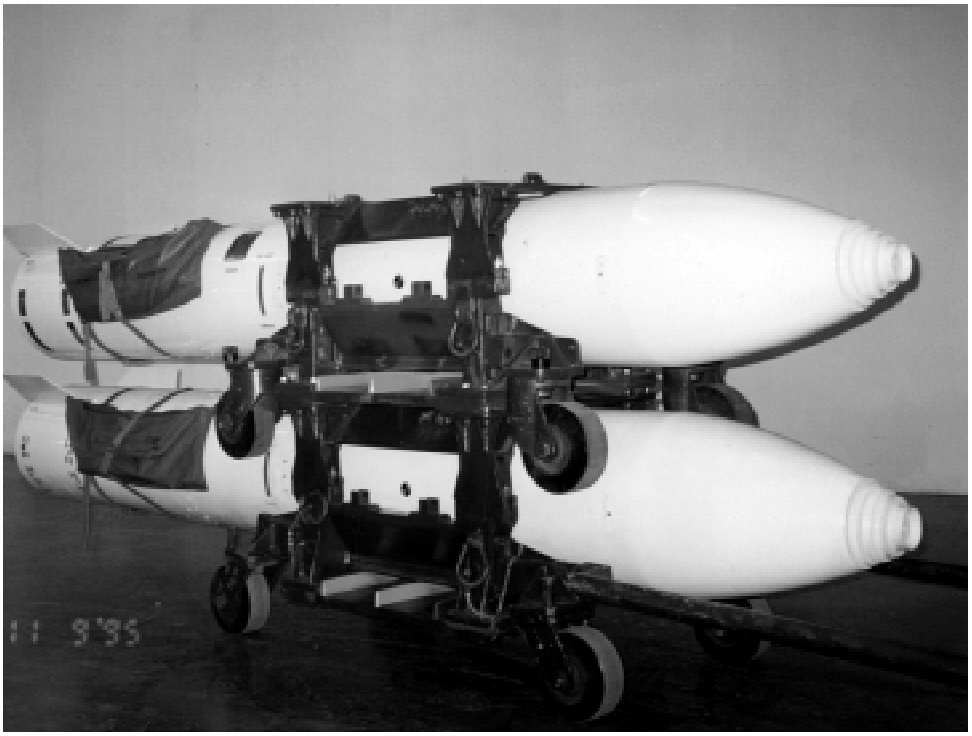

Figure 2. Two-high stack of B83 bombs in H1347 bomb hand truck**.**

In July 1992, the Air Force requested 391 additional bomb hand trucks to meet B83 storage and movement requirements. This request was met by Y-12 reprocessing 62 available H1347s and processing an additional 329 bomb hand trucks, called the H695B, beginning in mid-1993. The H695Bs were fabricated from excess H695As by adapting the stacking fixture with a plate to capture the B83 bomb lugs (Figure 3, upper bomb). The H695B was designed and qualified for storage only and not for transportation.

Quality problems that were persisting on the H1347 bomb hand truck resulted in a quality improvement program and in reprocessing upgrades on all deliveries to the Air Force beginning in mid-1993. This included improvements on the casters, stacking frame, stacking fixture bolts, stacking frame bolts, and the retaining plate that holds the stacking fixture bolts. In addition, changes were made to the requirements involving transport on trucks and trailers and towing with motorized vehicles. This reduced vibration inputs on the casters to reduce weld cracking on the cradle assembly and cracking of the caster mounting brackets.

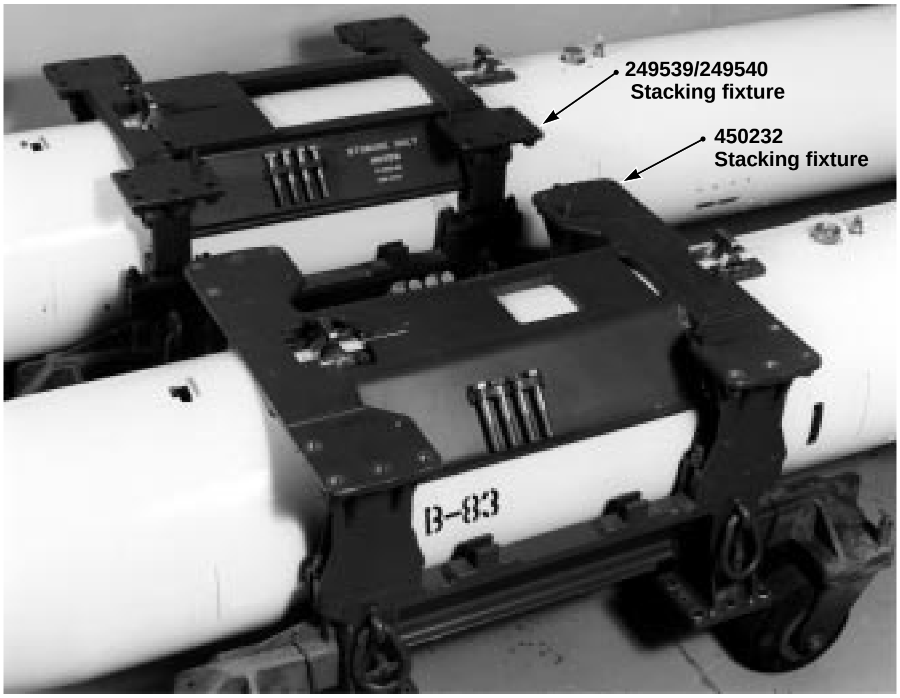

Figure 3. B83 bombs in H695B (upper) and H1347 (lower) bomb hand truck.

In 1995, an upgrade program to convert the H695Bs into H1347A bomb hand trucks to provide transportation capability was started. This bomb hand truck incorporated a newly built stacking fixture (Figure 4). The original plan called for the new stacking fixture to replace all stacking fixtures on both the H1347s and H695Bs (approximately 800), and the Air Force would have only the H1347A bomb hand truck in their inventory. Due to budget restraints, only 415 new H1347A-associated stacking fixtures were fabricated by AlliedSignal/FM&T/KCP. The new stacking fixtures will be used on 329 of the H695Bs and 86 of the H1347s to convert them into H1347As. See Figure 5 for a fabrication and upgrade flowpath for the B83 bomb hand trucks.

Background

The increased attention given to the B83 bomb hand truck started with an H-gear adequacy study in November 1991 by Sandia/California and Sandia/New Mexico task force teams. H-gear items were assessed for the W56, B57, B61, W62, W69, W70, W71, W76, and B83 weapons and a final report published in February 1993 (Ref. 1). The B83 findings and recommendations were based on a review of URs, user briefings, design analysis, and evaluation (Ref. 2). In June 1992, considerable attention was given to URs that reported cracks in the H1347-associated stacking fixtures. This led to weld inspections in the field and a temporary restriction being placed on using H1347s with cracked stacking fixtures for transport of B83 bombs.

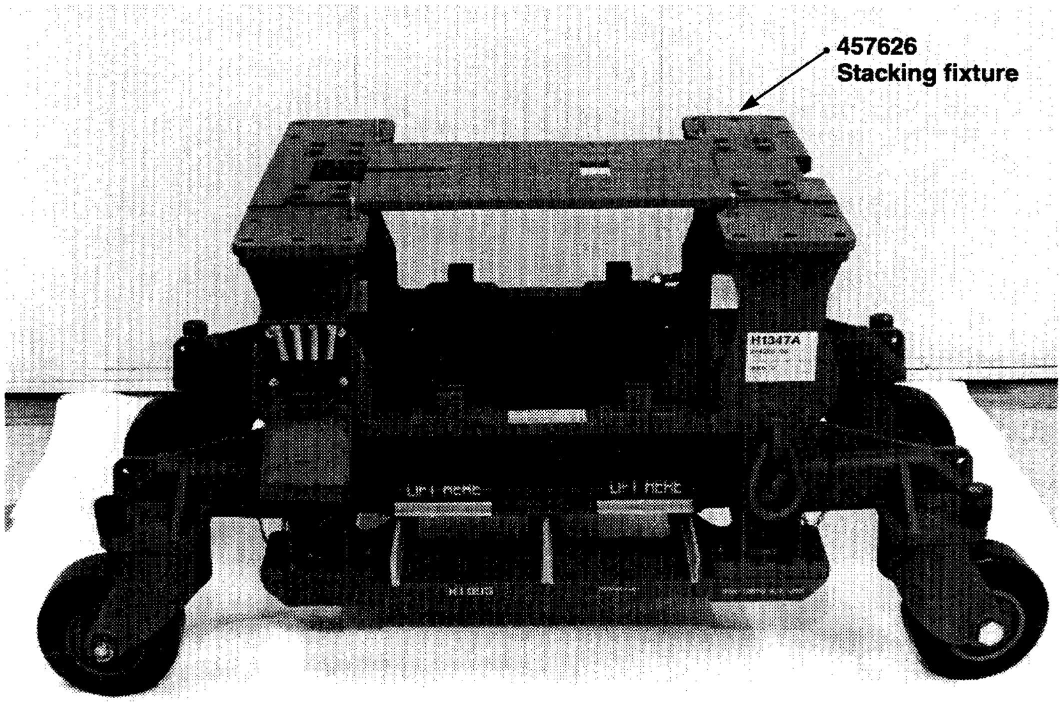

Figure 4. H1347A truck, P/N214255-00.

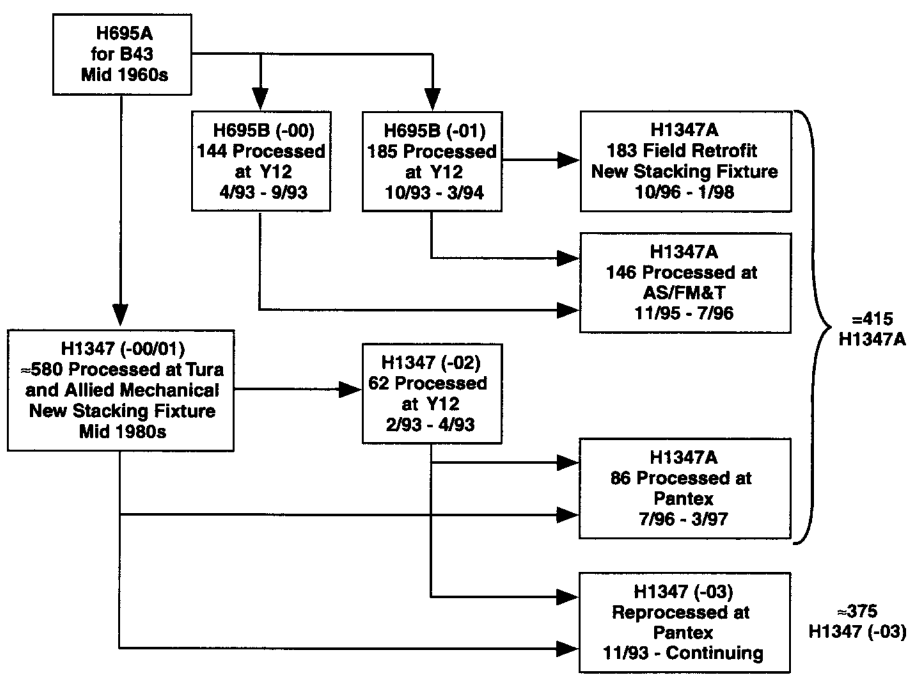

Figure 5. Fabrication and upgrade flowpath for B83 bomb hand truck.

Also at this time, the Air Force also requested 391 additional bomb hand trucks (increasing the total inventory to ~800) to meet their increased needs which resulted from:

1 Upgrade of the B83-0 bomb to a Mod 1 definition requiring increased movements of bombs to and from Pantex,

2 Delegation of a number of B83s to inactive reserve status requiring bomb movements from operational bases to depots,

3 Reduction of the number of operational Air Force bases that would field the B83 bomb requiring additional bomb movements between operational Air Force bases, and

4 Downloading of B83s from aircraft clips and rotary racks.

The Air Force's dissatisfaction with the quality problems of the H1347 bomb hand truck and the fact that the B83 would be in the enduring stockpile for many years resulted in a quality improvement program being initiated in 1993 for all the bomb hand trucks being reprocessed at the DOE facilities. The DOE's concern with the weld quality on the H1347 stacking fixture and the fact that the Air Force desired to have the H695Bs usable for transportation purposes resulted in the program to acquire new H1347A-associated stacking fixtures. The upgrade to H1347A started in 1995 and is part of the overall quality improvement program.

Bomb Hand Truck Description

The B83 bomb hand truck (Figure 6) is 62 inches long, 31 inches wide, 28.5 inches high and weighs 330 pounds. The bomb is positioned on the cradle assembly such that, with the addition of the stacking fixture assembly, the bomb is encircled (Figure 1). Eight swing bolts on the cradle assembly engage the stacking fixture to secure the bomb. The bomb lugs are engaged by cutouts on the stacking fixture to prevent both longitudinal and rotational movement of the bomb.

There are three configurations of stacking fixtures for the hand trucks: 1) H1347-associated, 2) H695B-associated, and 3) H1347A-associated.

The configuration of stacking fixture assembly defines the bomb hand truck as H1347 (Figure 7), H695B (Figure 3, upper), or H1347A (Figure 4). The same cradle assembly is used on all three bomb hand trucks. Table 1 is a breakdown of the product definition for the various versions of the three bomb hand trucks.

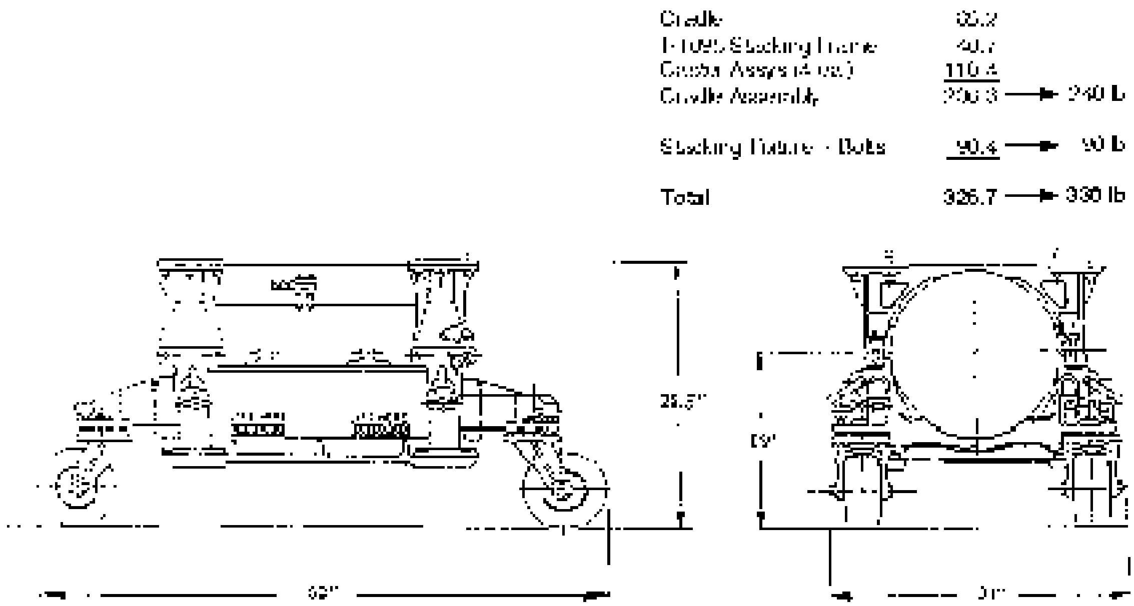

Figure 6. Size and weight of the H1347 bomb hand truck.

