

Amersham International plc

Packaging Design Group

Test Report No. 1901

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.0m Puncture (Drop II).

1.3 Procedure PGP 55, Issue 1.

1.4 Orientation The cask was slung at an angle of 24° from the vertical, placing the centre of gravity over the point of impact (fig 1).

1.5 Location of impact The impact point was the lower edge of the cask shell, midway between two feet and avoiding the base fins (fig 2).

1.6 Special conditions The Test Plan (ref 6.3) required the package to be tested at -40°C.

1.7. Notes

1.7.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The cask had been damaged in the previous 1.2m and 9.0m drop tests (Tests 1989 & 1900) as required by the Test Plan (ref 6.3). The damage was limited to minor indentations on the base fins.

(3) Although the Test Plan called for the whole package to be tested the pallet and cage were omitted in order to subject the cask to a more severe impact. This with the agreement of the DoT witnessing engineer.

1.7.2 Orientation:

(1) Angle: The orientation required in the test plan was vertical. It was decided to change this to 24° off the vertical as it would bring the centre of gravity over the point of impact thereby imparting the maximum shock load. This with the agreement of the witnessing DoT engineer.

(2) Control: The orientation of the package was controlled by a two leg sling adjusted by means of a turnbuckle on each leg.

(3) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level against the cask jacket.

(4) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.7.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range: -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature. Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure. After the previous 9.0m drop test, Test 1900, only two of the thermocouples were giving readings (Nos. 1 & 4).

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

1.7.4 Target:

The target was 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

1.7.5 Punch:

The punch was a third scale, carbon steel bar welded vertically to a plate bolted at each corner to the target. A 75 mm long bar was used. The bar protruded slightly below the plate to ensure positive contact with the target plate (see also Drg No. A25230, Issue A).

1.7.6 Secondary impact:

A plywood sheet was placed next to the punch to avoid distortion of the cask feet should it land on them. This would have made assembly to the pallet difficult for the further tests. Normally secondary damage would be considered part of the test but, as the package was to be subjected to a 9.0 m side drop in Test 1908, the protection was considered acceptable. This with the agreement of the DoT witnessing engineer.

2 Pass/Fail Criteria

2.1 Closure

The cask closure must remain attached to the cask body.

2.2 Jacket

The jacket must remain attached to the cask.

2.3 Notes

The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
Cask closure studs	217554/04	1-8	-	-
Punch (short)	212750/01	-	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Torque wrench: Norbar Model SLO	-	-	30	10/01/97
Height gauge: 1.0m	-	-	31	08/01/97
Level: RS Stock No. 651-428	-	-	34	08/01/97

3.1.2 Notes:

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any measuring equipment used.
- (5) The QC No. is the identify of specific measurements records made by the Packaging Design Group.

3.2 Assembly

The third scale 3750A cask was assembled prior to Test 1898 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C.

3.3 Records

3.3.1 Photographic:
See Appendix A.

3.3.2 Video:
(1) Film No. 23, Start time 47min 50sec.
(2) Film No. 24, Start time 07min 10sec.

3.3.3 Operational:
See Appendix B.

4 Results

4.1 Temperature

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-42.6
2	No reading
3	No reading
4	-43.0
5	No reading

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed on the punch, bounced upwards approximately 50 mm, landed back on the punch impacting the lower edges of the adjacent cooling fins, rotated over its base onto two feet and fell onto its side (fig 3).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached.

4.4 General observations

4.4.1 Cage: Not applicable.

4.4.2 Pallet: Not applicable.

4.4.3 Cask body: The cask and jacket were undamaged except for a bruise on the lower edge of the cask shell 35 mm long x 5 mm maximum width (fig 4). The test caused no damage to the base fins, the base plate, its weldment or the leak test point. The edges of the cooling fins nearest the shell bruise were indented to a maximum depth of 3 mm over a 15 mm length (fig 5). All eight closure studs and nuts were undamaged, secure and unscrewed freely. All twelve jacket screws were undamaged, secure and unscrewed freely.

4.4.4 Cask closure: The closure was undamaged.

4.4.5 Punch: The punch carried an indentation 30 mm across by 6 mm wide and 2 mm maximum depth (fig 6) indicating a good impact and two fainter marks from the fins.

5 **Conclusions**

5.1 **Pass/Fail**

The package passed the test.

5.2 **Other**

None.

6 **References**

6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(b).

6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(2).

6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.2.5.

6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author: DW Raper Position: PKG ENGR Date: 16/02/96

7.1 Checked: [Signature] Position: Project Controller Date: 16.02.96

Appendix A

Photographs

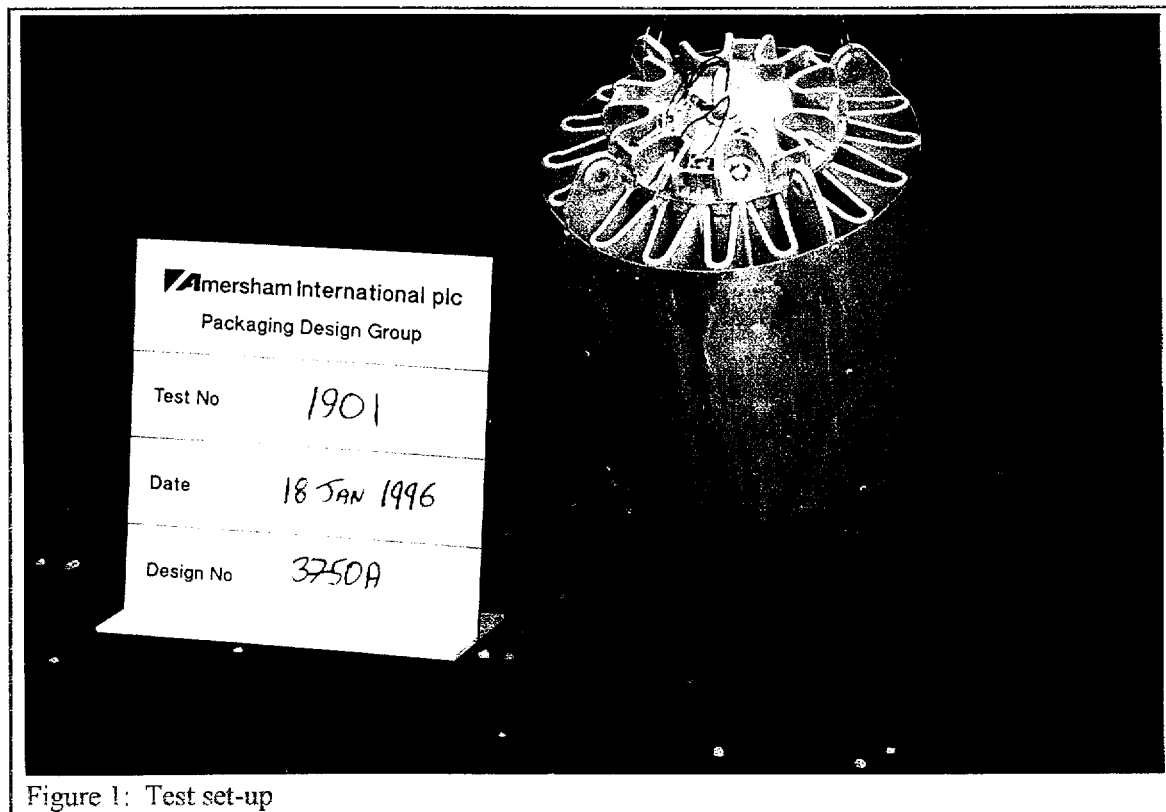


Figure 1: Test set-up



Figure 2: Cask base-to-punch orientation

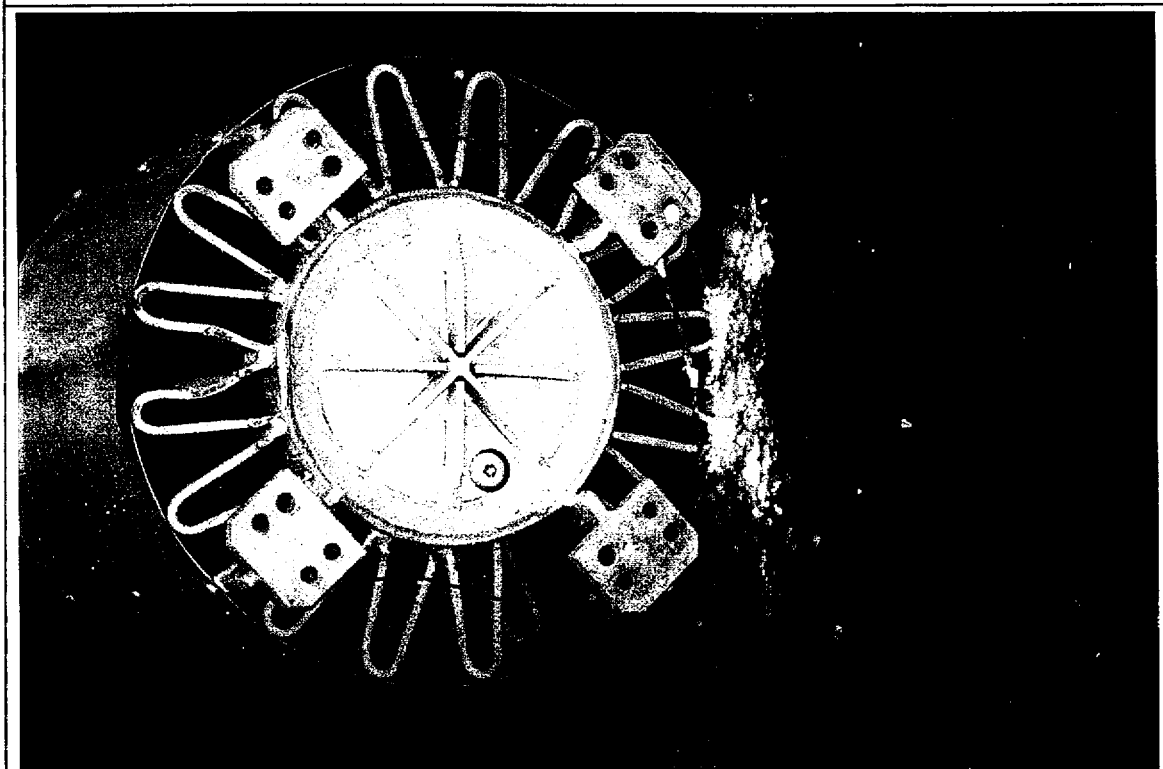


Figure 3: After impact



Figure 4: Cask base showing bruise to shell



Figure 5: Cask base showing secondary indentations to cooling fins

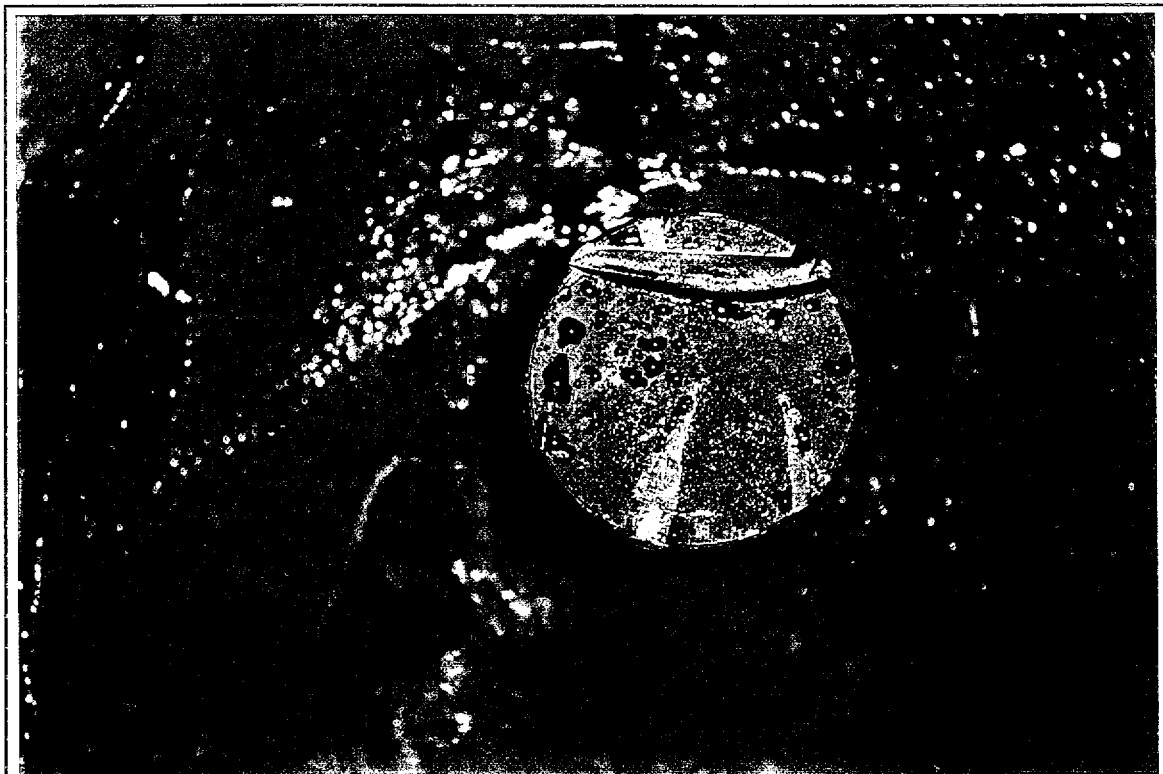


Figure 6: Punch face after impact

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Puncture Test Check List

Test No: 1901

Date: 18 JAN 96

1. Notes:

- a) This checklist forms the operations section of PGP 55, Packaging Group Procedure for Puncture Testing. If in doubt ask.
- b) A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c) Check hoist cable weight is lowered onto the target plate before entering compound.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm punch is rigidly mounted	✓
6	Confirm sample is correctly orientated ***	✓
7	Photograph sample just over punch (optional)	✓
8	Raise sample to test height	✓
9	Record height between punch and impact point	1.00 metre
10	Remove all non-essential personnel from compound	✓
11	Start video	✓
12	Drop sample	✓
13	Confirm impact point is correct	✓
14	Record damage to sample with video	✓
15	Take still photographs (optional)	✓

* Delete as appropriate

** PALLET AND FRAME OMITTED TO REPRESENT WORST CASE

*** CASK ANGLED BY HANGING FROM TWO ADJACENT LIFTING POINTS. PUNCH AIMED TO LOWEST COOLING FINS TO MAXIMISE BASE LOADING.

4. Notes:

TEST PLAN NO : PGM 921, ISSUE 3 (PARA 8.2.5)

MODEL 3750A : GRN NO 217554/04

HEIGHT GAUGE : TOOL NO 31

PUNCH (SHORT) : GRN NO 212750/01

TEMP RECORDER : TOOL NO 27

FILM NO 23 : START TIME - 47 M 50 S.

FILM NO 24 : START TIME - 7 M 10 S.

LEVEL : TOOL NO 34.

TEMP READINGS AT DROP

T/C NO 1 : -42.6°C

T/C NO 2 : _____

T/C NO 3 : _____

T/C NO 4 : -43.0°C

T/C NO 5 : _____

TIME OF DROP : 12.06 AM

ANGLE OF DROP : 24° FROM VERTICAL

5. Personnel:

Conducted: DW Rogers

Posn: PKG ENGR.

Witnessed: P S Savin

Posn: Quality Manager.

Amersham International plc

Packaging Design Group

Test Report No. 1902

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.2m Free Drop.

1.3 Procedure PGP 15, Issue 5.

1.4 Orientation At 36.4° from the vertical inverted with the centre of gravity over top edge of cage (figs 1-3).

1.5 Notes

1.5.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The package was not repaired in any way after Series 1 (Tests 1898, 1900 & 1901). The principal damage from these tests was local crushing of the pallet under the cask feet and partial crushing of the pallet shock absorber. This was considered to be of no significance in an inverted package orientation test series. This with the agreement of the DoT witnessing engineer.

(3) The pallet screw holes around the lower edge of the cage were drilled out by 1.5 mm to facilitate assembly. This with the agreement of the DoT witnessing engineer.

(4) Four small lugs were added to the underside of the pallet to facilitate slinging (fig 4). This with the agreement of the DoT witnessing engineer.

(5) Five thermocouples were added in readiness for the following tests, Tests 1904 & 1905, and the cables lead out through a small hole cut in the lower right hand corner of the mesh panel on side No. 2 (fig 2). This with the agreement of the DoT engineer.

1.5.2 Orientation:

(1) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 1).

(2) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the package in the horizontal axis and on a machined angle placed on the package along the inclined axis.

(3) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.5.3 Target:

The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall mass is in excess of 8,000 kg.

2 Pass/Fail Criteria

2.1 Pallet

The pallet must remain attached to the cage.

2.2 Cask

The cask must remain attached to the pallet.

2.3 Closure

The cask closure must remain attached to the cask body.

2.4 Notes

The criteria above are based on what was readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before, during and after the mechanical test programme. The additional tests measure each parameter and sentence it against quantified criteria (see Ref 6.3).

3 **Quality Assurance**

3.1 **Materials and equipment**

3.1.1 **Identification**

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC No.
One third scale 3750A cask	217554/04	01	-	-	-
One third scale 3750A pallet	217554/04	01	-	-	-
One third scale 3750A cage	217554/04	01	-	-	-
Cask closure studs	217554/04	01-08	-	-	-
Machined angle: 36.4°	215917/02	-	-	-	-
Height gauge: 1.2m	-	-	32	08/01/97	-
Level: RS Stock No. 651-428	-	-	34	08/01/97	-

3.1.2 **Notes**

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any other measuring equipment used.
- (5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 **Assembly**

The third scale 3750A package was assembled in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. None of the damage from the previous tests prevented the package being assembled correctly.

3.3 **Records**

3.3.1 **Photographic**
See Appendix A.

- 3.3.2 Video:
(1) Film No. 23, Start time 48min 56sec.
(2) Film No. 24, Start time 10min 09sec.

- 3.3.3 Operational:
See Appendix B.

4 Results

4.1 Orientation and impact

The video recordings confirmed the assembly dropped correctly. It landed on the top edge of the cage which gave way until it was trapped against the top edge of the cask, fell onto its side and then rocked back onto the top edge.

4.2 Pass/Fail criteria

The cask closure, cask, pallet and cage all remained securely attached.

4.3 General observations

- 4.3.1 Note: The inspection was limited to an external examination as the package was not permitted to be disturbed before the last test in Series 2, Test 1905.
- 4.3.2 Cage: The upper section of the cage was twisted sideways by 100 mm at the top giving it an angle of 28° from the vertical (figs 5 & 6). Most of the joints had buckled to accommodate the movement (figs 7 & 8) but the two joints on each side that were in tension on their inner edge had split near the weld (figs 9 & 10). The mesh panel nearest the cask was 4 mm away from the top edge of the cask jacket and 40 mm from the top of the cask shell. The two lifting points underneath the impact were slightly bruised (fig 9). The top member underneath the impact was indented by the two of the shock absorbers on the cask closure (fig 11). The lower half of the cage was undamaged apart from scratches on two of the tie-down points. All twelve pallet screws were in place and appeared undamaged.
- 4.3.3 Pallet: The pallet showed no additional damage. It supported the cask centrally and upright. All twelve cask feet screws were in place and appeared undamaged.
- 4.3.4 Cask body: The cask sat centrally within the cage and showed no additional damage. All eight closure studs and nuts were in place and appeared undamaged. All twelve jacket screws were in place and appeared undamaged.
- 4.3.5 Cask closure: The closure was undamaged except for some slight marks on the two shock absorbers that were hit by the cage top member.

5 **Conclusions**

5.1 **Pass/Fail**

The package passed the test

5.2 **Other**

None.

6 **References**

6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 622.

6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 71.7.

6.3 3750A Test Plan, PGM 921, Issue 3, paragraph 8.3.2.