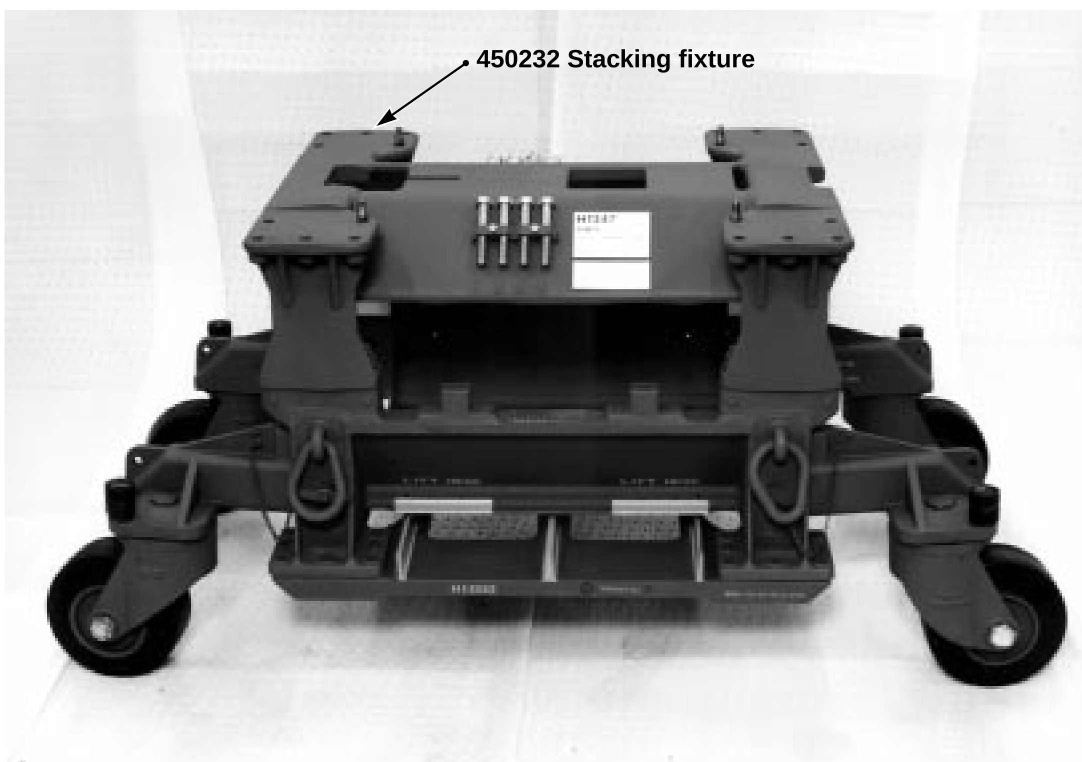

Figure 7. H1347 bomb hand truck, P/N 214073-03.

Table 1. B83 bomb hand truck hardware definition.

Nomenclature	Part No.	Suffix						
H1347	**214073**	**-00**	**-01**	**-02**	**-03**			
H695B	**214253**					**-00**	**-01**	
H1347A	**214255**							**-00**
Cradle Assy	450441	-00	-01	-02	-03	-02	-03	-03
Cradle (Cast)	172645	-01	-01	-01	-01	-01	-01	-01
Cradle (Welded)	152781	-01	-01	-01	-01	-01	-01	-01
Swivel Caster (Barrel)	156982	-00/01	-00/01	-01	-02	-01	-02	-02
Swivel Caster (Barrel)	156983	-00/01	-00/01	-01	-02	-01	-02	-02
Swivel Caster (Flat)	153790	-00	-00	-00	-01	-00	-01	-01
Swivel Caster (Flat)	153791	-00	-00	-00	-01	-00	-01	-01
H1095 Stack. Frame	320464	-00	-00	-01	-01	-01	-01	-01
H1095 Bolt (Grade 8)	MS90727-64	Yes	Yes	Yes	No	Yes	No	No
H1095 Bolt (Grade 5)	456289				-00		-00	-00
Stk. Fxt. Bolt (Grd. 8)	MS90728-172	Yes	Yes	Yes	No	Yes	No	No
Stk. Fxt. Bolt (Grd. 5)	456290				-00		-00	-00
Plate, Retaining	154304	-00	-00	-00	-01	-00	-01	
Bolt Pouch	457679							-00
Stacking Fixture Assy	450232	-00	-00	-00	-00			
Stacking Fixture Assy	249539					-00	-00	
Stacking Fixture Assy	249540					-00	-00	
Stacking Fixture Assy	457626							-00

The cradle assembly (Figure 8) includes the cradle, the H1095 stacking frame (Figure 9) and four caster assemblies. There are two types of cradles, fully interchangeable, one being a cast cradle and one a welded cradle. There are also two types of caster assemblies used on the cradle assemblies, again interchangeable, one defined as a barrel caster (Figure 10) and the other defined as a flat-sided caster (Figure 11). The barrel caster mounting bracket is made from an aluminum casting while the mounting bracket for the flat-sided caster uses structural aluminum tubing. All combinations of cradles and caster assemblies are allowed on the cradle assemblies.

The bomb hand truck part marking is on the stacking fixtures. Bomb hand trucks in field service include the 214073-00/-01/-02/-03 suffix for the H1347; 214253-00/-01 suffix for the H695B; and the 214255-00 for the H1347A.

B83 bombs may be stored in one- or two-high stacks with any combination of bomb hand trucks. However, only the H1347 or H1347A bomb hand trucks may be used for transportation. The H695B cannot be used for over-the-road transportation as the stacking fixture modifications are not designed for transportation environments.

Figure 8. Cradle assembly used for H1347, H695B, and H1347A bomb hand trucks.

Figure 9. H1095 stacking frame, P/N 320464-01.

Figure 10. Barrel-type caster assemblies.

Figure 11. H1640 Castering tool engaging wheel hub on flat-sided caster assembly.

Summary of the Problems and Concerns on the Bomb Hand Truck Leading to the Quality Improvement Program

The problems and deficiencies that were identified on the H1347 bomb hand truck through the H-gear adequacy study, UR reviews, user interface meetings, and analysis are summarized below:

a) Stacking fixture weld cracks on the H1347-associated stacking fixture (Figure 12).

b) Concern with meeting the 10-g load requirement with a tail-forward loading configuration in the Safe Secure Trailer (SST).

c) Cracked welds on the female receptacle on the welded cradle for the caster mounting bracket (Figure 13).

d) Broken or cracked caster mounting brackets for the barrel casters (Figure 14).

e) Casters unlocking from the swivel lock position during transportation.

f) Poor condition of bearings (corrosion, no lubrication), seals, nuts, and dust caps in caster assemblies (Figure 15).

g) Caster tires rubbing against the H1095 stacking frame causing binding or tire damage.

h) The bolt that holds the retaining plate to mount the stacking fixture bolts breaks off in the helicoil on the stacking fixture, or the helicoil gets damaged.

i) Longitudinal cracks in the stacking fixture bolts (Figure 16).

j) The Air Force requested alternate marking methods since spray paint was disallowed by DOE.

k) Caster callouts in TP B83-1 manual do not show which casters go where in the IPB (Illustrated Parts Breakdown).

l) Castering tools (H631 and H1216) cause damage to the barrel caster frame as straight sided forks gouge curved caster yoke (Figure 17).

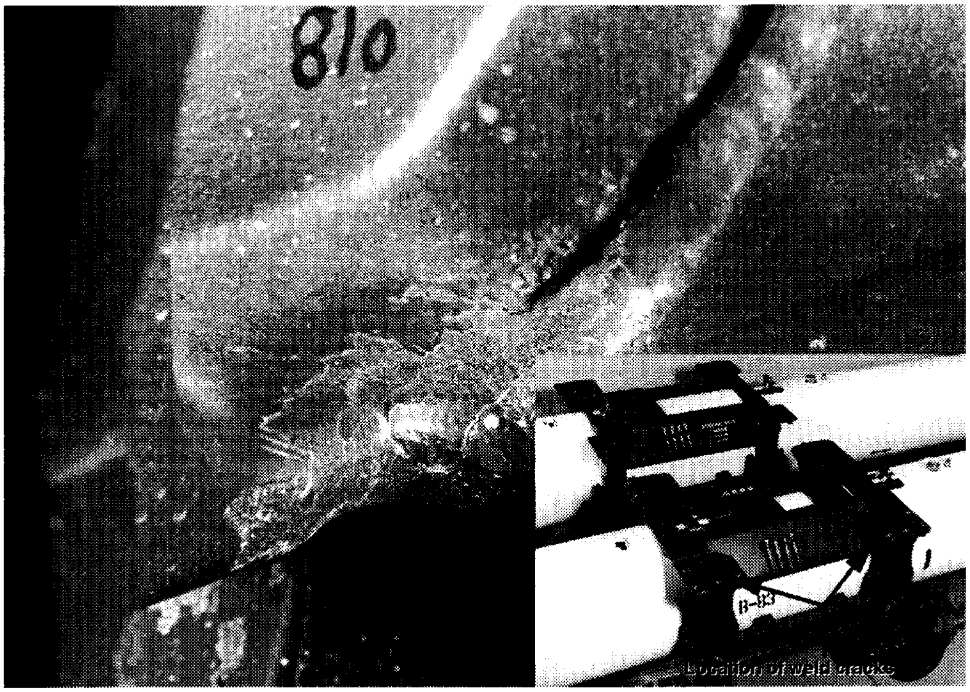

Figure 12. Weld cracks on H1347-associated stacking fixture.

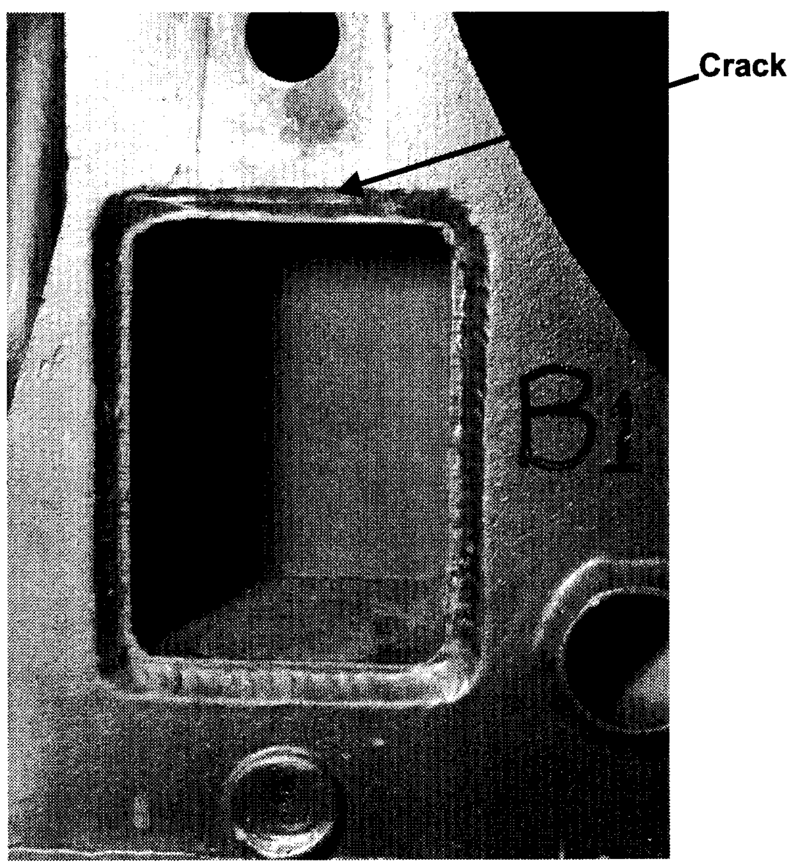

Figure 13. Weld cracks on caster assembly receptacle on cradle.

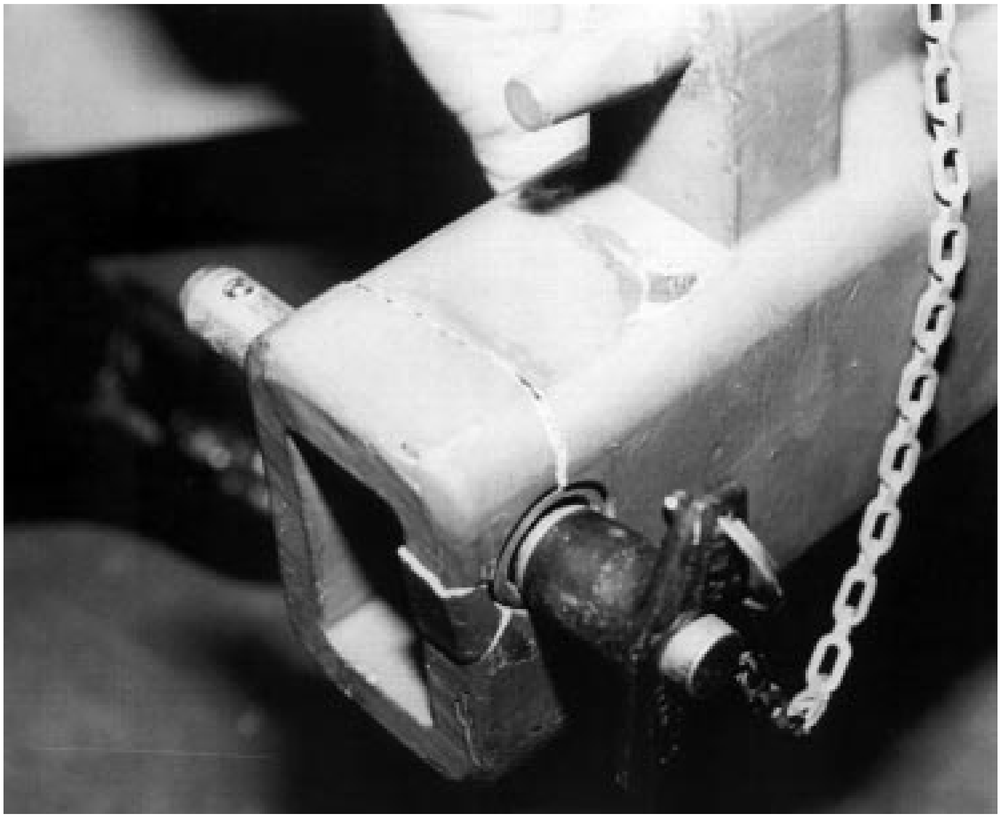

Figure 14. Cracks in caster assembly mounting bracket (barrel caster).

Figure 15. Condition of bearings, seals, nuts, and dust caps in caster assembly.

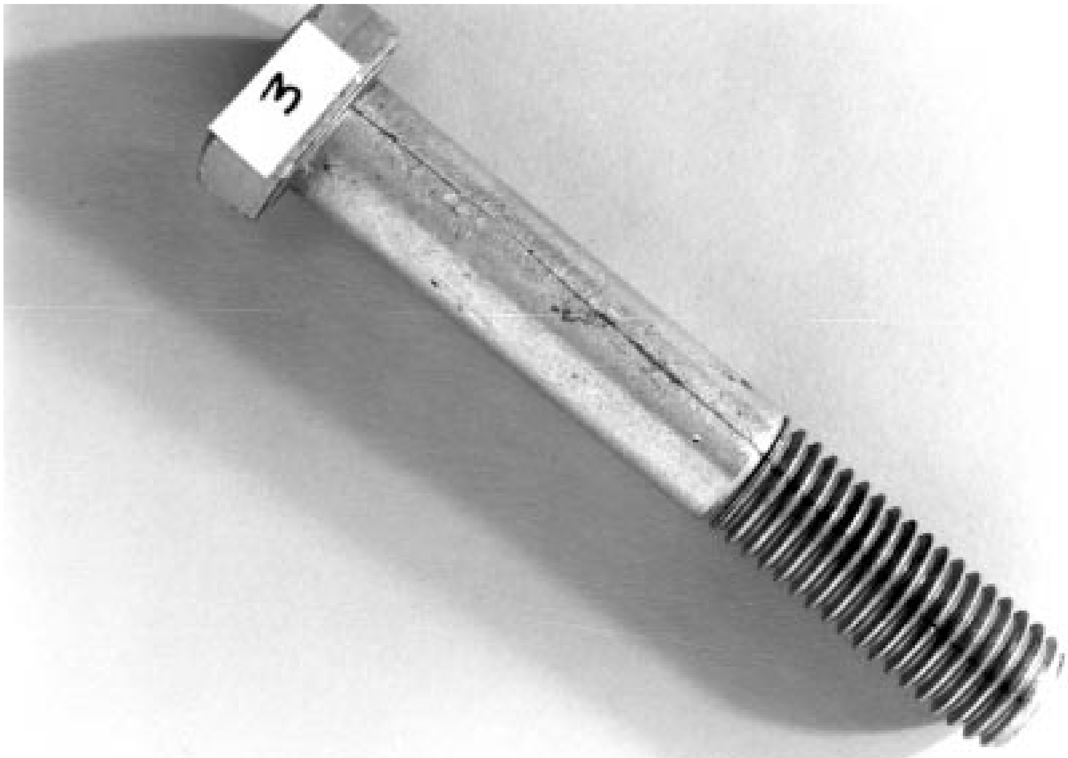

Figure 16. Longitudinal cracks in stacking fixture bolts.

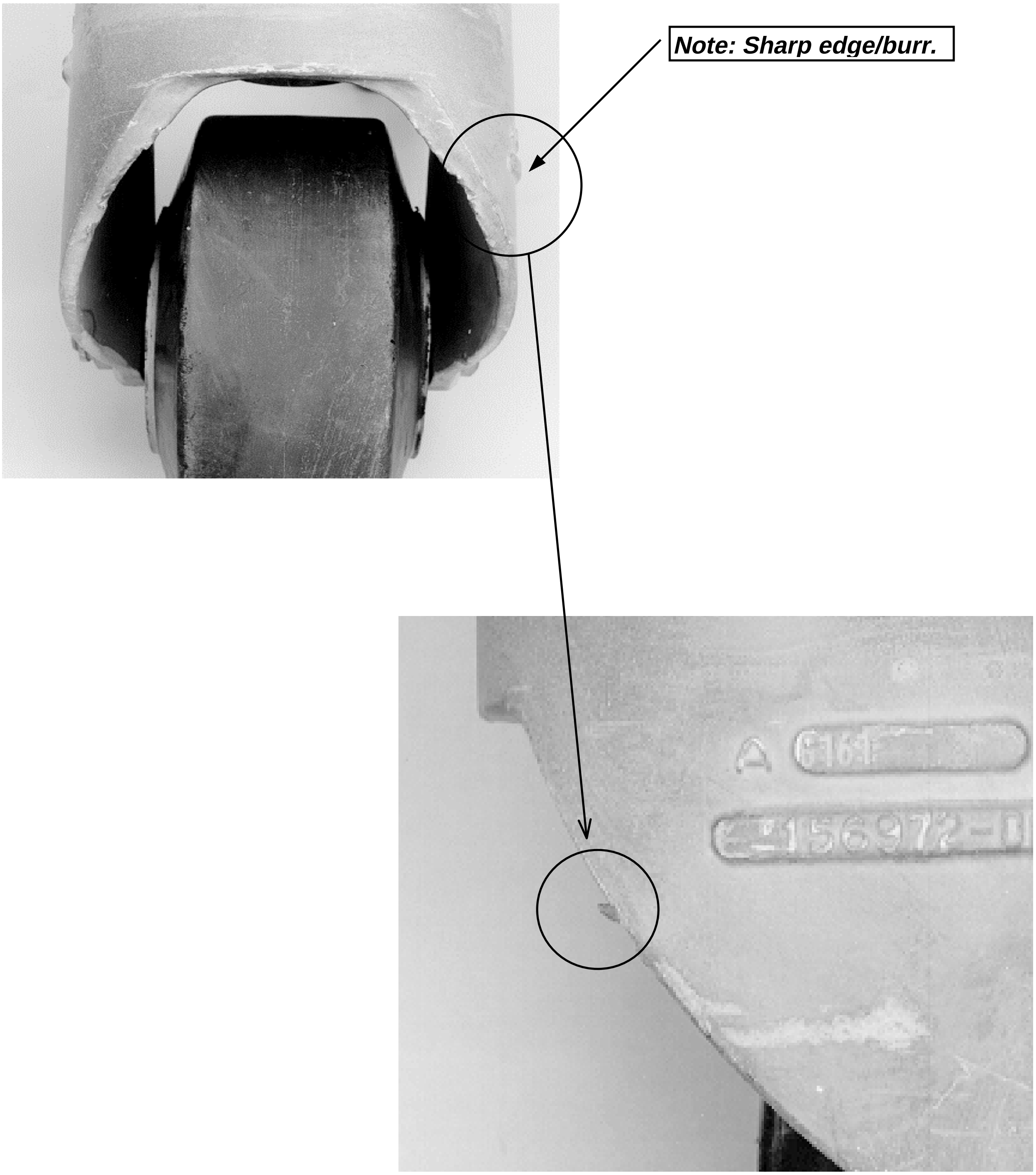

Figure 17. Typical damage to barrel-type caster from castering tool.

Table 2 is a compilation of URs against the B83 bomb hand truck.

Table 2. H1347 unsatisfactory reports (URs).

UR Number	Date	Comments
95-063	June 1983	Casters unlock during transit
24-123	Dec 1983	Casters unlock during transit
17-074	July 1984	Casters unlock during transit
54-105	Oct 1985	Caster pin corroded
42-046	April 1986	Casters unlock during transit
011-017	Jan 1987	Manual inconsistent with caster suffix use
082-107	Oct 1987	Manual inconsistent with caster suffix use
014-117	Nov 1987	Manual inconsistent with caster suffix use
046-068	June 1988	Holes in welds for caster mounting
009-078	July 1988	Caster wobbles
055-078	July 1988	Casters unlock during transit
064-108	Oct 1988	Caster tire rubbing on stacking frame
36TP108	Oct 1988	Caster tire rubbing on stacking frame
078-118	Nov 1988	Tire separating from hub
060-049	April 1989	Forklift use
017-059	May 1989	Cracked weld in female caster receptacle on cradle
086-099	Sept 1989	Broken caster mounting bracket
058-119	Nov 1989	Broken caster
078H010	Jan 1990	Caster tire rubbing on stacking frame
014H020	Feb 1990	Hairline crack in stacking fixture bolts
114-050	May 1990	Cracks in stacking fixture weld
072-031	March 1991	Cracks in cradle
084HG0391	March 1991	Loose swing bolts
060-061	June 1991	Swing arm bolts loose
062HG0691	June 1991	Broken helicoil on stacking fixture
063BO0691	June 1991	Broken helicoil on stacking fixture
043HG0991	Sept 1991	Void in caster weld
053HG0991	Sept 1991	Cracks in stacking fixture welds
087BO0991	Sept 1991	Cracks in stacking fixture welds
062HG1091	Oct 1991	Cracks in stacking fixture welds
017HG0392	March 1992	Cracked weld in female caster receptacle on cradle
021HG0492	April 1992	Cracked weld in female caster receptacle on cradle
053HG0692	June 1992	20 of 38 stacking fixtures have cracked welds
011HG0792	July 1992	Cracks in stacking fixture welds (2 parts)
006HG0792	July 1992	Casting voids in cradle
033HG0892	Aug 1992	Casting voids in cradle
038BO0892	Aug 1992	Cracks in stacking fixture welds
076HG0992	Sept 1992	Broken helicoil on stacking fixture
081HG0992	Sept 1992	Damaged caster frame from caster tool
035HG1092	Oct 1992	Mfg. cracks in rolled lip on stacking fixture

Table 2. H1347 unsatisfactory reports (URs). (cont.)

UR Number	Date	Comments
030HG1292	Dec 1992	Cracked weld in female caster receptacle on cradle
009BO0293	Feb 1993	Cracked caster mounting bracket
025BO0593	May 1993	Loose H1347 bolts
050HG0593	May 1993	No space below part number; Swing bolts nuts unserviceable
046HG0993	Sept 1993	Damaged caster assembly
006HG1293	Dec 1993	H695B felt and safety caps
017HG0794	July 1994	Broken caster assembly
001TP0894	Aug 1994	Shoring under single high stack
021HG1194	Nov 1994	Loose caster assembly bolt
033HG1194	Nov 1994	Defective caster assembly
043HG0195	Jan 1995	Defective caster assembly
062TP0295	Feb 1995	Manual discrepancy on forklift procedure
047HG0395	March 1995	Tire separating from hub
080HG0395	March 1995	Nine casters on seven bolsters unlocked during transit
081HG0395	March 1995	Seven casters on six bolsters unlocked during transit
073HG0595	May 1995	Five casters on three bolsters unlocked during transit
001HG0795	July 1995	Fourteen casters on twelve bolsters unlocked during transit
051TP0895	Aug 1995	Request double stack towing with motorized vehicle
035HG0995	Sept 1995	Cracked mounting brackets on three caster assemblies
029HG1095	Oct 1995	Axle bolts on caster assembly below flush
032HG1095	Oct 1995	Cracked mounting brackets on one caster assembly
033HG1095	Oct 1995	Two casting voids on stacking fixture
034HG1095	Oct 1995	Two rivets not seated on stacking fixture
002HG1195	Nov 1995	Cracked and fractured mounting bracket on caster
039HG1195	Nov 1995	Cracked mounting brackets on one caster assembly
019TP0396	March 1996	Missing dust cover on caster assemblies manual note
012BO0496	April 1996	Cracked caster mounting bracket
032HG0297	Feb 1997	Loose swing bolts pins - 3 units
001TP0697	June 1997	Manual change - Axle bolt replacement
015TP0797	July 1997	H12-2 Manual change - Inspection procedures
028HG1097	Oct 1997	Cracked weld (5/16") on left pillar of H1347 stacking fixture
061TP1027	Oct 1997	Manual Change - Lifting procedure
036HG1297	Dec 1997	a) Caster Assy – Large chip in caster lock area b) Caster Assy – Tire separation c) Caster Assy – Crack near quick-release hub d) Caster Assy – Molding defect (bubble) in corner of caster

Summary of Quality Improvement Program Upgrades

Upgrade to H1347 (-03) and H695B (-01)

Beginning in the fall of 1993, bomb hand trucks delivered to the Air Force met the 214073-03 definition for the H1347 and the 214253-01 definition for the H695B (see Table 1). The H1347 (-03) and the H695B (-01) bomb hand trucks contain the same upgrades (but have different stacking fixtures). Changes and improvements to the hand truck include:

a) Upgraded the swivel caster definition to 156982-02 and 156983-02 for the barrel casters and 153791-01 and 153790-01 for the alternate flat-sided casters. The barrel casters with cam lock mechanisms were converted to the swivel lock option. Reprocessing was improved to include replacing worn or damaged bearings and seals. The casters were relubricated. The plunger detent on the locking mechanism was properly adjusted and the center bolt was properly tightened to allow normal swivel motion of the caster and normal engagement of the plunger detent locking mechanism. These upgrades greatly reduced the incidences of casters unlocking during transportation.

b) A larger chamfer on the H1095 stacking frame defined by 320464-01. This allows the caster to swivel without binding and tearing rubber off the tire.

c) New Grade 5 stacking fixture bolts defined by 456290-00. These replaced Grade 8 bolts that were susceptible to longitudinal cracking.

d) New Grade 5 stacking frame bolts defined by 456289-00, also replacing Grade 8 bolts.

e) A new retaining plate defined by 154304-01 to hold the stacking fixture bolts. The shank of the bolt that secures this plate could previously engage the helicoil causing damage. The new retaining plate prevents this from happening and is incorporated on the H1347 (-03) and H695B (-01) bomb hand trucks.

f) Use of decals for marking the bomb hand trucks as an alternate marking method. This eliminates the need for painting.

g) A Retrofit Order defined by TP H1347-501 moved the bomb hand truck marking from the cradle assembly to the stacking fixture. Since the cradle assemblies for the H1347, H695B, and the H1347A bomb hand trucks are essentially the same, the type of stacking fixture used controls the definition of the bomb hand truck.

Manual Changes

a) Changes to the TP manuals were made to allow cracks (any length) in the welds for the H1347-associated stacking fixture after load testing resolved there were no safety concerns. However, product shipped from DOE to the Air Force covered by Reprocessing Specification RS214073 limits the length of any individual crack to 2 inches and the accumulative length of all cracks to less than 8 inches, total.

b) Changed TP45-51 manual allowing only nose-forward configuration for both the one- and two-high stack loading in the Safe Secure Trailer (SST).

c) Changes to the TP manuals allowing cracks up to 2.5 inches total length in the welds for each of the cradle receptacles for the mounting brackets for the four caster assemblies. However, product shipped from DOE to the Air Force covered by Reprocessing Specification RS214073 or RS214255 limits the cracks to 1-inch length in each of the four cradle receptacles.

d) Changes to the TP manuals to control conditions and speeds for transport by truck or trailer or by towing with a motorized towing vehicle. Reducing the shock and vibration environment will reduce cracking in the welded region of the cradle receptacle for mounting the caster. Cracking of the caster mounting bracket will also be reduced. (See Table 3 defining the new towing and truck/trailer transport conditions.)

e) Changes to the TP manuals to update base spares callouts and to correct many problems and deficiencies.

Table 3. Towing and truck/trailer transport requirements.

Towing	
One-High Stack	**Two-High Stack**
Over smooth, hard surfaces for a distance of up to 1 mile at speeds not to exceed 5 mph.	Over smooth, hard surfaces for a distance of up to 1,000 feet at a slow walking speed (approximately 1 mph).
Truck or Trailer Transport	
One-High Stack	**Two-High Stack**
No shoring required at speeds less than 20 mph. Shoring required at speeds greater than 20 mph.	Shoring required at all speeds.

Upgrade to H1347A

The processing of the bomb hand truck to H1347A involved using the upgrades to the H1347 (-03) or the H695B (-01) bomb hand trucks with the following:

a) A new H1347A-associated stacking fixture defined by 457626-00 to replace all of the H695B-associated and a portion of the H1347-associated stacking fixtures.

b) A new bolt pouch (457679-00) to hold the stacking fixture bolts for the H1347A-associated stacking fixture. This allows access to the bolts without using a tool that was required to disengage the retaining clip used on the H1347- and H695B-associated stacking fixtures.

Other Changes

A new castering tool, the H1640, replaced the H631 and H1216 for the B83. The new tool will not gouge the frame (yoke) on the barrel casters.

Possible Future Upgrades

A development program was started in January 1996 to design a stronger caster mounting bracket for the barrel caster assembly. The barrel caster assembly uses a cast aluminum mounting bracket that cracks under normal usage conditions as reported by URs.

Stockpile Upgrade Program to H1347A

A new H1347A-associated stacking fixture defined by 457626-00 was implemented in 1995. When this stacking fixture is used with cradle assemblies from the H1347 (-03) or the H695B (-01), the resulting bomb hand truck is the H1347A (-00) (see Table 1).

The Stockpile Upgrade Program to H1347A is described in Product Change Proposal 6-93 and the procedures for the field portion of the retrofit are found in TP H1347-502. The original plan called for the new stacking fixture to replace all stacking fixtures on both the H1347s and H695Bs (approximately 800), which would result in the Air Force having only one bomb hand truck in their inventory. This would be the H1347A. Due to budget restraints, only 415 new H1347A-associated stacking fixtures are being fabricated by AlliedSignal/FM&T at the rate of 15 per month. The Upgrade Program to H1347A will upgrade the 329 storage-only H695Bs and 86 of the H1347s into H1347As. This is done by adding improvements to bring the H695B to the -01 version and the H1347 to the -03 version and then exchanging the stacking fixture with a new H1347A-associated stacking fixture.

The Air Force inventory of 329 H695B is further broken down to 146 H695B (-00) and 183 H695B (-01). The H1347s are a mix of -00, -01, -02, and -03s.

The 146 H695Bs (-00) were returned from the Air Force to AlliedSignal/FM&T for conversion into H1347A. This phase was started in November 1995 and was completed in July 1996.

The 183 H695B (-01) will be converted at Air Force facilities by sending the H1347A-associated stacking fixture directly to the Air Force for the stacking fixture exchange. This will be during the time period of October 1996 through January 1998.

The remaining 86 H1347A-associated stacking fixtures will be sent to Pantex to upgrade H1347 to H1347A in support of Mod 1 deliveries. This will extend over the time period of June 1996 through February 1997. All other Mod 1 and quality assurance units delivered to the Air Force from Pantex are to the H1347 (-03) configuration. The Air Force inventory will then consist of H1347 and H1347A bomb hand trucks, all of which can be used for either storage or transportation purposes.

The H1347A upgrade will be completed by March 1998 with the Air Force inventory at that time totaling 415 H1347As. The upgrade of H1347 to the -03 configuration will be ongoing as some -00s, -01s, and -02s will be returned to Pantex from the Air Force with quality assurance units that are scheduled throughout the life of the B83 program.