6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author: DW Byes Position: PKG ENGR Date: 16/01/96

7.1 Checked: [Signature] Position: Head of Engineering Date: 16 02 96

Appendix A

Photographs



Figure 1: Test orientation

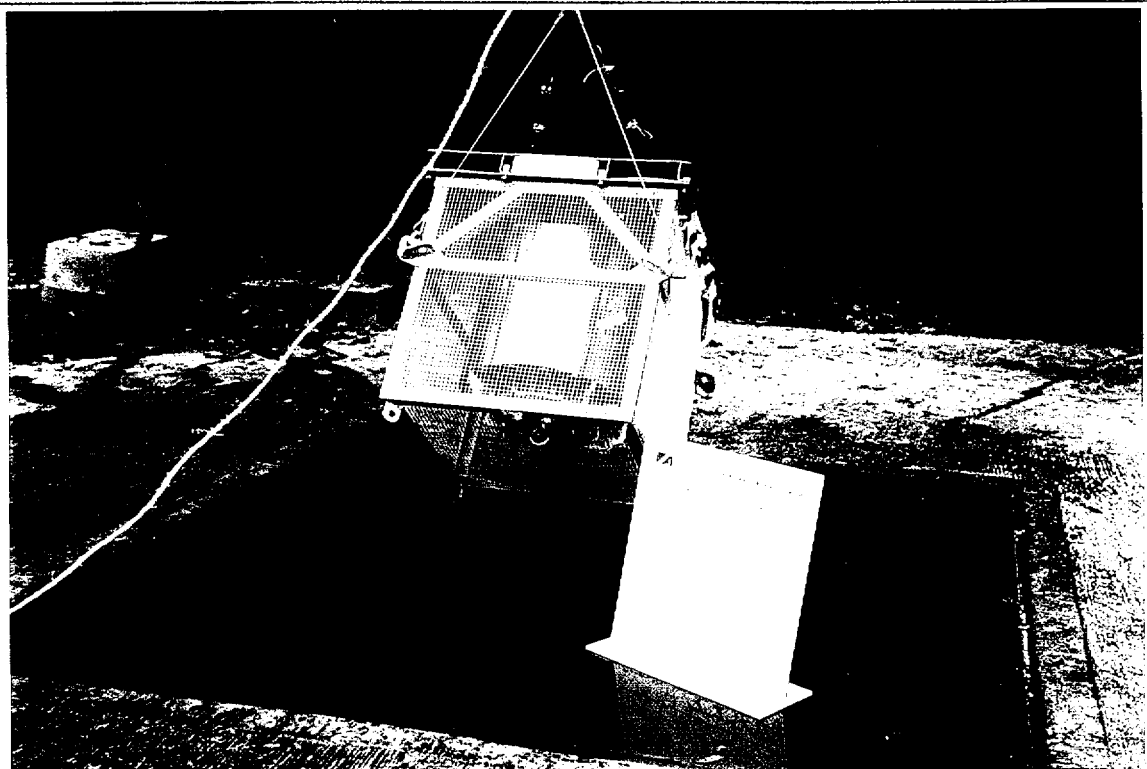


Figure 2: Test orientation

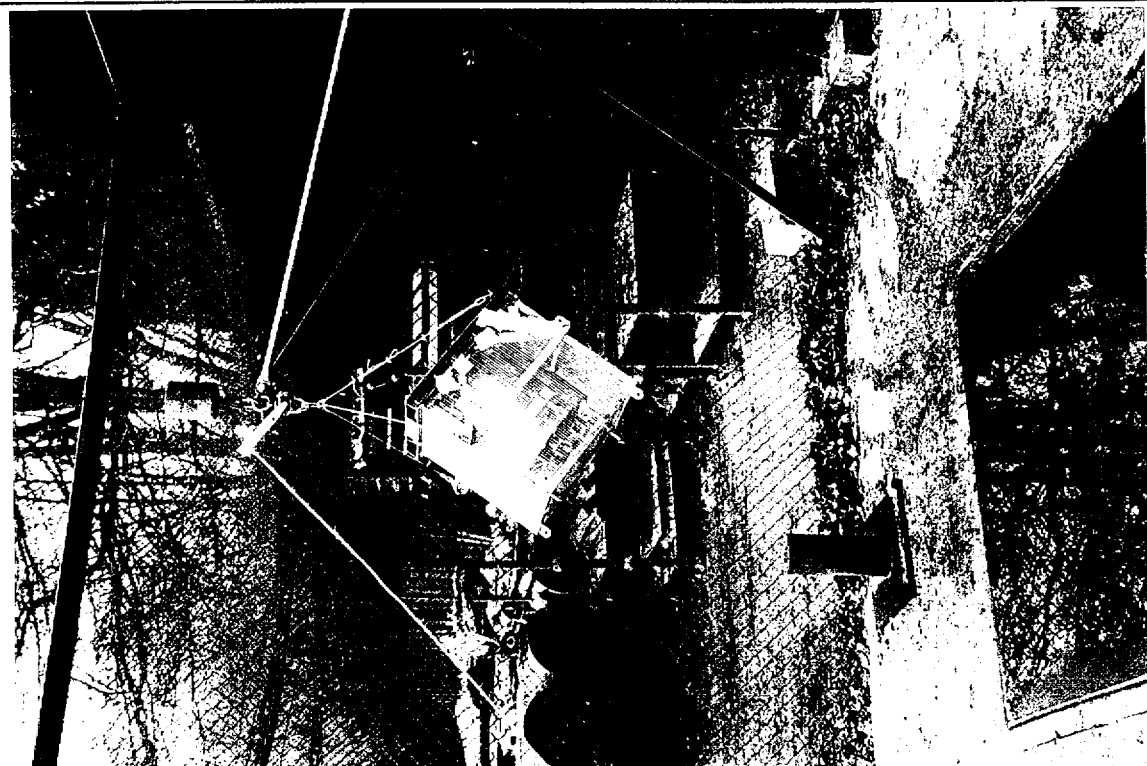


Figure 3: Test set-up

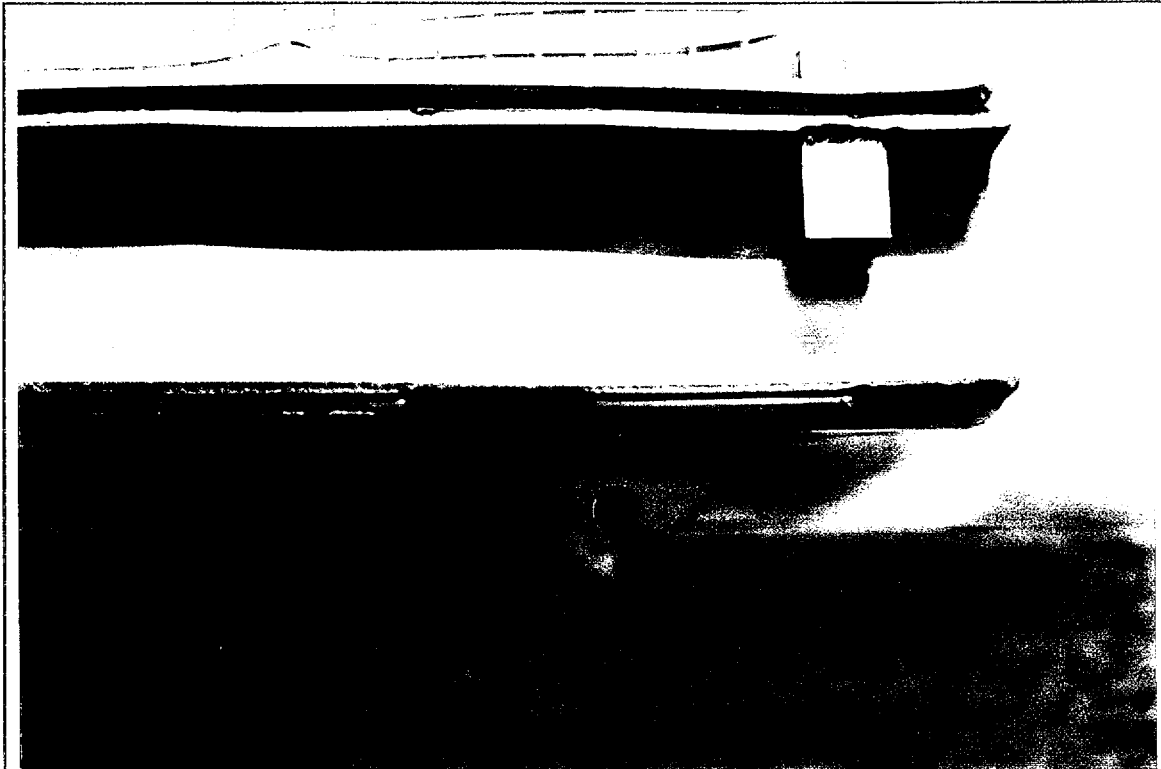


Figure 4: Lug added to pallet for slinging

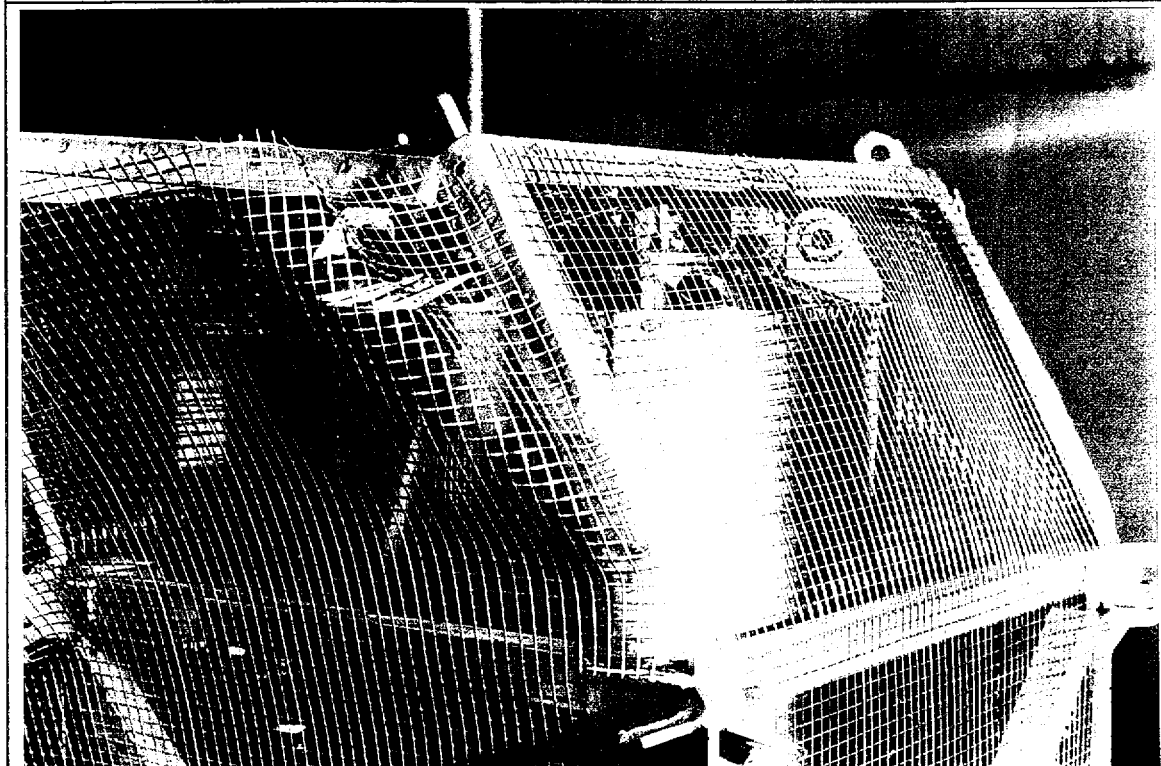


Figure 5: Distortion in upper section of cage

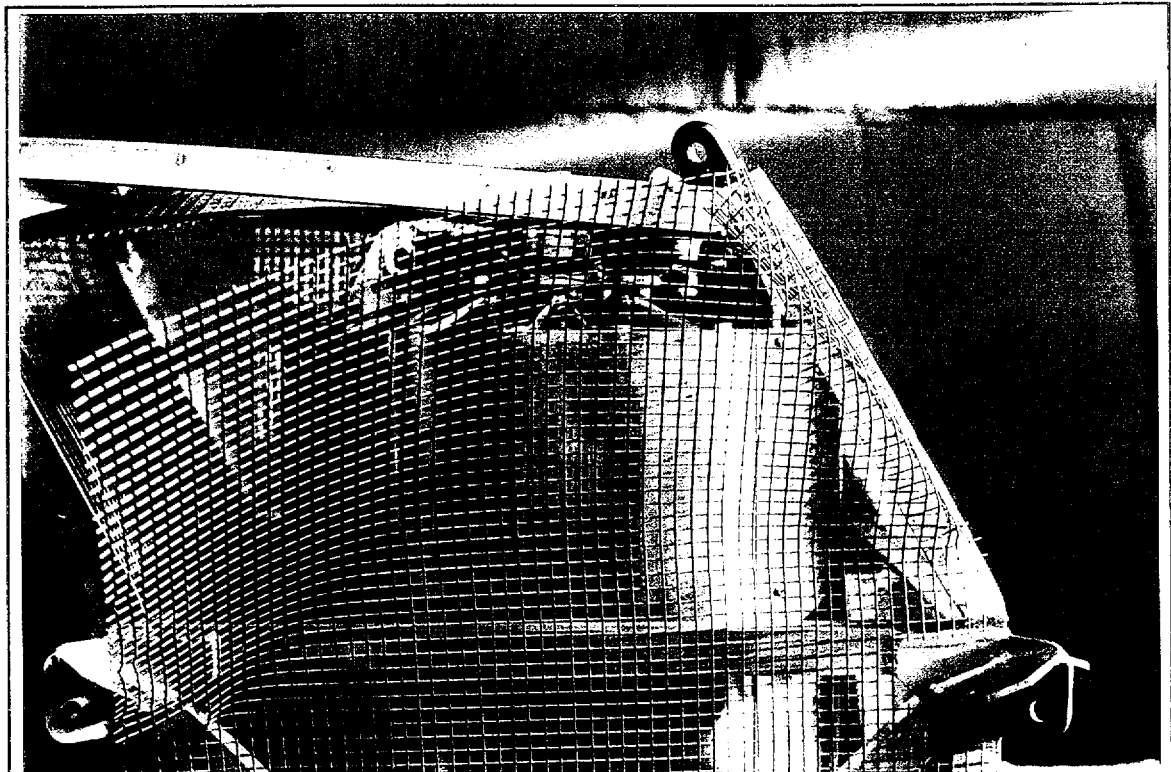


Figure 6: Side view

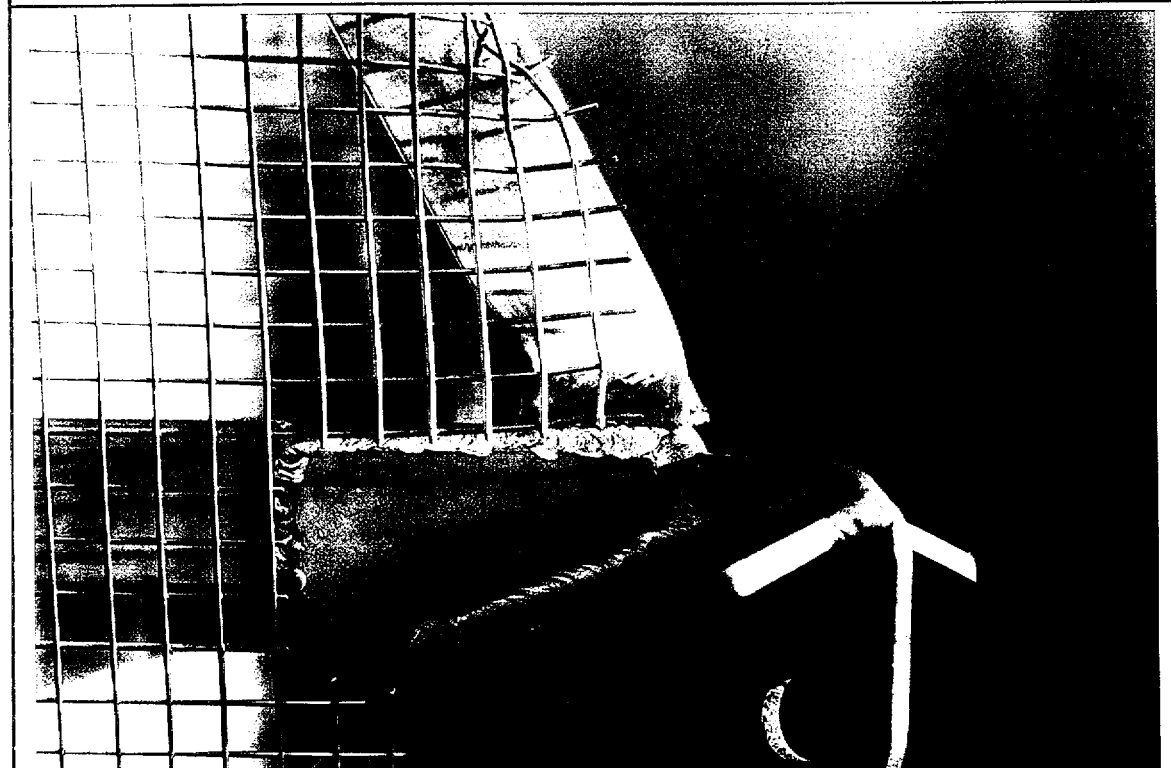


Figure 7: Buckled joint in cage



Figure 8: Buckled joint in cage



Figure 9: Split near cage weld and lifting point showing bruise