Bomb Hand Truck Definition and History

The bomb hand trucks in the Air Force inventory include the H1347 (214073-00/01, -02 and -03 suffix) and the H695B (214253-00 and -01 suffix). The overall plan is to convert all 329 of the H695Bs into H1347As (214255-00) and 86 of the H1347s into H1347As. The remainder of the H1347s will be upgraded to H1347 (-03 suffix).

The following is a more detailed description of the bomb hand trucks listed in Table 1 along with the histories of their development.

H1347 (214073-00/01)

The original build for the B83 program was the H1347, P/N 214073-00/01. In the mid-1980s approximately 209 of the H1347s were fabricated at Tura Inc., Folcroft, PA and 370 at Allied-Mechanical Products, Ontario, CA. Approximately 685 new casters were fabricated at Aerol Corp., Los Angeles, CA (4 required per bomb hand truck) but the majority of casters were reused from the H695A. The cradle assemblies, H1095 stacking frames, and other parts were reused from the H695A program. The cradle assemblies (450441) were reprocessed from existing H695A bomb hand trucks using reprocessing requirements from SS450441. The H695A-associated stacking fixtures were replaced by a new stacking fixture (450232-00) with cast end pieces welded to a center section. A new stacking fixture was required because of a change in the way the bomb interfaced with the hand truck. The B43 had an attachment on the side of the bomb that bolted directly to a lug on the cradle rail, while the B83 bomb hand truck captured the bomb lugs in cutouts on the new stacking fixture.

The H1095 stacking frame (320464-00), which was a separate part for the H695A, was reused but became part of the 450441 cradle assembly. The 214073-00 bomb hand trucks used a cam lock device on the caster assemblies that lead to URs from the Air Force because of caster unlocking problems. Midway through the original build, changes were made to use a swivel lock, and the suffix of the cradle and bomb hand truck raised. However, the caster definition was not changed, and new caster assemblies fabricated by Aerol still contained the cam lock design. Since the new caster assemblies were not upgraded with swivel locks, raising the suffix on the cradle and bomb hand truck was ineffective in controlling product definition on the caster assemblies.

H1347 (214073-02)

As a result of the problems identified in the H-gear adequacy study, improvements were started to the H1347 bomb hand truck. The additional 62 H1347s supplied by Y-12 to the Air Force from February 1993 through April 1993 were reprocessed to the 214073-02 version that included a larger chamfer on the H1095 stacking frame (320464-01) to solve a problem with the caster binding against the stacking frame. Also, all casters were disassembled, damaged bearings and seals were replaced, and the bearings were relubricated. The casters used were 156982-00/01 and 156983-00/01 referred to as barrel casters (many that still contained the cam lock). An alternate version of casters (153790-00 and 153791-00), referred to as flat-sided casters, were not used in this production.

H1347 (214073-03)

Continued improvements to resolve problems on the H1347 were made on the 214073-03 definition. This version, started in November 1993, supports all B83 shipments (Mod 1 and QA returns) from Pantex to the Air Force. The improvements include:

a) The larger chamfer on the stacking frame defined by 320464-01.

b) Upgraded swivel casters defined by 156982-02 and 156983-02. (Alternates are 153790-01 and 153791-01). The upgraded 156982-02 and 156983-02 swivel casters replaced all cam locks with swivel locks. The swivel casters were also disassembled, inspected, and relubricated. The 153790-01 and 153791-01 flat-sided casters had covers added to the locking handles besides the disassembly, inspection, and relubrication process.

c) New Grade 5 stacking frame bolts defined by 456289-00 and new Grade 5 stacking fixture bolts defined by 456290-00. The original Grade 8 stacking fixture bolts had been the subject of URs because of bolt cracking attributed to an improper quenching process (Figure 16). This, in addition to finding suspect/counterfeit bolts, lead to a redefinition of the stacking fixture and stacking frame bolts from a Grade 8 to a Grade 5 requirement and required that replacement bolts from military spares be eliminated and replaced by base spares. Base spare items for the Air Force are purchased by DOE through AlliedSignal/FM&T.

d) New retaining plate defined by 154304-01. The retaining plate is used to clip the stacking fixture bolts to the stacking fixture for storage when the bomb hand trucks are in the single-stack configuration. A 1/4-28 UNC bolt with an unthreaded shank is used to fasten the retaining plate to the stacking fixture engaging an insert in the stacking fixture. When the stacking fixture bolts are removed and the 1/4-28 bolt tightened to keep the retaining plate from rattling, the shank engages the insert. This led to URs when the shank engaged the threaded insert and the insert was either damaged or the bolt broke off in the insert. The retaining clip was redesigned so that the shank of the 1/4-28 bolt does not engage the insert whether or not the stacking fixture bolts are in the clip.

H695B (214253-00)

A total of 144 H695Bs to the 214253-00 definition were reprocessed at Y-12 with deliveries to the Air Force from April 1993 through September 1993. These units were reprocessed from existing H695As and are limited to storage use only. They can be double stacked with other H695Bs or H1347s. The stacking fixture from the H695A was used but modified to 249539-00 or 249540-00, which allowed capture of the B83 by the bomb lug. The modification also positioned the center-of-gravity of the B83 in the same location on the H695B as on the H1347. These units used the 320464-01 stacking frame with the larger chamfer and either barrel (156982-00/01 and 156983-00/01) or flat-sided (153790-00 and 153791-00) casters that were disassembled, inspected and relubricated.

H695B (214253-01)

A total of 185 H695Bs to the 214253-01 definition were supplied to the Air Force by Y-12. The first delivery was October 1993 and the last was March 1994. These units are also reprocessed from existing H695As and are limited to storage use only. These units contain all the upgrades found on 214073-03.

H1347A (214255-00)

The H1347A can be defined as putting a new stacking fixture (457626-00) on the 214073-03 (H1347) bomb hand truck or on the 214253-01 (H695B) bomb hand truck. For suffixes lower than 214073-03 and 214253-01, additional upgrades are required.

The justification for building new stacking fixtures for the H1347A is as follows:

a) To convert the H695B into transportation-capable bomb hand trucks.

b) To remove the poor quality stacking fixtures from the H1347 bomb hand truck.

c) To replace the mixture of H695B and H1347 bomb hand trucks in the Air Force inventory with a single design, the H1347A. However, due to budget constraints, there will be a mixture of H1347As and H1347 to the -03 suffix.

History of the H1347-Associated Stacking Fixture

Description of the H1347-Associated Stacking Fixture

The stacking fixture (see Figure 18) has three functions:

a) Positions the center-of-gravity of the B83 in the center of the cradle.

b) Provides a stacking platform for a two-high stack of bombs in the bomb hand truck.

c) Restrains the B83 from moving in the event of a simultaneous 10-g load in the forward direction of travel, 5-g lateral load, and a 2-g vertical upward load as specified as a tie down requirement for transportation for the Safe Secure Trailer (SST).

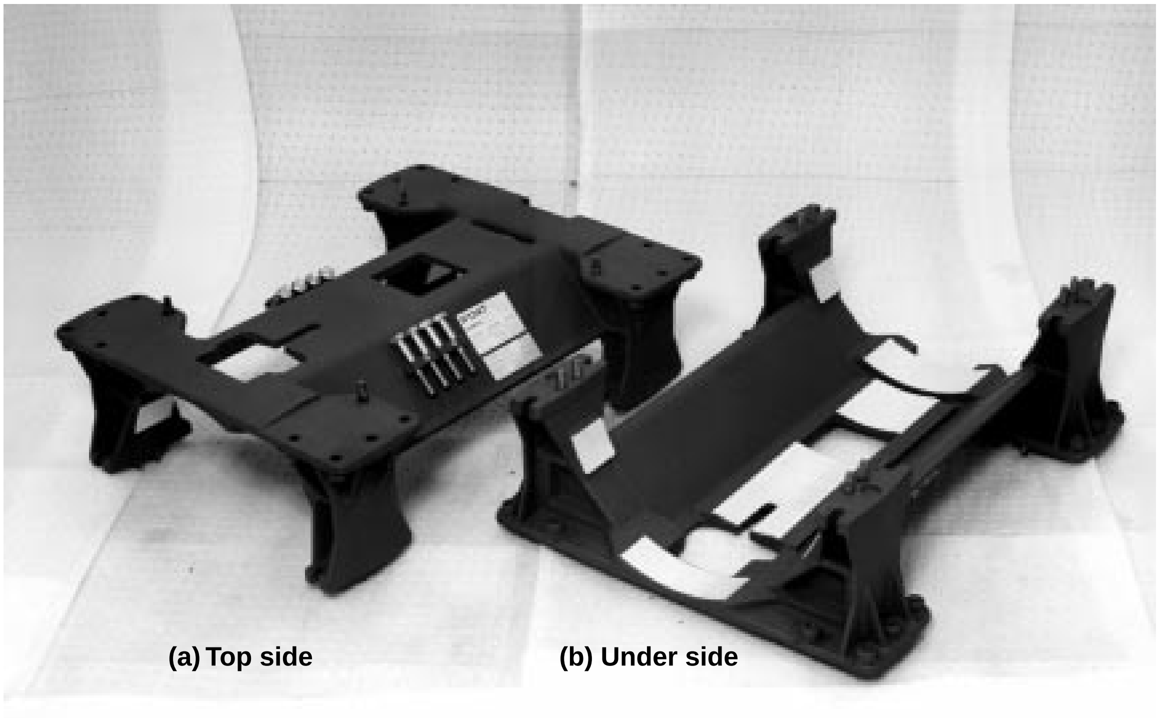

Figure 18. H1347-associated stacking fixture, P/N 450232-00.

The most critical function of the stacking fixture is restraining the movement of the B83 in the 10-g, 5-g, 2-g accident scenario for the SST. The primary interface between the stacking fixture and the B83 are the bomb lugs. When the B83 is loaded nose forward in the direction of travel, both lugs are forced directly into the strongest area of the stacking fixture casting. Unfortunately, when the weapon is loaded tail forward in the direction of travel, only one lug will make contact with the stacking fixture (see Figure 1). The single point of contact is not with the strong arched casting but with a 3/4-inch plate, (450234-00) weakened by a slot for clearance for the H1004 bomb hoisting adapter. Testing showed the stacking fixture does not meet the 10-g requirement for tail-forward loading in the direction of travel.

Approximately 580 new stacking fixtures defined by 450232-00 were fabricated for the H1347 bomb hand trucks in the mid-1980s. A center section weldment consists of two aluminum braces (450233-00) welded at a 45° angle to a 3/4-inch-thick aluminum center captivating plate (450234-00) that restrains the forward lug in the aft direction. The braces on the center section weldment are then welded to two arched end pieces defined by 450237-00 (an aluminum alloy casting, permanent mold, 356 per AMS 4284) using ER5183 or ER5356 welding rod. The welding specification and inspection is per 9912117, Class II. There are a total of four welds: one on each end of each brace separating the two aluminum castings. The brace and corresponding weld cross-section is approximately 8 inches by 0.375 inch. The weld is made with passes on both the inside and outside surfaces of the stacking fixture. The entire welded assembly is machined as a unit. The lug capture cutouts are end milled. The bomb contour was lined bored into the assembly, simultaneously cutting the B83 diameter into the casting and the center section stiffener of the stacking fixture. This provided a center section that matched the B83 diameter and allowed full capture of the edge of the lug.

Welding of the center section to the end castings was difficult. Due to the design of the casting in the areas of the welds, a uniform weld cross section was impossible to produce. The weld cross section varied from a butt to a fillet. The symmetry of the weldment also created problems for the welder due to limited access. Welding also created warpage of the assembly, requiring it to be machined after welding. Control of the welding process was difficult.

Weld Cracking Problem

The first major indication of weld quality problems on the stacking fixture was reported by the Air Force via UR Code No. 053HG0692 dated June 22, 1992 where 20 of 38 units inspected were reported as cracked. The cracks are in the outboard regions of the 45^{o} plates where the center section is welded to the end castings (Figure 12). An on-site inspection by an evaluation team consisting of Sandia, AlliedSignal/FM&T, and DOE/AL/WQD personnel was completed on July 21, 1992. Two H1347s with the cracked stacking fixtures were sent to AlliedSignal/FM&T for evaluation. The cracks were characterized as crater cracks with some propagating to form longitudinal cracks up to 1.1 inches in length. There was lack of fill of the weld crater at the time of manufacture and the cracks formed upon solidification of the weld metal. Some stacking fixtures had cracks in three of the four welds. The welding specification does not allow crater cracks, cracks in the weld bead, or in the parent material. Product with these defects do not meet the design requirements and should not have been accepted for WR use.

An interim UR response dated August 6, 1992 from SNL/Dept 5513 to the Commander, Field Command / Defense Nuclear Agency allowed only stacking fixtures without cracks to be used in over-the-road operations that required a prescribed tie down configuration, such as the TP45-51 series. This includes transportation in the Safe Secure Trailer, aircraft, and trailer tie down modes. Normal operations with the H1347s, including storage and forklift movement of weapons, were unrestricted with stacking fixtures having weld cracks of less than 1 inch in length. The interim response also requested an asset-wide inspection of all stacking fixtures in the Air Force inventory.

A Special Instructions Engineering Release (SIER 920472SL) was released to the DOE complexes requiring an asset-wide inspection and imposed the same transportation restrictions as placed on the Air Force. The SIER required special marking on acceptable inspected units and also defined repair criteria.

An asset-wide inspection program for the H1347-associated stacking fixture, including both Air Force and DOE inventories, showed 106 out of 529 units inspected to be cracked (20%). These inspections identified cracks that were visible through the paint.

Weld Evaluation and Repair Program

The weld evaluation and repair process work carried out at AlliedSignal/FM&T showed the original welds did not meet drawing requirements and exhibited significant lack of penetration, lack of fusion, weld crater cracks, undercut and overlap (Figure 19). The weld repair process proved to be difficult and labor intensive. ES&H concerns were a factor as welding of a painted structure created fumes. This required stripping a significant amount of paint at a high labor cost. When the defective welds were removed and new beads started, contamination in the old welds bubbled up causing voids in the new welds. The weld repair process could not control distortion of the stacking fixture or limit it to acceptable amounts. Stacking fixture pull tests on weld repaired units showed no increase in joint strength. The weld repair process proved to be capable of improving appearance of the stacking fixture but did nothing to increase quality or improve strength of the welded joint. Later testing showed weld joint strength not to be a safety issue in transportation environments.

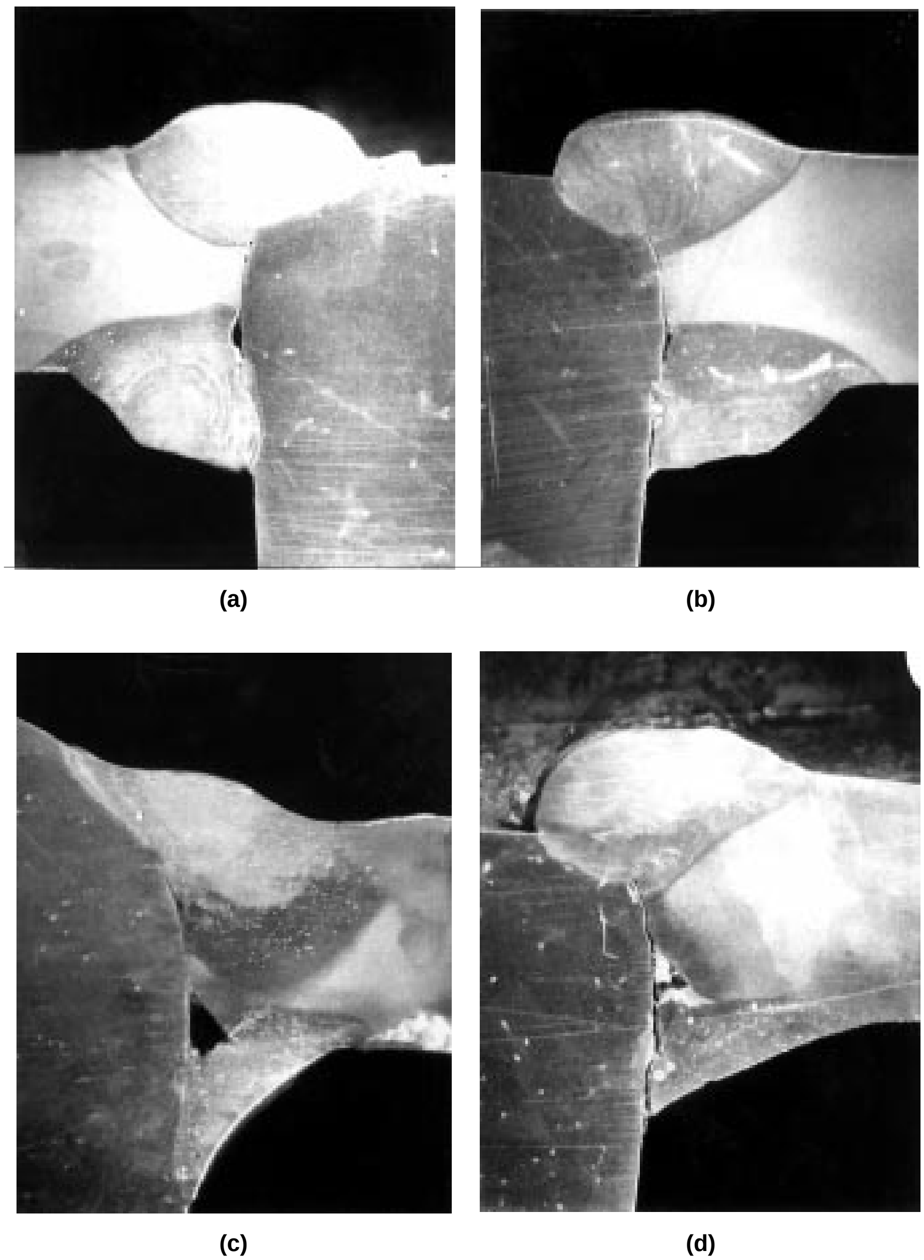

Figure 19. Cross-section of welds on H1347-associated stacking fixture.