Figure 10: Split near cage weld

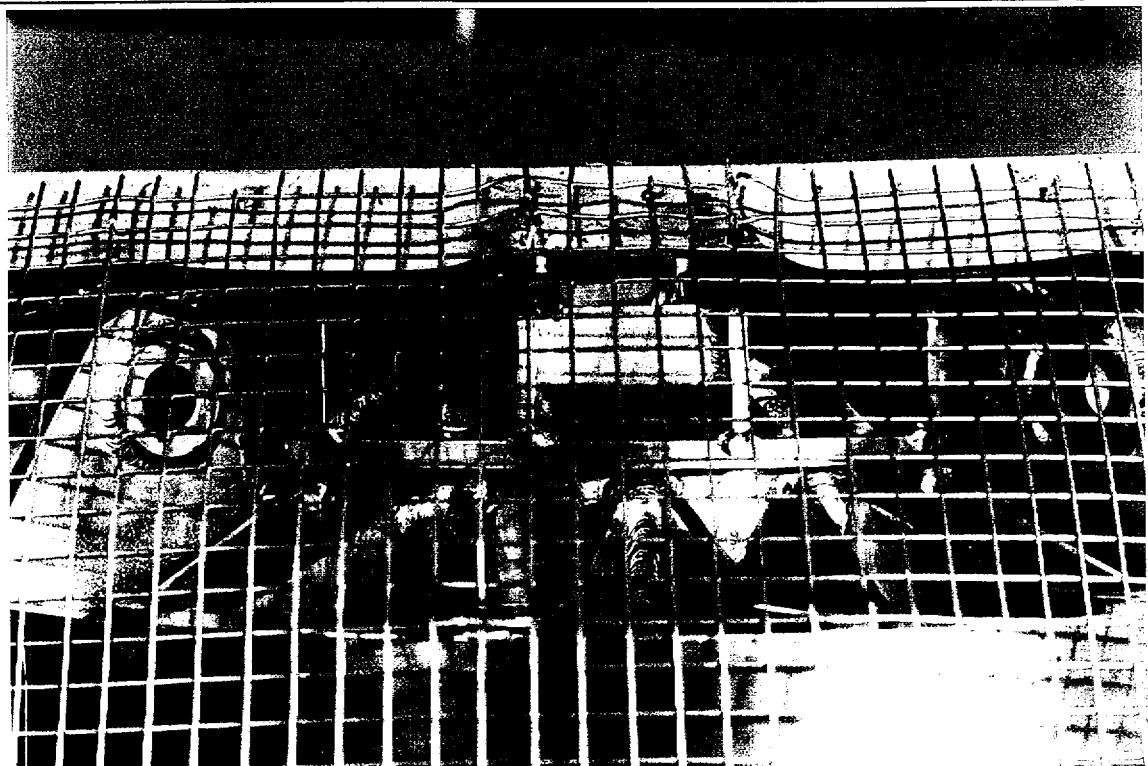


Figure 11: Indentation to cage cross member from closure fins

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1902
Date: 22/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height.	<div>0.3m*1.2m*9.0m*</div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	✓

* Delete as appropriate

** PALLET AND FRAME FROM SERIES 1 USED.
FOUR SMALL WGS WELDED TO BASE OF PALLET FOR SLINGING.

4. Notes: TEST PLAN NO: PGM 921, ISSUE 3, PARA 8.3.2.
MODEL 3750A: GRN NO. 217554/04, STD NOS. 1-8.
TORQUE WRENCH: TOOL NO 30PALLET No. 01.
HEIGHT GAUGE: TOOL NO 32CAGE NO. 01.
36.4° MACHINED ANGLE: GRN NO. 215917/02
LEVEL: TOOL NO. 34
FILM NO: 23, START TIME: 48 MIN 56 SEC.
FILM NO: 24, START TIME: 10 MIN 09 SEC.

5. Personnel:
- Conducted:

DWROGERS

Posn: Pkg ENGR.
- Witnessed:

M.P. WHEATLEY

Posn: QA ENGINEER.

Amersham International plc

Packaging Design Group

Test Report No. 1904

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
9.0m Free Drop (Drop I).

1.3 **Procedure**
PGP 15, Issuc 5.

1.4 **Orientation**
At 25.5° from the vertical inverted, with the centre of gravity over top edge of cask (figs 1 & 2).

1.5 **Special conditions**
The Test Plan (ref 6.3) specifies a test temperature of -40°C.

1.6 **Notes**

1.6.1 **Package:**

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The pallet had four small lugs welded to its underside to facilitate slinging. This with the agreement of the DoT engineer.

(3) The damage to the package from Series 1 (Tests 1898, 1900 & 1901) had not been repaired. This with the agreement of the DoT witnessing engineer.

(4) The package had been damaged in the 1.2m drop, Test 1902, as required by the Test Plan (ref 6.3).

(5) The package had five thermocouples added to monitor temperature.

1.6.2 Orientation:

(1) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 1).

(2) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the package in the horizontal axis and on a machined angle placed on the package along the inclined axis.

(3) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.6.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature (fig 1). Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure. A small section of mesh was cut out of the lower right panel on side No. 2 to allow the cables and connectors to be lead out.

Note: The thermocouples were installed prior to Test 1902 to avoid disturbance of the package assembly between tests.

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

1.6.4 Target:

The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

2 Pass/Fail Criteria

2.1 Closure

The cask closure must remain attached to the cask body.

2.2 Jacket

The jacket must remain attached to the cask.

2.3 Notes

The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
One third scale 3750A pallet	217554/04	01	-	-
One third scale 3750A cage	217554/04	01	-	-
Cask closure studs	217554/04	01-08	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Machined angle: 25.5°	215917/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Level: RS Stock No. 651-428	-	-	34	08/01/97
Height gauge: 9.0m	-	-	35	15/01/97

3.1.2 Notes:

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any measuring equipment used.

3.2 Assembly

The third scale 3750A package was assembled prior to Test 1902 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C.

3.4 Records

3.4.1 Photographic:
See Appendix A.

3.4.2 Video:
(1) Film No. 23, Start time 49min 22sec.
(2) Film No. 24, Start time 13min 20sec.

3.4.3 Operational:
See Appendix B.

4 Results

4.1 Temperature

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-43.8
2	-44.2
3	-48.0
4	-40.5
5	-55.1

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed on the edge of the cask closure, bounced to a height of approximately 400 mm and rotated through approximately 140° to land on its base (fig 3).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached to the cask body.

4.4 General observations

4.4.1 Note: The inspection was limited to an external examination as it was not permitted to dismantle the package before the following puncture test, Test 1905, the last test of Series 2, when more detailed observations could be made.

- 4.4.2 Cage: The cage showed relatively little additional damage. The upper half of the cage was twisted sideways at an angle of approximately 32° from the vertical (fig 4). The top mesh panel was largely detached. The upper cross member underneath the impact was flattened over a length of 150 mm and almost severed by two of the closure shock absorbers (figs 5 & 6). Otherwise the cage was undamaged. All twelve pallet screws were undamaged.
- 4.4.3 Pallet: The pallet showed no additional damage. It supported the cask centrally and and upright. All twelve cask feet screws were undamaged.
- 4.4.4 Cask body: The tips of the two cooling fins under the impact showed minor bruising (fig 5). The six closure studs and nuts that could be seen were undamaged. The twelve jacket screws were undamaged.
- 4.4.5 Cask closure: The two fins under the impact were crushed flat (fig 7). Other than this the closure appeared free from damage.

5 Conclusions

5.1 Pass/Fail

The package passed the test.

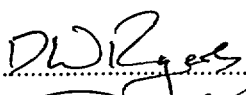

5.2 Other

None.

6 References

- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(a).
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(1).
- 6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.2.4.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 Signatures

- 7.1 Author:  Position: PKG ENGR Date: 16/01/96
- 7.1 Checked:  Position: PERSONAL CONTROL Date: 16.01.96