H1347-Associated Stacking Fixture and Bomb Hand Truck Testing Program

Weld Pull Testing on the H1347-Associated Stacking Fixture

The purpose of this testing was to determine the tensile loads required to fracture the welds on each end of the H1347-associated stacking fixture. These tests were conducted in January 1993 and are documented in SAND97-8260, Appendix D (Ref. 3).

Each end of two stacking fixtures was tensile tested by mounting into a fixture and pulling. Results show failure strengths from 68,000 to 100,000 pounds (see Table 4). All welds exhibited lack of penetration. A full penetration weld would be expected to fail at approximately 150,000 to 200,000 pounds. Simulated cracks up to 2 inches in length did not appear to affect weld fracture strength.

Table 4. Summary of tensile test results and conditions.

Test Number	Casting Mfg Code	End Tested	Breaking Strength (Pounds)	Type of Weld	Comments
1	AFG	Forward	100,000	GTA	2-inch cut in each weld to simulate cracks
2	AFG	Aft	83,000	GTA	No cracks in weld
3	AWW	Aft	68,000	GMA	Weld with suspect crack (Actually a cold lap)
4	AWW	Forward	68,000	GMA	No cracks in weld

Additional Weld Pull Testing on the H1347-Associated Stacking Fixture after Weld Repair

The purpose of this testing was to determine the tensile loads required to fracture the welds on each end of the H1347-associated stacking fixture after the welds were cosmetically repaired by grinding out visible cracks and rewelding. These tests were conducted in April 1993, and are documented in SAND97-8260, Appendix E (Ref. 3).

A weld repair process was being considered as a cosmetic fix to repair visible cracks but lowered the breaking strength of the weld (see Table 5).

Table 5. Tensile test results after weld repair.

Test Number	Casting Mfg Code	End Tested	Breaking Strength (Pounds)	Type of Weld	Comments
1	AFG	Forward	49,000	GTA	Lowered strength
2	AFG	Aft	63,000	GTA	Lowered strength

Forward and Aft Loading of Bomb in H1347 Bomb Hand Truck to Simulate SST "g" Loading Requirement

The purpose of this testing was to determine if a safety issue existed when using cracked H1347-associated stacking fixtures in the Safe Secure Trailer (SST) transport environment of 10-g in the direction of travel. This test was conducted in February 1993, and is documented in SAND97-8261, Appendix A (Ref. 4).

Four tests were performed using a section of the B83 bomb with bomb lugs engaging the stacking fixture on the H1347 bomb hand truck. The first two tests were on a one-high stack configuration with the bomb nose in the forward direction of travel. The H1347-associated stacking fixture had the center section removed to simulate a worst-case condition where the weld had completely failed. Test loads of 50,000 pounds were applied to the bomb simulating a 20-g load (10-g requirement). Displacement of the bomb to the bomb hand truck was negligible.

The third test was on a two-high stack with the bomb nose in the forward direction of travel. The center sections of both H1347-associated stacking fixtures were removed. A test load of 60,000 pounds was applied to the upper bomb. Displacement of the bomb to the bomb hand truck was negligible.

The fourth test was on a one-high stack with the bomb tail in the forward direction of travel (10-g requirement) and the center section of the H1347-associated stacking fixture intact. The bomb started to slip relative to the bomb hand truck at a load of 25,550 pounds (10 g). At a test load of 30,000 pounds (12 g), the bomb had slipped 1.625 inches. The bomb lug slides under the center section of the stacking fixture. This test shows the stacking fixture is marginal in meeting the 10-g requirement in the forward direction of travel with the tail orientated in the forward direction. This led to a manual change to disallow tail-forward orientation of the bomb in the SST.

The 5-g requirement in the aft direction is met with a design margin of two when the bomb is oriented with the nose forward in the SST.

Conclusion and Recommendations Regarding the H1347-Associated Stacking Fixture

The conclusions reached from the testing program are:

a) Cracked welds on the stacking fixture do not constitute a safety concern for single- or double-stacked configurations if the bomb is orientated with the nose in the forward direction of travel (10-g requirement) for Safe Secure Trailer (SST) transport.

b) There is a safety concern when the B83 bomb is orientated with the tail in the forward direction of travel (10-g requirement) for Safe Secure Trailer (SST) transport. This concern is independent of whether or not any welds are cracked as the bomb lug slides under the center section.

c) Weld joint strength or quality is not improved by weld repair.

d) Product quality issues must be resolved for customer satisfaction.

Recommendations incorporated following the testing and evaluation program on the H1347 stacking fixture were:

a) Remove the restrictions in the response to UR Code No. 053HG0692. Use of H1347s with cracked (any length) stacking fixtures on over-the-road operations requiring tie down configurations was allowed. However, product shipped from DOE to the Air Force covered by Reprocessing Specification RS214073 limits the cracks to 2 inches in length in each of the four welds.

b) Make changes to the TP45-51D manual requiring the bomb to be orientated with the nose in the forward direction of travel in either the one- or two-high stack configuration for the Safe Secure Trailer (SST) transport. Tail-forward orientation in the direction of travel was eliminated.

c) Discontinue the weld repair development program on the H1347-associated stacking fixture at Allied Signal/FM&T.

d) Resolve product quality issues by designing a new stacking fixture, 457626-00, resulting in the H1347A bomb hand truck when incorporated. This stacking fixture was intended to replace the 450232-00 stacking fixture on the H1347 and the stacking fixture on the H695B. However, budget constraints limited the number of units built to 415 with 329 going on H695Bs and 86 on H1347s.

History of the H695B-Associated Stacking Fixture

Lead design efforts for the H695B-associated stacking fixture were directed by Larry Brown, 2265. This work started in late 1992 with the request from the Air Force for 391 additional bomb hand trucks. (In order to meet schedule requirements, it was agreed by DOE and the Air Force that the H695Bs would be designed for storage only.) The requirement was met by supplying 329 H695B bomb hand trucks processed from available H695As at Y-12. The remaining 62 bomb hand trucks were H1347s reprocessed at Y-12 as H1347 (-02).

Processing of the H695A bomb hand truck into the H695B is covered under SS214253. The major modification is converting the existing H695A-associated stacking fixture into the H695B-associated stacking fixture. The H695A-associated stacking fixture used for the B43 bomb had attachment points to lugs on the side of the bomb. The B83 requirement is to capture the forward bomb lug with the stacking fixture.

Two versions of stacking fixtures exist on the H695A defined by 172644 (casting) and 152782 (welded). The 172644 stacking fixture is modified per 249539 while the 152782 is modified per 249540. Both of these modifications require machining the lug cutout in the forward section of the stacking fixture and adding a 3/8-inch-thick aluminum plate to the top of the stacking fixture to capture the bomb lug. The plate is attached by 10-32 UNF screws in six places.

Load Testing

Load test results on this stacking fixture are documented in SAND97-8261, Appendix C (Ref. 4). Test results show the cast cradle started to fail at 27,800 pounds in the forward direction and 8,600 pounds in the aft direction equivalent to 11.1 and 3.4 g, respectively. Requirement is 10 g in the direction of travel and 5 g in the aft direction. The welded stacking fixture started to fail at 28,100 pounds in the forward direction and 8,200 pounds in the aft direction, equivalent to 11.2 and 3.3 g, respectively.

Development of the H1347A-Associated Stacking Fixture

Lead design efforts for the H1347A-associated stacking fixture (Figure 20) were directed by Karl Arnold, a Allied Signal/FM&T engineer on assignment to SNL/CA from February to December 1993. Karl assembled a team to brainstorm ideas on creating a new design. The team produced six proposals: two involved rework of the old design and four involved building new product. Lorenzo Asia, 2282, was instrumental in working out the details of each concept to determine its feasibility. The most attractive option involved bolting in the center section as opposed to welding in the center section. A prototype unit was built using modified castings from a used H1347-associated stacking fixture. Center sections were machined from 6061 and 7075 aluminum plates of various thickness (5/8, 3/4, and 1 inch), bolted to the modified cast end pieces, and tested in both forward and aft direction loading.

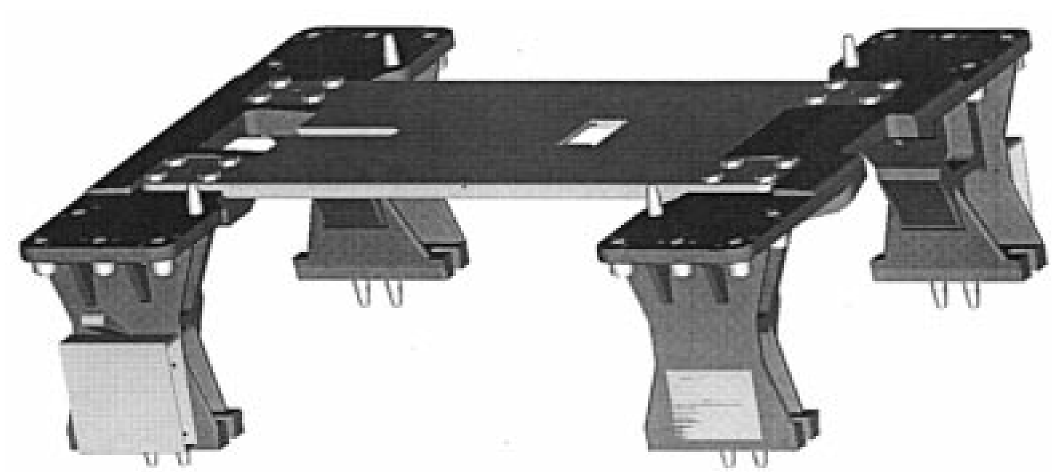

Figure 20. H1347A-associated stacking fixture.

The center section is the critical component in the design. Considerable emphasis was placed on improving the performance of the stacking fixture in the aft loading direction. The requirements are a simultaneous 10-g forward direction, 5-g lateral, and 2-g vertical load on the bomb weighing 2,500 pounds in a one- or two-high stack in the Safe Secure Trailer (SST). Aft direction loading requirement is 5 g. Our goal was to design the stacking fixture to two times the longitudinal load requirements. Since the manuals were changed to limit B83 transportation to a nose-forward direction only in the SST, our design goals were 50,000 pounds load capability in the forward direction and 25,000 pounds load capability in the aft direction.

Center Section Design and Test Results

The prototype stacking fixture proved to be a valuable asset in the development of the optimum center section design. The bolted configuration allowed experimentation with many different center sections and replication of the experiments. The prototype stacking fixture was used in approximately 16 tests to evaluate design changes. A summary of the stacking fixture development tests for the center section are shown in Table 6 below.

Table 6. Summary of stacking fixture development tests for the center section.

Center Plate Test Number	Thickness[1] (inch)	Direction of Load	Load (pounds)	Displacement		Comments
				Total[3] (inch)	Relative[4] (inch)	
One-High Stack Configuration						
1	0.625	Fwd	50,000	0.808		No visual damage
2	0.625	Aft	30,000	0.900		Lug slipped
3	0.625[2]	Aft	16,700	0.875		Lug slipped
4	0.625	Aft	30,000	0.910		
5	0.750	Aft	30,000	0.645		
6	0.750	Aft	30,000	0.620		
7	0.750	Aft	30,000	0.550	0.090	
8	0.750	Aft	30,000	0.550	0.075	
9	1.000	Aft	30,000	0.645		
10	1.000	Aft	30,000	0.700		
11	1.000	Aft	30,000	0.520	0.250	
12	1.000	Aft	30,000	0.515		
			50,000	1.020		
Assembly "B" Configuration						
13	1.000	Fwd	15,200	0.450		Lug slipped
14	1.000	Fwd	18,000	0.500		Lug slipped
			30,000	2.020	1.750	
15	1.000	Fwd	30,000	0.350	0.220	
Two-High Stack Configuration						
16	0.750	Fwd	60,000	0.655		

(1) All plates are 6061-T6 except as noted.
(2) 7075-T6 plate.
(3) Total displacement is stacking fixture movement with respect to the static frame.
(4) Relative displacement is stacking fixture movement with respect to the bomb.

The final design for the center section was stock 5/8-inch-thick 6061-T6 aluminum plate. Although the center section went through many iterations the following illustrates the major differences from the old design.

- The center section was bolted to the cast end pieces rather than welded. The cast end pieces are similar to the H1347-associated stacking fixture casting except for some added material in the region of the bolted interface.

- The center section was made from a single flat plate of 6061-T6 aluminum, 5/8-inch thick; no welded-on side flanges were used to increase flexural strength.

- The center section inner contour was changed from curved to flat. Contact with the bomb lug changed from curved to tangent.

- The cutout in the center section to engage the bomb lug was changed by adding material over the lug engagement area to increase aft direction loading capability.

Casting Design and Casting Process

The casting for the two end pieces for the H1347A-associated stacking fixture is defined by 457589. This is an aluminum alloy (A356-T6) dry sand casting per SS457589. Two castings are used for each stacking fixture assembly, one at each end of the flat center plate. These castings are similar to the 450237 casting used on the H1347-associated stacking fixture. One change is the addition of approximately 1 3/8-inch of material near the interface to the bolted-on center section. Material properties in critical areas of the casting are 28-ksi tensile strength, 20-ksi yield strength, and 2% elongation; while in noncritical areas requirements are 26-ksi tensile yield, 18-ksi yield strength, and 1% elongation. These properties are determined by cutting up castings to machine tensile bars. Requirements in SS457589 require one casting be cut up for each 100 castings produced for the first 500 castings and one casting thereafter for each 200 castings produced. Mechanical property requirements for as-cast integral tensile bars made with the castings require 34-ksi tensile yield, 24-ksi yield strength, and 3.5% elongation.

AlliedSignal/FM&T has the production responsibility to fabricate the H1347A-associated stacking fixture and contracted the casting of the two end pieces to Hitchcock Industries, Inc. located in Bloomington, Minnesota. The castings were produced over the time period from January 1994 to June 1996 with a total production of approximately 900. These supported the 415 stacking fixtures to be shipped from AlliedSignal/FM&T over the time period from October 1995 to February 1998 for the upgrade of the H695B and a portion of the H1347 bomb hand trucks to the H1347A.

The dry sand casting process involves making two cores for each stacking fixture casting using a gas activated binder (Isocure) process. The pattern for the casting is composed of two large aluminum boxes with positive replicates (made of epoxy-filled metal) of one half of the casting in each box. Main gating flow is created by aluminum passageways in each box. Riser areas are created by painted wooden inserts. Custom iron chills are placed in the pattern to achieve optimum material properties. The cope and drag molds are created by filling these two pattern boxes with sand, compacting, and removing the chemically bonded sand mold. (There are two castings per mold.)