Appendix A

Photographs



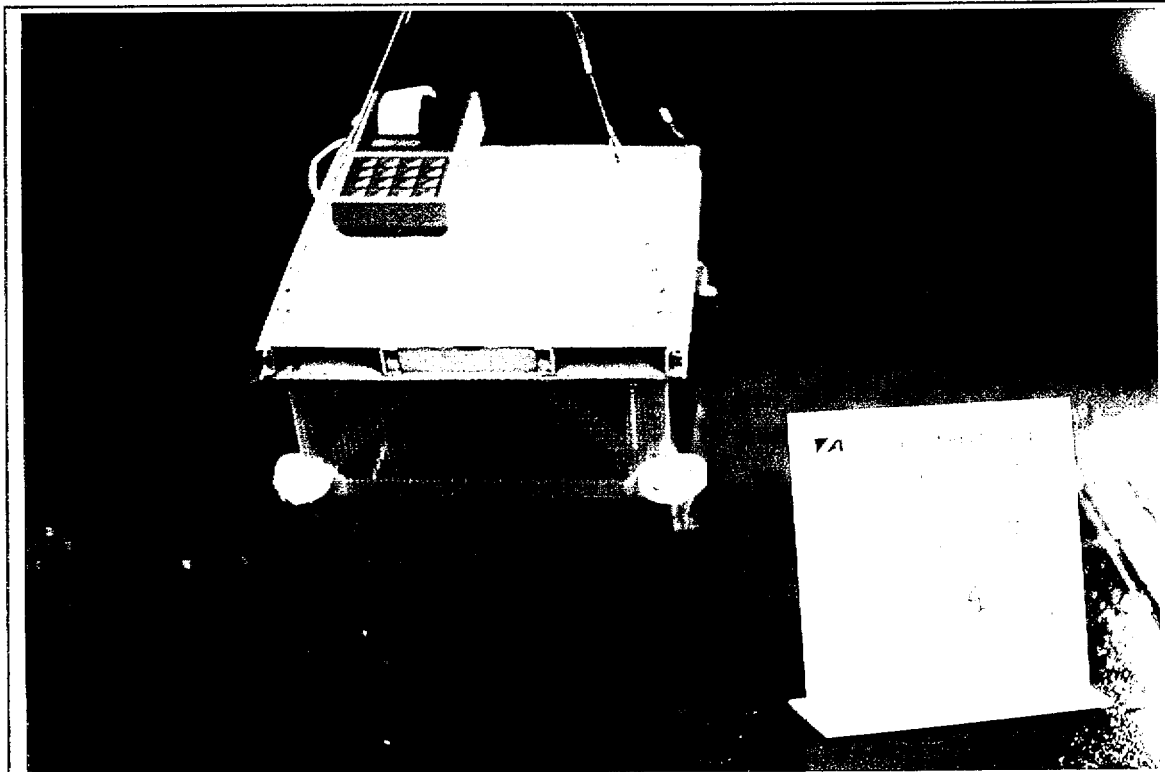


Figure 2: Test orientation

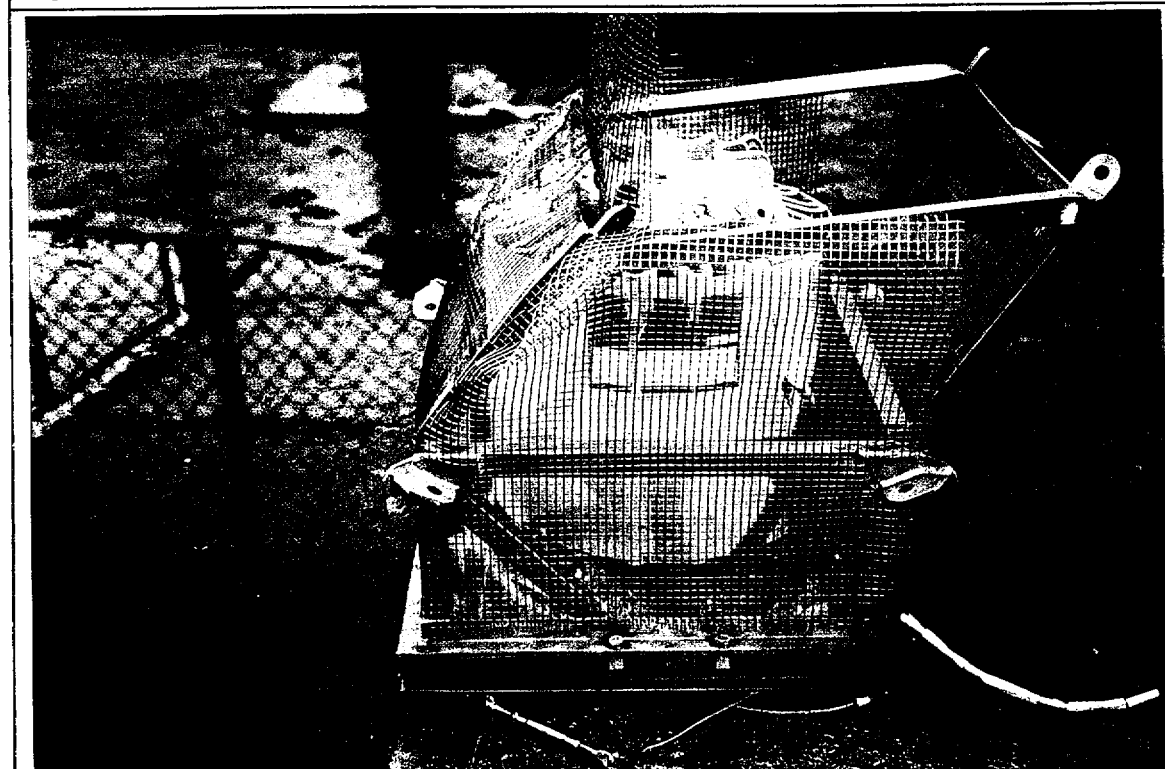


Figure 3: After impact

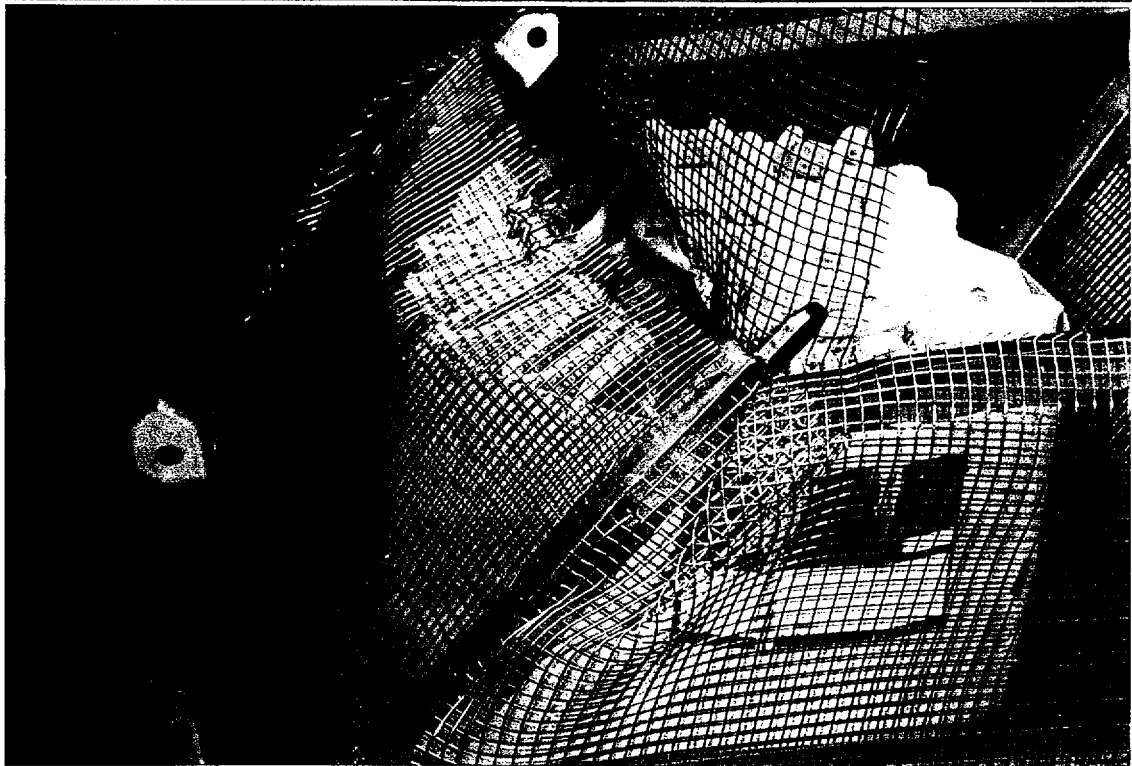


Figure 4: After impact

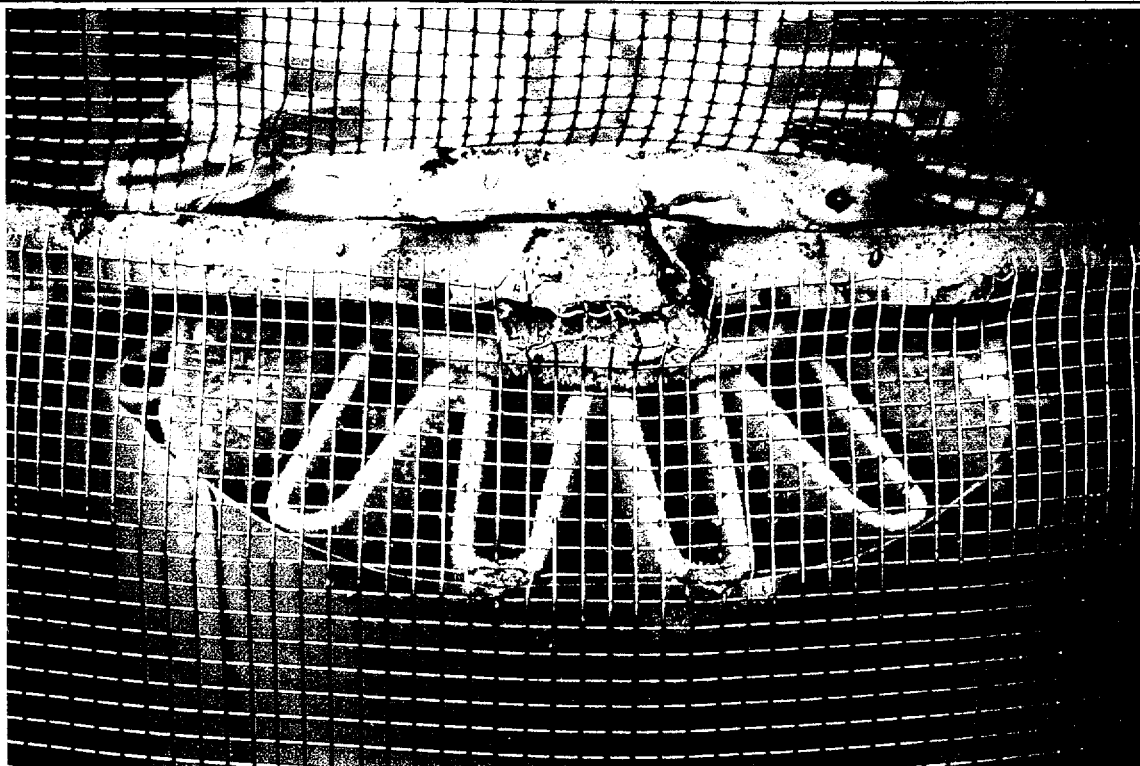


Figure 5: Upper cage showing cross member damage and minor bruising to tips of cooling fins



Figure 6: Upper cage showing cross member damage

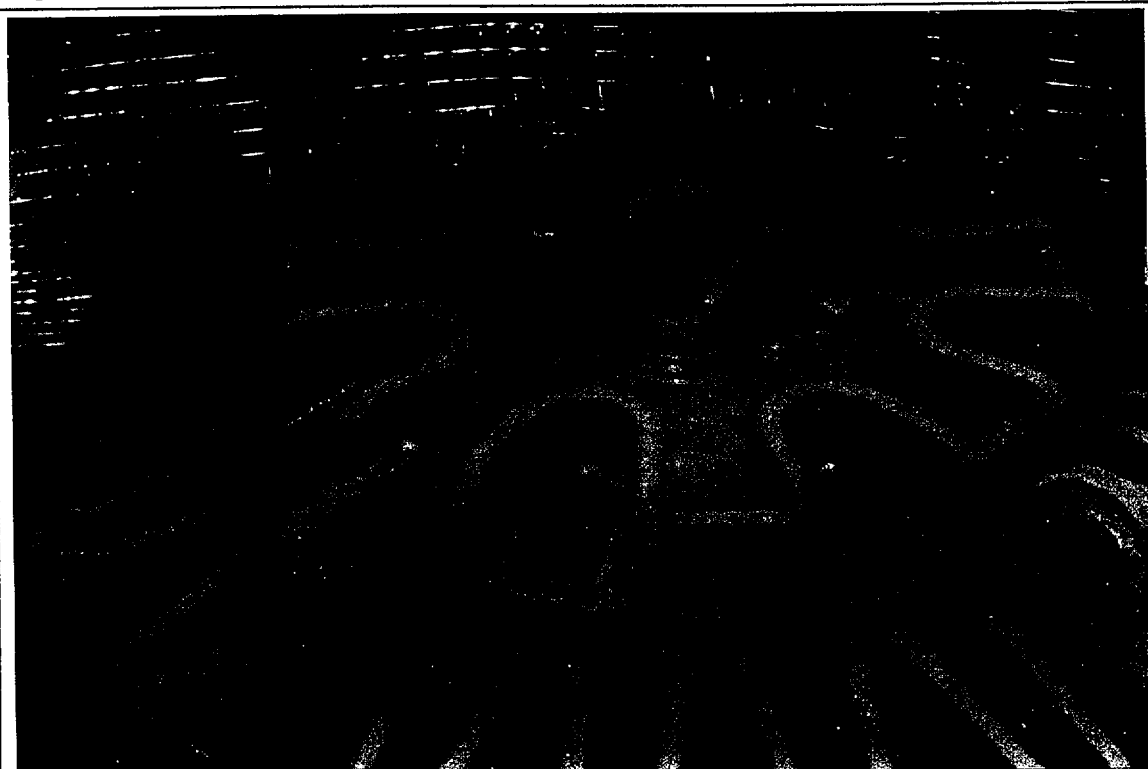


Figure 7: Top of closure showing two crushed shock absorbers

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1904

Date: 24/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	SEEW ✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height.	<div>0.5m <input checked="" type="checkbox"/> 1.2m <input checked="" type="checkbox"/> 9.0m* <input checked="" type="checkbox"/></div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	✓

** PACKAGE DAMAGED FROM SERIES 1 + TEST 1902
* Delete as appropriate

4. Notes: TEST PLAN NO: PGM 921, ISSUE 3, PARA 8.3.3.
- MODEL 3750A: GRN NO. 217554/04

25-5° MACHINED ANGLE: GRN NO. 215917/02

LEVEL: TOOL NO 34.

HEIGHT GAUGE: TOOL NO. 35.

FILM NO: 23, START TIME: 49 MIN 22 SEC

FILM NO: 24, START TIME: 13 MIN 20 SEC

TEMPERATURE RECORDER: TOOL NO 27
- TEMP. AT DROP

T/C NO 1: -43.8

T/C NO 2: -44.2

T/C NO 3: -45.0

T/C NO 4: -40.5

T/C NO 5: -55.1

TIME OF DROP: 1130 AM

5. Personnel:
- Conducted: DWROGERS DW ROGERS

Posn: PKG ENGR.
- Witnessed: S. T. WINFIELD

Posn: Pkg Engineer

Amersham International plc

Packaging Design Group

Test Report No. 1905

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.0m Puncture (Drop II).

1.3 Procedure PGP 55, Issue 1.

1.4 Orientation The package was slung at an angle of 25.5° from the vertical placing the centre of gravity over the point of impact (fig 1).

1.5 Location of impact The impact point was the upper edge of the cooling fins, midway between two lifting points and avoiding the closure (fig 2).

1.6 Special conditions The Test Plan (ref 6.3) required the package to be tested at -40°C.

1.7. Notes

1.7.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The pallet had four small lugs welded to its underside to facilitate slinging. This with the agreement of the DoT engineer.

(3) The damage to the package from Series 1 (Tests 1898, 1900 & 1901) had not been repaired. This with the agreement of the DoT witnessing engineer.

(4) The package had been damaged in the previous 1.2m and 9.0m drop tests (Tests 1902 & 1904) as required by the Test Plan (ref 6.3).

1.7.2 Orientation:

(1) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg.

(2) Measurement: Immediately prior to the test the orientation was checked with a spirit level placed across the package along the horizontal axis and on a machined angle plate along the inclined axis.

(3) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.7.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range: -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature (fig 1). Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure.

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

1.7.4 Target:

The target was 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

1.7.5 Punch:

The punch was a third scale, carbon steel bar welded vertically to a plate bolted at each corner to the target. A 75 mm long bar was used. The bar protruded slightly below the plate to ensure positive contact with the target plate (see Drg No. A25230, Issue A).

2 Pass/Fail Criteria

2.1 Closure

The cask closure must remain attached to the cask body.

2.2 Jacket

The jacket must remain attached to the cask.

2.3 Notes

The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
One third scale 3750A pallet	217554/04	01	-	-
One third scale 3750A cage	217554/04	01	-	-
Cask closure studs	217554/04	01-08	-	-
Punch (short)	212750/01	-	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Machined angle: 25.5°	215917/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Height gauge: 1.0m	-	-	31	08/01/97
Level: RS Stock No. 651-428	-	-	34	08/01/97

3.1.2 Notes:

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any measuring equipment used.

(5) The QC No. is the identify of specific measurements records made by the Packaging Design Group.

3.2 Assembly

The third scale 3750A package was assembled prior to Test 1902 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C.

3.3 Records

3.3.1 Photographic:
See Appendix A.

3.3.2 Video:
(1) Film No. 23, Start time 50min 20sec.
(2) Film No. 24, Start time 17min 39sec.

3.3.3 Operational:
See Appendix B.

4 Results

4.1 Temperature

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-41.0
2	-41.1
3	-43.8
4	-39.5
5	-48.4

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed on the punch, bounced upwards approximately 25mm and landed just next to it on its side (fig 3).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached.

4.4 General observations

4.4.1 **Note:** A large proportion of the observations relate to damage caused in the previous 9.0m drop test, Test 1904, when it was not possible to dismantle the package for examination.

4.4.2 **Cage:** The punch made a circular impression in the mesh (fig 4), otherwise the cage was undamaged. All twelve pallet screws were undamaged, secure and unscrewed freely.

4.4.3 **Pallet:** The pallet showed no additional damage. It supported the cask centrally and upright. All twelve cask feet screws were undamaged, secure and unscrewed freely.

4.4.4 **Cask body:** The inner edges of the two fins hit by the punch were bent over away from each other (figs 5 & 6). The jacket was bent inwards between the two fins. The remainder of the damage was from the 9.0m drop. The lifting points to each side were bent over at 30° and 40° respectively from the vertical (figs 7-9) and were bruised on their top edge. On one of the lifting points a crack had opened on the tensile side of the bend adjacent to the jacket fixing screw (fig 10). The screw and jacket remained quite secure. The body flange had two, smooth-edged, semi-elliptical bruises at its outer edge under the crushed closure shock absorbers (fig 11). The bruises were less than 0.5 mm deep, 10 mm maximum width and extended inwards not more than 5 mm. There was no distortion below, towards the flange-to-shell weld, or inwards, towards the closure studs. There was no other damage to the cask body. All eight closure studs and nuts were undamaged, secure and unscrewed freely. All twelve jacket screws, including the one next to the crack, were undamaged, secure and unscrewed freely.

4.4.5 **Cask closure:** The closure disengaged freely from the body. The two fins under the 9.0m impact were crushed flat (fig 12). The two to each side were slightly distorted (figs 13 & 14). Under the inner edges of the two crushed fins the closure flange had taken a gently rippled profile outside the edge of the body flange (figs 15 & 16) creating a lip some 5 mm wide, 60 mm long and 1 mm maximum depth. Other than this the closure was free from damage. There was no evidence of bruising, scratching or distortion to the leak test plug, the closure flange or the underside.

4.4.6 **Punch:** The punch carried two indentations from the cooling fins (figs 17 & 18) indicating a good impact.

5 Conclusions

5.1 Pass/Fail

The package passed the test.

5.2 Other

None.

6 **References**

- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(b).
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(2).
- 6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.3.4.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

- 7.1 Author: DW Ryers Position: PKG ENGR Date: 16/02/96
- 7.1 Checked: [Signature] Position: Review Controller Date: 16-02-96