The cores are placed within the sand molds and the molds are assembled together and sealed. A pouring trough is attached to the top of the mold to aid in stabilizing the introduction of liquid metal in the pouring step. After chemistry checks, the liquid metal is poured with hand ladles into the mold assembly. Approximately 220 pounds of metal is required for each mold (two castings). A disc for chemical evaluation is poured at this time. After pouring, the mold is allowed to cool.

The mold assembly is placed on a vibratory shaker that removes most of the sand material. Hand tools are used to remove any remaining mold material. The risers and gates are then removed from the castings with bandsaws. Integral appendages (test bars) are also cut off at this time and labeled for traceability.

Castings are heat treated and quenched to achieve a soft T4 condition. A fixture is used to help check for straightness of each stacking fixture casting. The castings are put in an aging furnace and taken to optimum material properties (T6 condition). The casting lot is now created and test bars are sent for on-site tensile testing.

Castings are 100% fluorescent penetrant inspected and undergo sampling for radiographic inspection. Defects can be weld repaired but reheat treating is then required, which will create a new casting lot. Castings are dimensionally inspected using fixture and/or hand gages. Certifications are checked and the castings are shipped. Included with each casting lot shipment are chem discs (one per melt), x-ray film, four appendages, hardness certs, and results from two tested appendages.

H1347A-Associated Stacking Fixture Testing Program

Vibration Tests to Qualify New H1347A-Associated Stacking Fixture

The purpose of this testing was to qualify the stacking fixture to vibration environments for B83 transportation. These tests were conducted in July 1995 and are documented in SAND97-8262, Appendix C (Ref. 5).

The B83 VTU-1 test unit assembly endured a five-hour, random vibration per the transportation vibration requirements in the z-axis. Post-test inspection of the H1347A-associated stacking fixture and the bolt pouches showed no irregularities or damage.

Structural Tests to Qualify New H1347A-Associated Stacking Fixture

The purpose of this testing was to qualify and assess the design margin of the stacking fixture to react the load of the B83 bomb through the bomb lug/stacking fixture interface for the SST requirements of 10 g in the forward direction of travel. Qualification tests to 5 g in the aft direction were also performed. These tests were conducted in July and August, 1995 and are documented in SAND97-8262, Appendix A (Ref. 5).

Four tests were performed: the first three on the H1347A-associated stacking fixture and the fourth on an H1347-associated stacking fixture. All tests were on a one-high stack configuration.

In the first test simulating the 2,500-pound B83 bomb, the nose was oriented in the forward direction of travel. Both bomb lugs engaged the stacking fixture. A test load of 75,000 pounds was applied to the bomb creating a 30-g load (10-g requirement) on the bomb lug/stacking fixture interface. Displacement of the bomb to the bomb hand truck was 0.17 inch.

The second test pulled the bomb in the aft direction where only the forward bomb lug interacts with the stacking fixture. A test load of 37,500 pounds was applied to the bomb creating a 15-g load (5-g requirement) on the bomb lug. Displacement of the bomb to the bomb hand truck was 0.32 inch at a 25,000-pound load and 1.20 inches at the 37,500-pound load. The bomb had started to slip but was still restrained by the stacking fixture.

The third and fourth tests were on a B83 assembly D configuration (tail section removed—equivalent bomb weight is 1,800 pounds). The bomb is shifted aft in the bomb hand truck so that the forward bomb lug engages a center cutout on the stacking fixture. The third test used the same H1347A-associated stacking fixture as used in tests one and two. In the fourth test, the set up was the same, but a H1347-associated stacking fixture was substituted as no previous data was available on this configuration.

In the third test, a test load of 72,000 pounds was applied to the assembly D creating a 40-g load (10-g requirement) on the bomb lug/H1347A-associated stacking fixture interface. Displacement of the bomb to the bomb hand truck was 0.98 inch.

In the fourth test on the H1347-associated stacking fixture, a test load of 36,000 pounds was applied to the assembly D creating a 20-g load (10-g requirement) on the bomb lug/H1347-associated stacking fixture interface. Displacement of the bomb to the bomb hand truck was 1.85 inches.

Conclusions Regarding the H1347A-Associated Stacking Fixture

The conclusions reached from the testing program are:

a) The H1347A-associated stacking fixture with the B83 bomb meets the SST requirement of 10-g loading in the forward direction of travel. With the bomb nose in the forward direction it was tested to a 30-g equivalent load. Displacement of the bomb to the bomb hand truck was 0.17 inch.

b) The H1347A-associated stacking fixture with the B83 bomb meets the SST requirement of 5-g loading in the aft direction. With the bomb nose in the forward direction it was tested to a 15-g equivalent load in the aft direction. Displacement of the bomb to the bomb hand truck was 1.20 inches.

c) The H1347A-associated stacking fixture with the B83 assembly D configuration meets the SST requirement of 10-g loading as it was tested to a 40-g equivalent load with 0.98-inch displacement.

Conclusion Regarding the H1347-Associated Stacking Fixture for Assembly D

The H1347-associated stacking fixture with the B83 assembly D configuration meets the SST requirement of 10-g loading as it was tested to a 20-g equivalent load with 1.85-inch displacement. This design is not as strong as the H1347A-associated stacking fixture.

Cradle and Caster Assembly Evaluation

The same cradles and casters are used on the H1347, H1347A, and H695B bomb hand trucks. There have been numerous URs involving cracks with the cradles and casters (see Table 2). Cracked welds in the female receptacle for the caster mounting bracket on the welded cradle (Figure 13) and cracked mounting brackets on the cast barrel caster (Figure 14) have been an issue.

The environments for the bomb hand truck include truck and trailer transport, towing, and forklift movements in both one-high and two-high stack configurations and aircraft transport in the one-high stack configuration. Vibration and shock requirements are found in the Stockpile-to-Target Sequence (STS) manual (Ref. 6) and the Manufacture-to-Stockpile Sequence (MSS) manual (Ref. 7). Worst-case environment in the vertical direction is estimated at approximately 5 to 7 g in the two-high stack configuration and 7 to 10 g in the one-high stack configuration.

Vertical load tests were performed on the cradle with casters to evaluate the effect of the weld cracks in the receptacle for the caster mounting bracket. The strength of the caster mounting bracket was also determined from these tests. Towing tests to measure shock and vibration inputs were also performed. A summary of the testing and analysis to evaluate the cradle and casters follows.

Structural Tests to Evaluate Weld Cracks in the H1347 Cradle Receptacle for the Caster Mounting Bracket and Strength of Caster Assembly Mounting Brackets

A series of structural tests to evaluate the weld cracks in the H1347 cradle receptacle for the caster mounting bracket was accomplished during September and October, 1993, and are documented in SAND97-8260, Appendix F (Ref. 3).

Vertical load and load cyclic testing of the cradle with four casters was performed. The first test used a welded cradle with no weld cracks. Four caster assemblies with cast A356-T6 aluminum mounting brackets were loaded to 27,300 pounds before the mounting brackets failed. Since a one-high stack weighs ~2800 pounds, this correlates to 9.8 g for the one-high stack configuration and 4.9 g for the two-high stack.

A second series of tests using a cradle with 1- to 2-inch weld cracks was load cycled to 11,500 pounds causing the cracks to grow 0.25 to 0.55 inch. Further cycling would not propagate the cracks any further. Eventual loading to 31,000 pounds was made with wrought aluminum mounting brackets (flat-sided casters) that yielded but did not fracture. A third series of tests starting with a cradle with no cracks cycled to 11,500 pounds (2 g) caused initiation and propagation of cracks. This correlates to 4.1 g for the one-high stack configuration and 2.0 g for the two-high stack configuration. This is well below the requirement of 10 g for the one-high stack and 7 g for the two-high stack.

The testing and analysis showed that cracks in the welded regions of the caster mounting positions on the cradle are expected to occur from normal usage of the bomb hand truck. The presence or absence of these cracks had no effect on the maximum vertical load capacity of the cradle or the casters. There are no safety concerns with regard to having cracks present in the welded regions of the caster mounting positions on the cradle. On SST transport, the bomb hand trucks are shored to prevent the loads from acting through the casters. Other preventive measures, such as limiting towing speeds and limiting the maneuverability of the bomb hand truck, were taken to reduce initiation and propagation of cracks in the cradle.

A change was made to the TP B83-1 manual to allow cracks up to 2.5 inches in length in the welded regions of each caster mounting position on the cradle.

Series of Towing Tests to Evaluate Towing a One-High Stack Configuration

A series of towing tests to evaluate a one-high stack configuration were accomplished during May 1995 and reported in SAND95-8253 (Ref. 8) and SAND 95-8253, Appendix C (Ref. 8). The purpose of the towing test was to characterize the shock and vibration experienced by the H1347 bomb hand truck and to determine the response of the B83 bomb and selected internal components when being towed at speeds up to 5 mph on hard surfaces having various surface characteristics. The data taken lead to a Power Spectral Density description of the vibration environment caused by towing. Post-test inspection of all hardware showed no irregularities or damage.

Towing Demonstration of a Two-High Stack Configuration

A towing demonstration to evaluate towing a two-high stack configuration was accomplished during November 1995 and reported in SAND95-8253 (Ref. 8). Results were to allow towing of a two-high stack configuration by a motorized vehicle using the H721 tow bar at a slow walking speed (approximately 1 mph) over smooth hard surfaces for distances not to exceed 1000 feet (see Table 3). Previous requirements were to tow a two-high stack only by hand. When crossing a ramp, this required higher speeds (up to 5 mph) to gain momentum that lead to higher shock inputs to the casters and cradle.

Analysis to Define Shoring Conditions for Truck/Trailer Transport

Truck/trailer transport requirements were analyzed and documented in a memo "B83/H1347 Shock Vulnerability to Air Force Restricted Base Transportation" by D. B. Nelson, 8283, to M. B. Loll, 5365, dated July 20, 1994 (SAND95-8253, Appendix A) (Ref. 8). Recommendations were made to require shoring for one- and two-high stacks at all speeds with the exception that no shoring is required for a one-high stack at speeds less than 20 mph (see Table 3).

12-Inch Drop Test of a One-High Stack B83/H1347 at 65° F

This test for information purposes to evaluate an STS requirement of a 12-inch drop of a B83 bomb in the bomb hand truck was conducted on March 14, 1996 and is documented in SAND97-8263, Appendix B (Ref. 9). The four caster assemblies on the bomb hand truck included three barrel casters with cast A356-T6 aluminum mounting brackets and one flat-sided caster with the mounting bracket made from 5456-H112 extruded aluminum tubing.

Test results showed the three cast mounting brackets fractured while the extruded mounting bracket severely yielded. These failures were expected as the casters are not required to survive the 12-inch drop. No damage occurred to the bomb or to the components within the bomb.

Conclusions Regarding the Cradle and Caster Assembly

The conclusions reached from the testing and analysis program are:

a) Cracks in the cradle mounting positions for the caster assemblies and cracks in the caster assembly mounting brackets may initiate and propagate under normal transport environments.

b) There are no safety concerns with regard to having cracks present in the welded regions of the caster mounting positions on the cradle. A change was made to the TP B83-1 manual to allow cracks up to 2.5 inches in length in the welded regions of each caster mounting position on the cradle.

c) There are concerns with cracks in the caster assembly mounting brackets. Current measures are to replace the caster assembly if cracks are found. Efforts are currently underway to strengthen the caster assembly mounting bracket to reduce or prevent cracks.

d) Other preventive measures, such as limiting towing speeds and limiting the maneuverability of the bomb hand truck, were taken to reduce initiation and propagation of cracks in the cradle and the caster mounting bracket.

Caster Mounting Bracket Evaluation and Redesign

Cracked Caster Brackets on the B83 Bomb Hand Truck

Cracked barrel caster assemblies used on B83 bomb hand trucks (H1347, H695B, and H1347A) have been reported through the UR system (Table 2) and observed during caster reprocessing at AlliedSignal/FM&T. Historical data at AlliedSignal from January 1994 through May 1997 showed 44 of 1464 (3%) of the caster assemblies reprocessed were found to have cracked mounting brackets. The cracks are occurring in a corner of the mounting bracket that contains a sleeve through which a quick-release pin is inserted (Figure 14). Resolution of the problem to date has been to replace the caster with one from base spares and to return the cracked caster to AlliedSignal/FM&T. The concern expressed by the Air Force is a potential disengagement of a broken caster from the cradle assembly causing an unstable condition for two-high stacks of B83s on the bomb hand truck. Observations from fracture tests show the quick-release pin had to be pulled before the caster assemblies could be disengaged from the cradle. A hook-like portion of the remaining bracket casting retained the sleeve preventing separation. However, we cannot be sure that this hook will always be present. Subsequent loadings could fracture the hook, or material flaws could result in a different fracture pattern where the hook may not be present. The customer (Air Force) would like to have a better product (Ref. 10).

Why the Casters Crack

Two versions of casters are found on the B83 bomb hand trucks. One type, known as the "barrel caster," has a cast A356-T6 aluminum alloy mounting bracket through which a steel sleeve is inserted with an interference fit. The second type, known as the "flat-sided caster," has a mounting bracket made from 5456-H112 aluminum alloy extrusion though which an aluminum sleeve has been welded into the bracket. The quick-release pin is inserted through the sleeve and attaches the caster to the cradle assembly on the bomb hand truck. All the cracks have been observed on the mounting bracket for the barrel casters. The flat-sided casters will yield when highly stressed but have not exhibited cracks.

High stresses and cracks generated in the corner of the mounting bracket in the area of the sleeve are the result of the following:

1) <u>Poor design</u>. The location of the quick-release pin and sleeve is very close to the edge of the mounting bracket. The resultant loads act through this thin section of material. Also, the interference fit of the steel sleeve to the cast aluminum mounting bracket generates significant stresses and can result in local yielding of the mounting bracket. The design and materials (A356-T6 aluminum) used in the mounting bracket are inadequate to accommodate these loads and stresses. Failure of the brackets occurred at 27,300 pounds vertical load on the bomb hand truck or approximately 4.9 g for the two-high stack configuration (Ref. 3). Estimated vertical load requirements for a two-high stack configuration is approximately 7 g or 40,000 pounds.

   This estimated requirement comes from truck transport environments found in the Manufacture-to-Stockpile Sequence, SAND83-0480, Figure 3.19, for Truck Superimposed Shock Response Envelopes—3% Damping (Ref. 7). In the low frequency range, 4-7 hertz, applicable to the bomb hand truck, shock response in the vertical direction is 7g. Also, forklift setdown shocks could be high as well as some shocks experienced during towing. We believe the vertical shock environments the hand truck actually experienced were approximately 5 g as supported by the failure observations.

2) <u>The bomb hand truck is old</u>. Most casters have been in use for many years (since the early 60s) and probably have developed cracks through normal use. The casters were originally designed for use with the B43, which is approximately 350 pounds lighter than the B83 (700 pounds difference in a two-high stack).

3) Two-high stack towing, truck/trailer transport, and forklift handling. Increased loads on the lower set of casters result when moving or transporting a two-high stack configuration of B83s. Total weight on the lower caster set is approximately 5600 pounds. The process of stacking or unstacking by forklift can generate shock loads on the casters if the "set down" movement is not smooth. Steps have been taken to reduce vibration and shock loads to the casters by limiting towing and truck/trailer transport speeds (Table 3).

The Options

Option 1: Disallow two-high stacking.

This is a totally unacceptable option as stated by the Air Force and one they will strongly resist. Storage space limitations in the depots drive this position. This option would create an unhappy customer.

Option 2: Continue current position.

The current position is to replace a cracked caster with one from base spares and return the cracked caster to AlliedSignal/FM&T under the base spares repair authorization. This position would be tenable in the short term if the incidence of cracked casters remained low and the supply of casters was not exhausted. However, this position ignores the customer's desire for a better product.

Option 3: Redirect the load path.

The mounting bracket fits loosely into a cavity on the cradle with the quick-release pin used to locate and position the bracket. A fulcrum point near the cavity entrance for the bracket leverages the load, which reacts through the quick-release pin. This load could be redirected into the cradle and away from the quick-release pin by adding shims to the bottom of the mounting bracket. However, large tolerances on the piece parts make it nearly impossible to ensure complete interchangeability of casters if shims are added to the mounting brackets. Another method to unload the quick-release pin would be to reduce the diameter of the pin or increase the inside diameter of the sleeve.

Option 4: Redesign and implement stronger caster mounting brackets.

A caster redesign focusing on a stronger mounting bracket by adding more material in critical areas, using a higher strength casting material, and using improved casting processes is a more viable option than redirecting the load path. Also, increasing the width of the mounting bracket and tightening the caster mounting bracket tolerances would reduce the clearance to the cavity on the cradle assembly. This will reduce a twisting effect of the mounting bracket within the cavity due to the wheel offset. A desire to retain the current cradle interface also puts limits on the design options.

Other considerations: Use of flat-sided casters.

The flat-sided casters have the mounting bracket made from extruded aluminum tubing (5456-H112), which is more ductile than the A356-T6 or A355-T6 aluminum casting used for the barrel casters. Using flat-sided casters resolves the cracking problem but does not change the fact that yielding will still occur under heavy loads. The inventory of flat-sided casters is only adequate to populate approximately 15-25% of the inventory. There are approximately 750 to 800 bomb hand trucks in the Air Force inventory.

Redesign, Analysis, and Testing of a Stronger Mounting Bracket

Option 4 is being pursued. A caster redesign program has been completed resulting in a stronger mounting bracket (Figures 21 and 22). Geometry changes to add more material in critical areas, reducing the interference fit between the steel sleeve and bracket, use of a higher strength casting material (A357-T6 aluminum), and improved casting processes resulted in prototype caster mounting brackets that have been tested to above 8 g (46,000 pounds) without failure. These tests were accomplished during March 1997 and reported in SAND97-8263, Appendix A (Ref. 9).

Structural models using the ABAQUS code were used to understand the stress distributions first for the existing design with the A356-T6 aluminum and then for the stronger design using A357-T6. The effect of the maximum interference fit of 0.006-inch between the steel sleeve and the cast aluminum mounting bracket for the existing design is shown in Figure 23. A stress of nearly 40,000 psi can result from the press fit with no vertical load on the assembly. At a 27,300 pounds vertical load (4. 55-g load for 6000 pound two-high stack as used in the analysis) the stress is above 40,000 psi regardless of the interference fit. The 27, 300-pound vertical load is the test failure load for this design. The vertical g-load requirement of 5 to 7 g has not been met.

A comparison of the stresses has been made for the current mounting bracket with A356-T6 properties (Figure 24) and the stronger design using A357-T6 (Figure 25) at a 5-g vertical load. (See Table 7 for the material properties.) The former shows a large area exceeds the 38, 000-psi ultimate strength of the A356-T6 material. The stronger design with an ultimate strength of 50,000 psi shows a stress level of approximately 20,000 psi, a design margin of 2.5 at the 5-g level. We estimate the design margin at approximately 1.8 at the 7-g requirement.

The prototype mounting brackets with the A357-T6 aluminum casting material were fabricated at Hitchcock Industries Inc. in Bloomington, MN. Design changes included:

a) Adding more material to the end of the mounting bracket.

b) Increasing the width of the mounting bracket and tightening the tolerances reducing clearance to the cavity on the cradle assembly. This reduces twisting of the mounting bracket within the cavity under heavy loads.

c) Filling in the space between the two walls of the bracket in the region of the steel sleeve. A supporting web was also added inside the bracket (Figure 22).

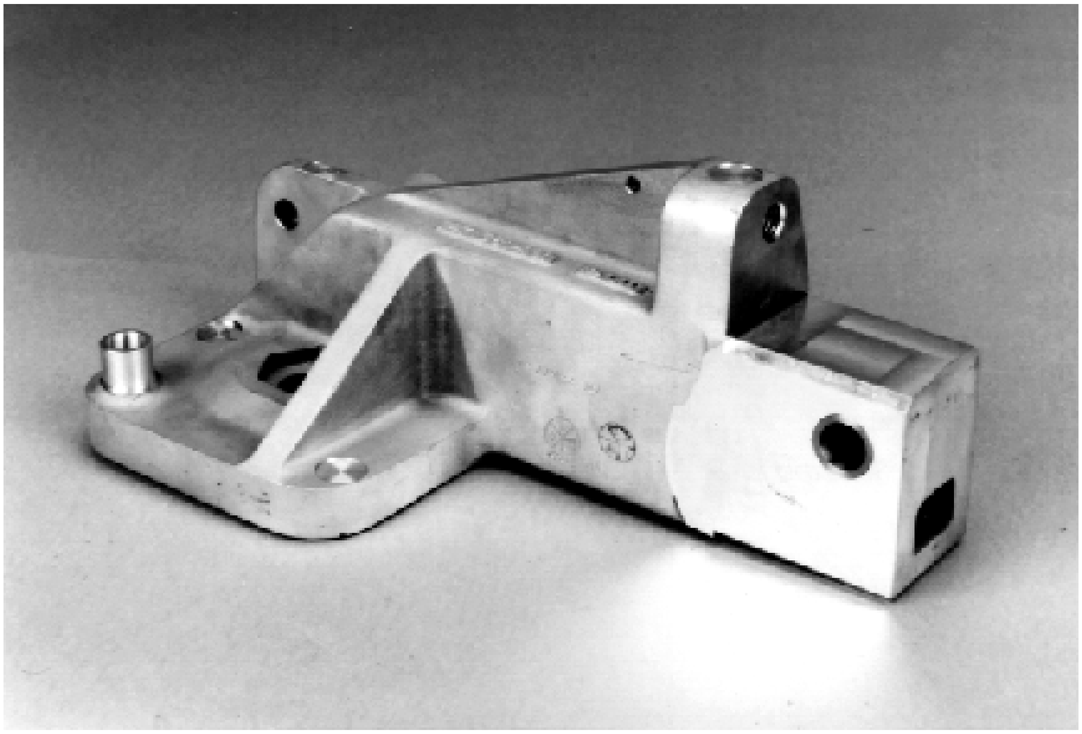

Figure 21. Prototype of a stronger caster mounting bracket (A357-T6).

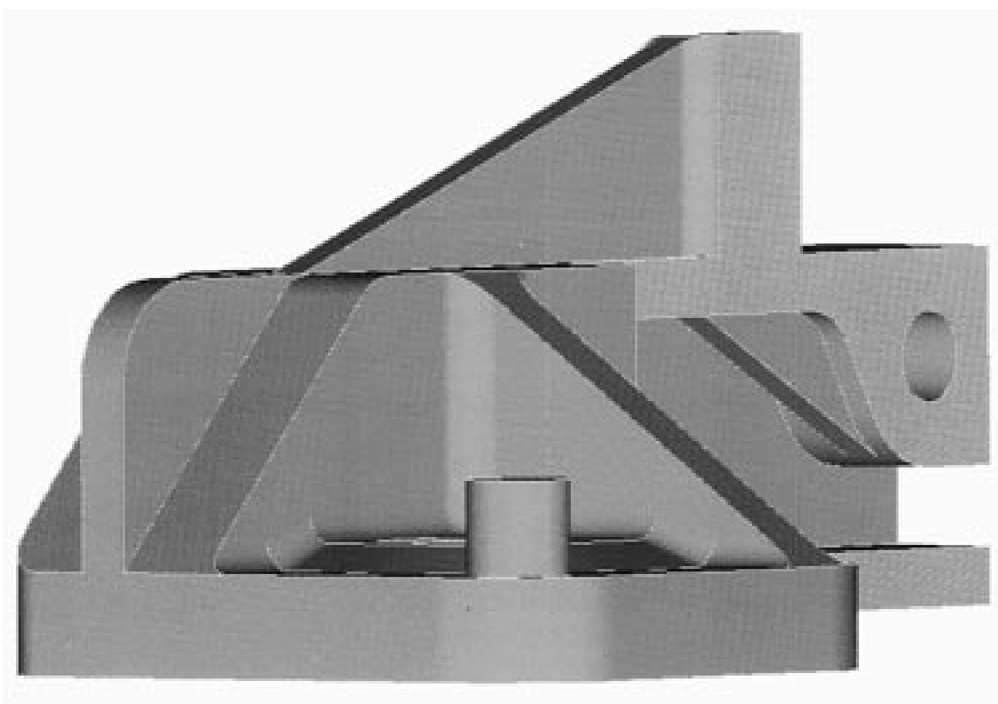

Figure 22. Cutaway of prototype caster mounting bracket.

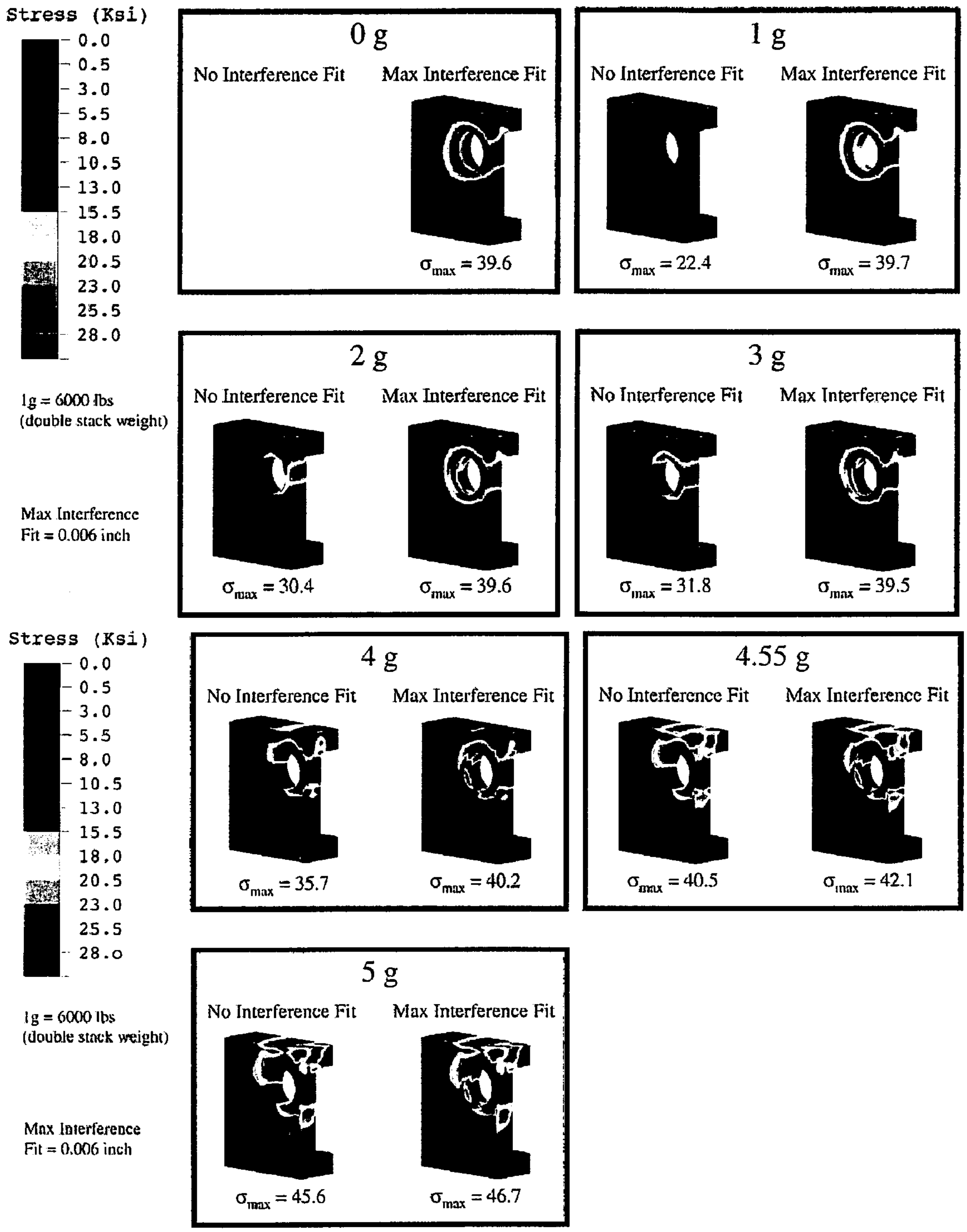

Figure 23. Effect of interference fit between steel sleeve and A356-T6 aluminum mounting bracket.

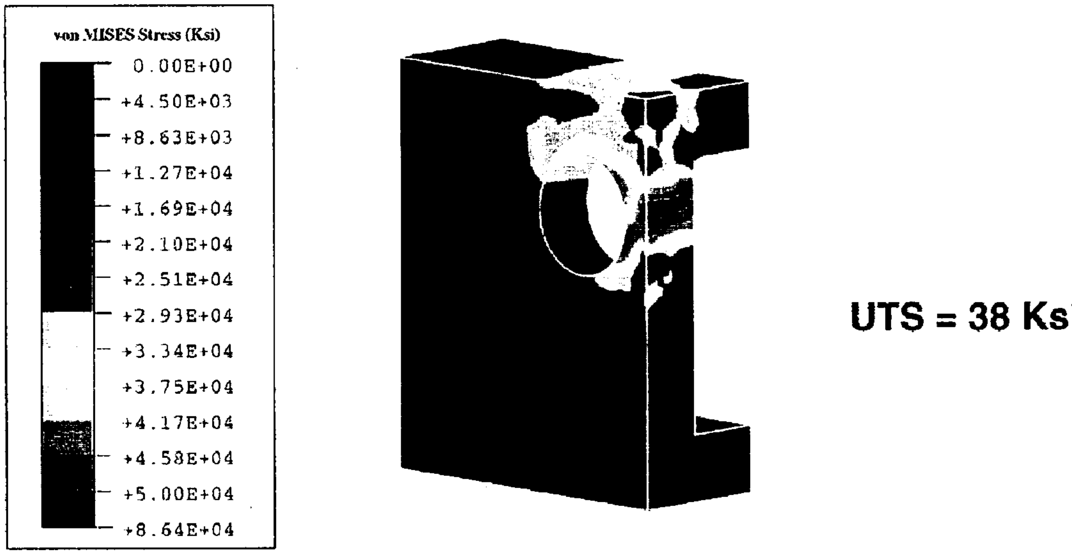

Figure 24. Stress distribution in current mounting bracket (A356-T6 aluminum).

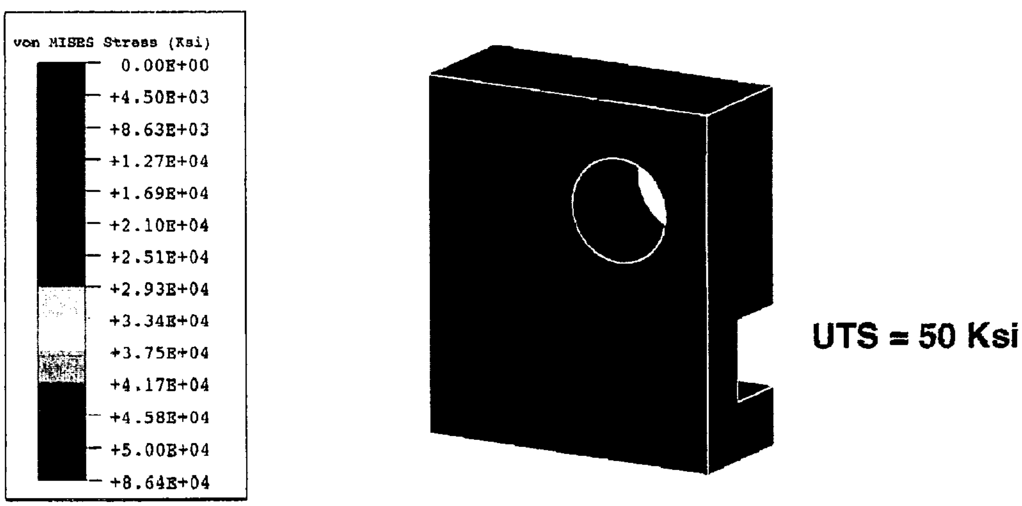

Figure 25. Stress distribution in stronger mounting bracket (A357-T6, aluminum).

Table 7 shows the tensile properties for the A357-T6 cast material for the prototype brackets and compares it to the A356-T6 cast material used on the barrel casters. The properties of the H5456-H112 used for the flat-sided caster mounting bracket are also shown.

Table 7. Aluminum material properties.

	Barrel Type Caster				Flat-Sided Caster	
	A356-T6 Casting (Current Design)		A357-T6 Casting (Prototype)		5456-H112 (Wrought) (Current Design)	
	Spec.	Test	Spec.	Test	Spec	Test
Yield Strength (ksi)	28	31	40	43	24	27.5
Ultimate Strength (ksi)	38	38	50	53	45	51
Elongation (%)	5	3	5	6-9	22	17

The improved casting process greatly reduced the void content of the prototype A357-T6 castings over those made with the A356-T6 castings produced in the 1960s timeframe. Metallographic samples using image analysis techniques were made on the A356-T6 and A357-T6 brackets (Ref. 11) with the results shown in Figures 26 and 27 respectively. The A356-T6 castings show an average void content of 1-1.5 % with some areas as high as 3%. Void sizes for the A356 casting averaged 0.5 mm but some were as large as 1.0 mm. The A357-T6 castings had negligible void content. The reduction in void content resulted in 6-9% elongation test results for the A357-T6 compared to the 3% obtained for the A356-T6 (see Table 7).

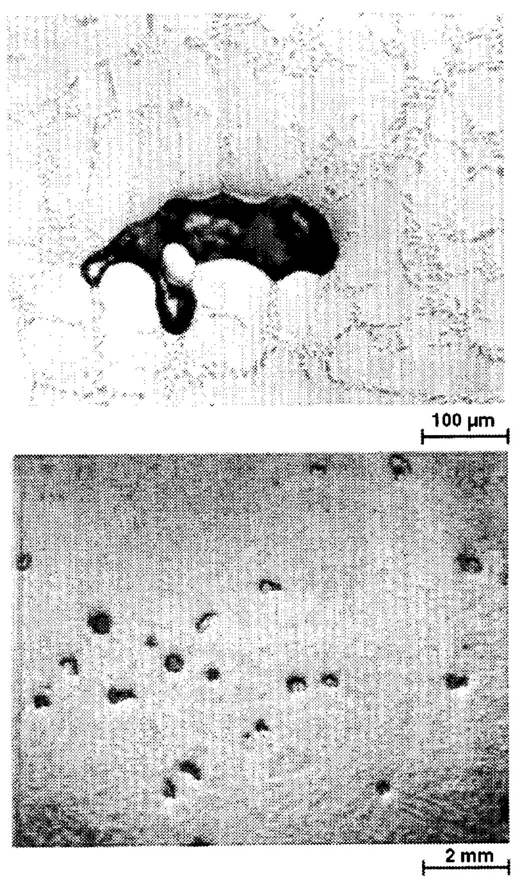

Figure 26. Voids in A356-T6 aluminum casting.

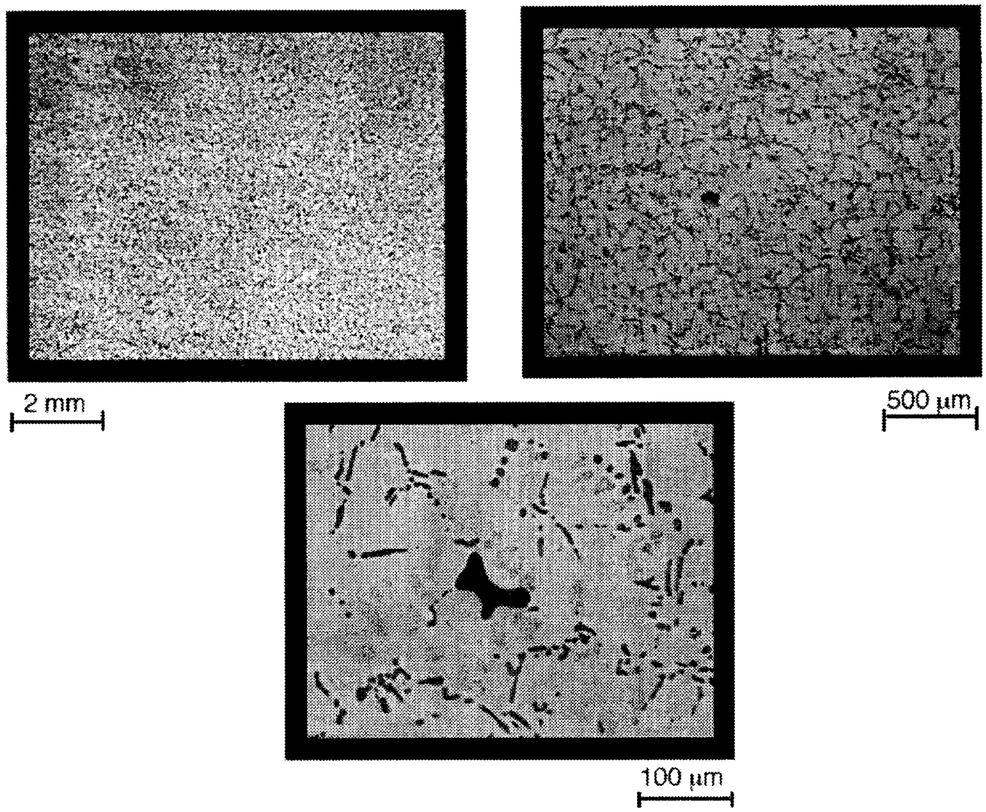

Figure 27. Voids in A357-T6 aluminum casting.

Prototype caster tests on the A357-T6 mounting brackets duplicated the test set-up to that previously used for the casters with A356T6 and 5456-H112 brackets. Prototype test results are documented in SAND97-8263, Appendix A (Ref. 9) and show the test was stopped at 47,000 pounds vertical load when the welds in the bracket cavity on the cradle assembly begin cracking. No damage resulted to the caster mounting bracket. This is equivalent to 8.2 g for the 5600-pound two-high stack and meets our expected 5- to 7-g requirement for that configuration.

This compares to 27,300 pounds (4.9 g) vertical load capacity for the barrel casters using A356-T6 and 31,000 pounds (5.5 g) for the flat-sided casters using the 5456-H112 aluminum. These tests are documented in SAND97-8260, Appendix F (Ref. 3). The A356-T6 casters fractured in the region of the sleeve for the quick-release pin while the 5456-H112 material showed severe deformation in this area but did not fracture.

Production drawings for the new swivel caster assemblies (A357-T6) being generated by AlliedSignal/FM&T are defined by P/Ns 458695 and 458696. These drawings will be called out as alternates to the existing caster assemblies (A356-T6 and 5456-H112) at the cradle assembly level.

Implementation Options and Recommendations

Cracked caster assembly mounting brackets are viewed as a potential personnel safety concern. The scenario postulated is that a fractured caster mounting bracket could result in the caster assembly separating from the bomb hand truck during movement of a two-high stack of

B83s causing the stack to topple. Although field experience suggests the risk is low, it is difficult to quantify, and we cannot guarantee the events will not happen. We believe the sequence of events resulting in a fractured mounting bracket separating from the bomb hand truck is possible. A two-high stack of B83 bombs supported by only three casters on the bomb hand truck is unstable and will topple if the weight shifts in the slightest towards the missing caster.

We also view the caster assembly with the current mounting bracket as inadequate to meet the long-term handling and transport requirements for the B83 bomb. Continued occurrences of cracks are expected.

A redesigned prototype mounting bracket has been evaluated and meets the handling and transport requirements with ample design margin. Implementation of the new design would resolve the cracking problem and satisfy customer requests. The new mounting bracket will provide a serviceable product over the expected B83 life.

Cost and schedule estimates by AlliedSignal/FM&T are approximately $1600-1700 per caster assembly with first delivery approximately 15 months after authorization and funding. Production rates are estimated at 60 per month maximum. Upfront tooling is estimated at approximately $175,000 (Ref. 12).

We recommended that AL develop plans to implement the redesigned caster mounting bracket. As a minimum all caster assemblies shipped from DOE (spares, rebuilds, JTAs, etc.) should incorporate the new mounting bracket. These quantities are estimated at 50 to 100 caster assemblies per year. Cost would be approximately $175K for tooling and $170 K a year for production of 100 casters.

Long term goals should be to replace all caster assemblies in the field. This would require approximately 3000 caster assemblies and cost approximately $5M over a 4-5 year period with a production rate of 60 caster assemblies per month. Replacement priority should be given to locations with B83 Mod 1 bombs.

We made the above production recommendations to DOE (Ref. 13). These recommendations are being considered but funding is an issue. In the meantime, we will continue the current practice of replacing cracked caster assemblies when they are discovered with ones from base spares inventory.

Additional Testing to Support the Quality Improvement Program

Tensile Tests on Cracked Stacking Fixture Bolts

Tensile tests to evaluate stacking fixture bolts were accomplished during January 1993 and reported in SAND97-8264, Appendix C (Ref. 14). The purpose of the test was to determine if longitudinal cracks discovered in bolts (Figure 16) and reported by URs exhibited lower tensile data than uncracked bolts. The bolts are MS90728-172, Grade 8 material, 0.625-11 UNC-2A thread by 4 inches length.

Test results show no differences in strength between the cracked and uncracked bolts. Since the cracks are longitudinal, they do not affect the tensile properties. The bolts yield at 30,000 to 35,000 pounds and exhibit an ultimate strength of 35,000 to 40,000 pounds.

A memo "Failure Analysis of Shipping Dolly Bolt" from B. C. Odegard, 8312, to J. D. Huntting, 8162, dated May 24, 1990, documented in (SAND97-8264, Appendix D (Ref. 14), reports the cracks are quench cracks resulting from the heat treat schedule. They occur because of high tensile stresses generated during the quenching process. Cracking occurs when the internal stresses are sufficient to exceed the tensile strength of the as-quenched part at the outer surface. Any conditions that concentrate the stresses, such as sharp discontinuities, will promote the formation of quench cracks.

As part of the quality improvement program of the B83 bomb hand truck, all stacking fixture bolts were replaced with new bolts (456290-00), which are Grade 5 and not susceptible to quench cracking.

Structural Evaluation and Qualification of New H1640 Castering Tool

The H1640 castering tool (Figure 28) was designed to rotate the caster assembly on the B83 bomb hand truck replacing the H631 and H1216 tools, which could damage the housings on the barrel casters. The new tool engages the wheel across the hub (Figure 11) rather than on the caster frame. The forks on the H631 and H1216 were designed to engage the flat-sided caster yoke (frame) and results in gouges on the curved frame for the barrel casters

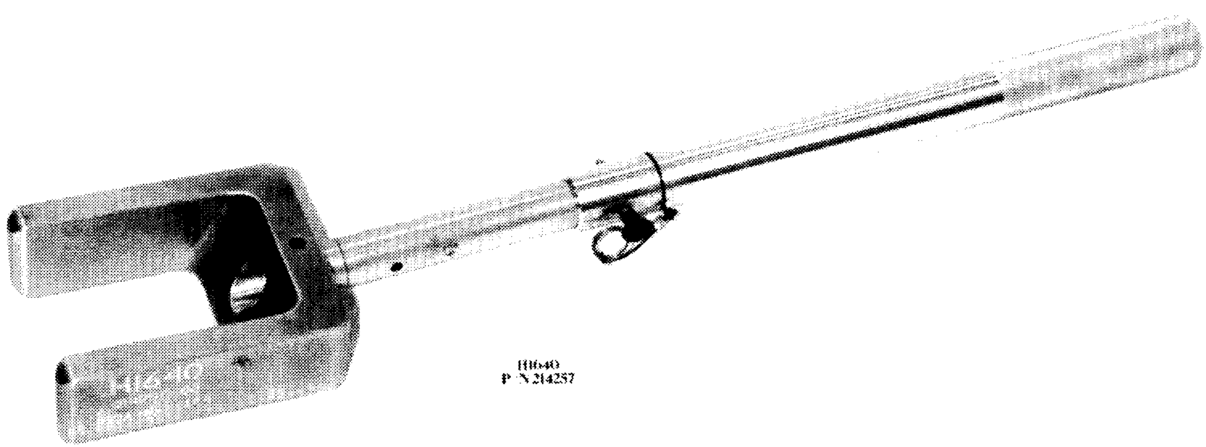

Figure 28. H1640 castering tool.

A series of structural tests to evaluate and verify design characteristics of the H1640 caster tool were conducted in 1994. Design and qualification tests are documented in three reports: SAND97-8264, Appendix A, B, and C (Ref. 14).

A development Sandia report on the H1640, SAND97-8291, has been published by L. A. Brown (Ref. 15).

Temperature Testing on Decals

The use of decals as part of the quality improvement program was incorporated on the 214073-03 version of the H1347 and on the 214253-00 H1347A bomb hand trucks as an alternative to painting. Photosensitive anodized aluminum with adhesive coating decals were used to mark the bomb hand truck identification on the stacking fixture (decal P/Ns 457637 and 457703), to mark the cradle assembly part number on the cradle (P/N 457639), and to mark reprocessing information (P/N 457640). A “Lift Here” decal (458229) to indicate forklift tine position used on the cradle assembly is made from polyester-backed plastic film with 0.005-inch adhesive (3M Dynamark II).

The decals were mounted on typical surfaces and temperature cycled from -55^{o}C to 75^{o}C for a 22-day cycle and then held at 75^{o}C for an additional 21 days. The tests for the aluminum decals are reported in SAND97-8264, Appendix K (Ref. 14). The decals were intact and showed no irregularities after testing.

Testing for the polyester-backed “Lift Here” decal is given in two reports: SAND97-8264, Appendix L and Appendix M (Ref. 14). The first test at 6^{o}C for 168 hours followed by 77^{o}C for 75 hours showed the corners of the decals could be lifted up by fingernail pressure. The adhesive thickness was 0.001 inch. The second test evaluated 0.001- and .005-inch adhesive for the same thermal conditions. The 0.005-inch adhesive made it much more difficult to peel up the corners on the decals. Recommendations were to use the thicker adhesive for the WR parts.

In late 1997, the “Lift Here” 3M Dynamark II material could no longer be purchased requiring an alternate selection. Evaluation tests were then conducted with a 0.002-inch thick vinyl (referred to as “CAST” material) with 0.002-inch thick acrylic adhesive and also on 0.0036-inch vinyl (“CALENDAR” material) also with 0.002-inch acrylic adhesive. These tests were run in December 1997, at SNL/CA. Candidate decals were mounted on bomb hand truck cradle surfaces (aluminum) and temperature cycled from -55^{o}C to 75^{o}C for a 22-day cycle and then held at 75^{o}C for an additional 21 days. The “Calendar” material with a 0.001-inch glossy overlaminate was selected based on ease of application and the ability to not show substrate imperfections through the decal. The thinner decal was more difficult to handle and showed the substrate artifacts. The adhesive bonded well to the substrate for all samples. Test results have not yet been documented.

Summary and Conclusions

Many problems reported by the customer have been resolved by improvements made to the B83 bomb hand trucks. Some of the problems resolved were casters binding on the stacking frame, casters unlocking from the swivel lock position during transportation, poor condition of the casters, broken helicoils on the retaining plate to hold the stacking fixture bolts, longitudinal cracks in the stacking fixture bolts, damage to the caster frame from the castering tool, allowing decals for marking thereby eliminating painting, and incorrect manual callouts.

Other issues such as weld cracks in the H1347-associated stacking fixture and weld cracks in the caster receptacle on the cradle assembly were resolved by analysis and testing to address safety concerns. Results were to allow weld cracks of any length on the stacking fixture and cracks up to 2.5 inches in the welded regions of each caster mounting position on the cradle.

A lack of bomb hand trucks for storage of B83 bombs was resolved by processing 329 H695As into H695Bs to be used for storage only. These hand trucks were then converted into H1347As by fabricating new stacking fixtures that contained no welds.

Many changes were made to the towing and truck/trailer transport requirements to minimize shock and vibration inputs to the bomb hand truck thereby minimizing the extent of cracked welds and cracked caster mounting brackets.

The problem of cracked caster mounting brackets is being addressed with a prototype design of a stronger caster design tested with excellent results. Production drawings of the new caster assembly have been prepared. Recommendations have been made to implement the new mounting bracket. However, until the caster mounting brackets are replaced with the stronger design, possible service problems may be anticipated with a worst case scenario leading to a potential personnel safety risk.

In conclusion, the bomb hand truck has been in service for many years and has experienced a number of problems in its application for B83 use. Many fixes and improvements have been made to resolve the problems. Serviceability of the bomb hand truck is expected to be greatly improved over the expected B83 lifetime extending to 2025.

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