Appendix A

Photographs

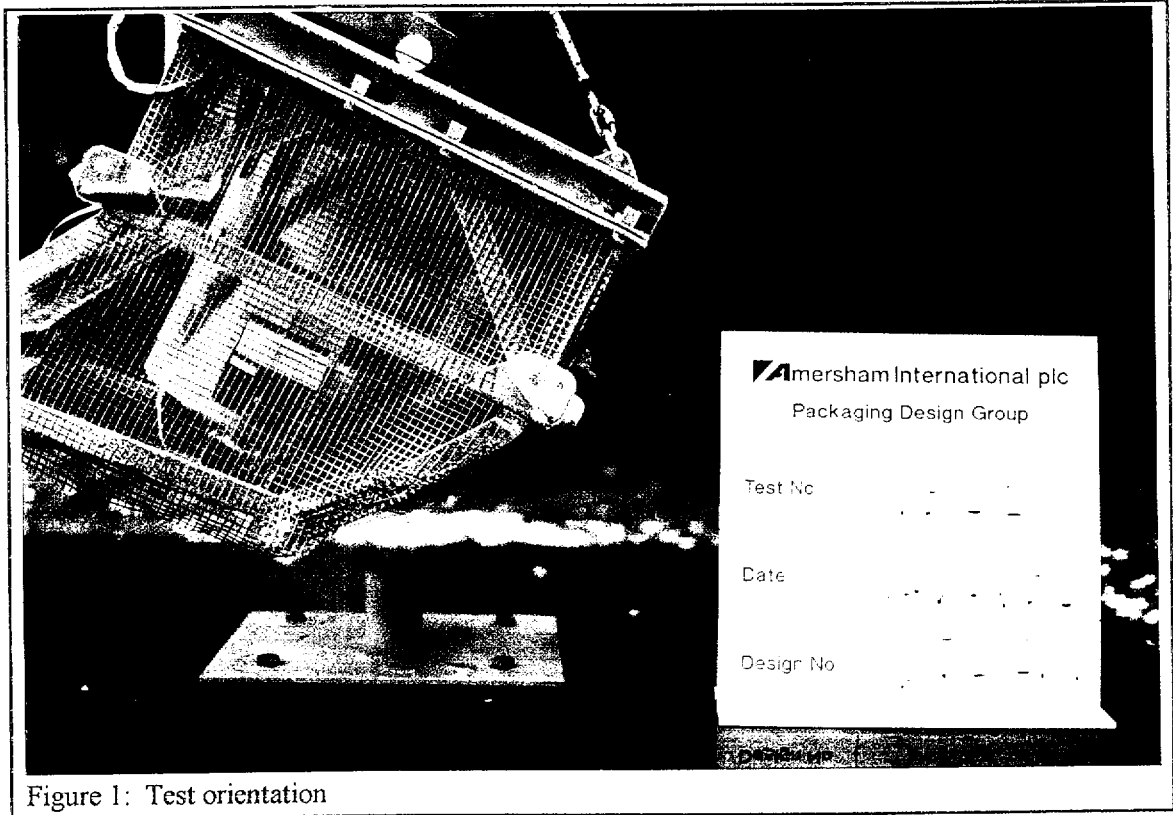


Figure 1: Test orientation

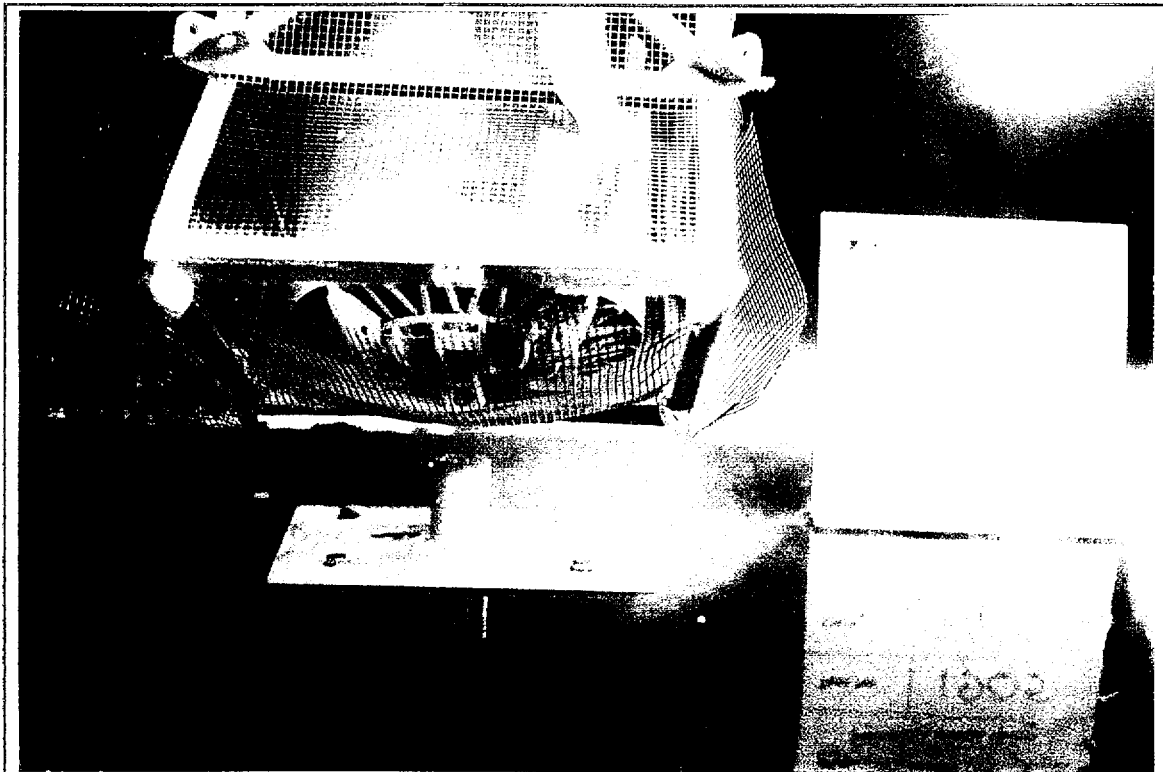


Figure 2: Test orientation

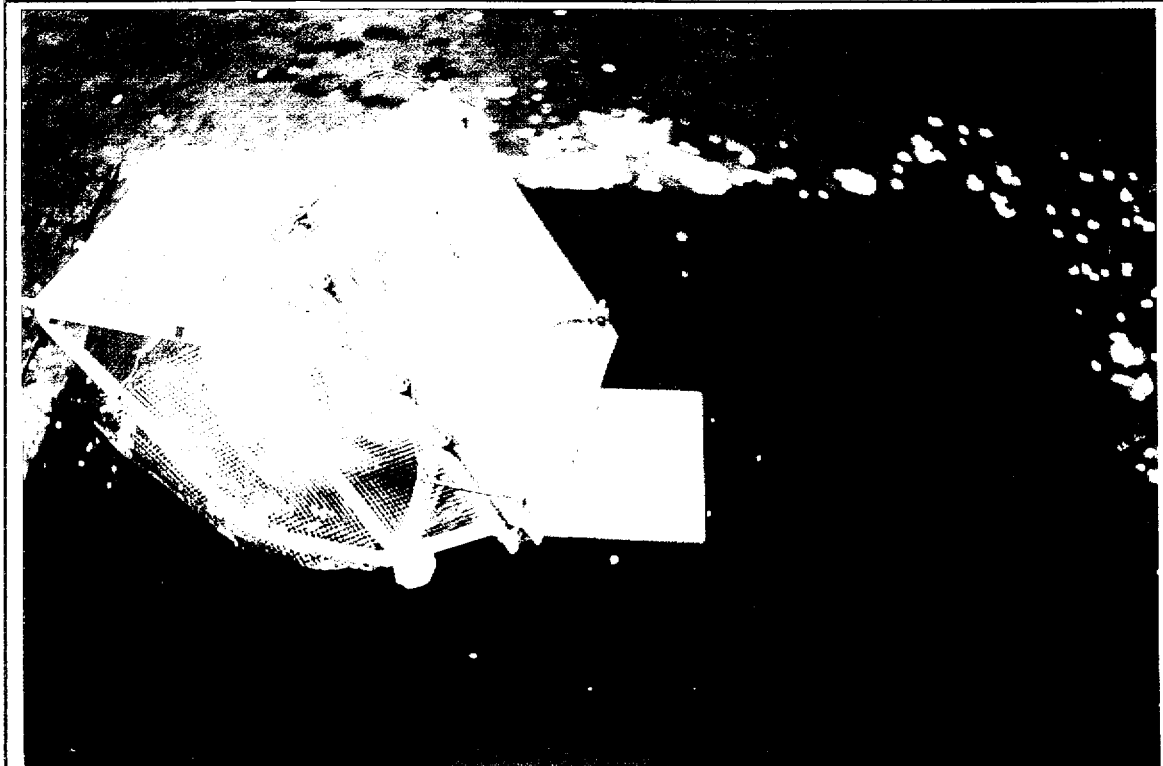


Figure 3: After impact

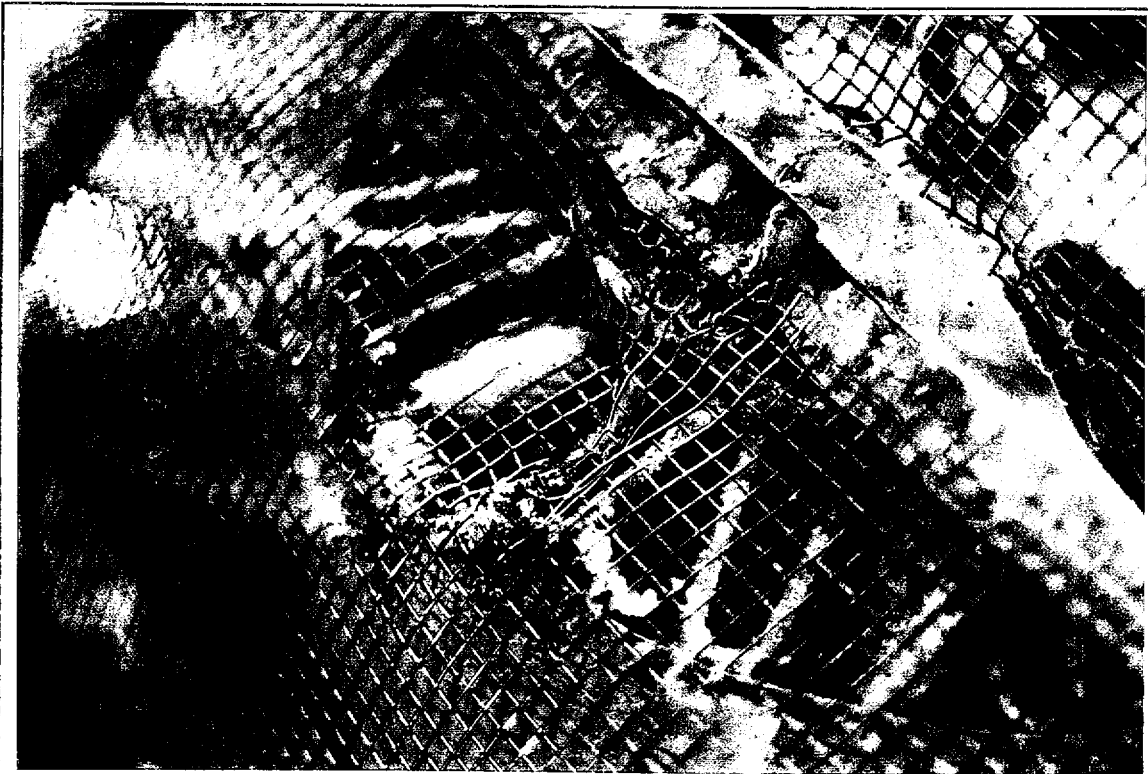


Figure 4: Cage showing punch indentation

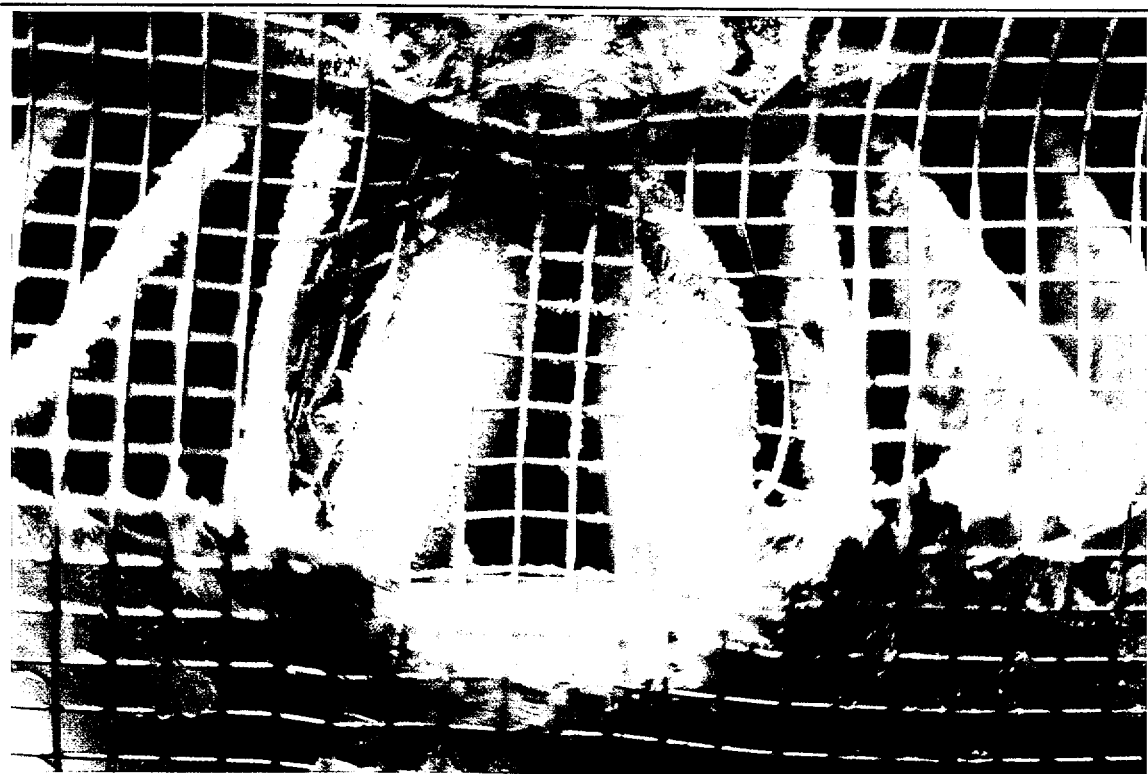


Figure 5: Cooling fin and jacket damage from punch

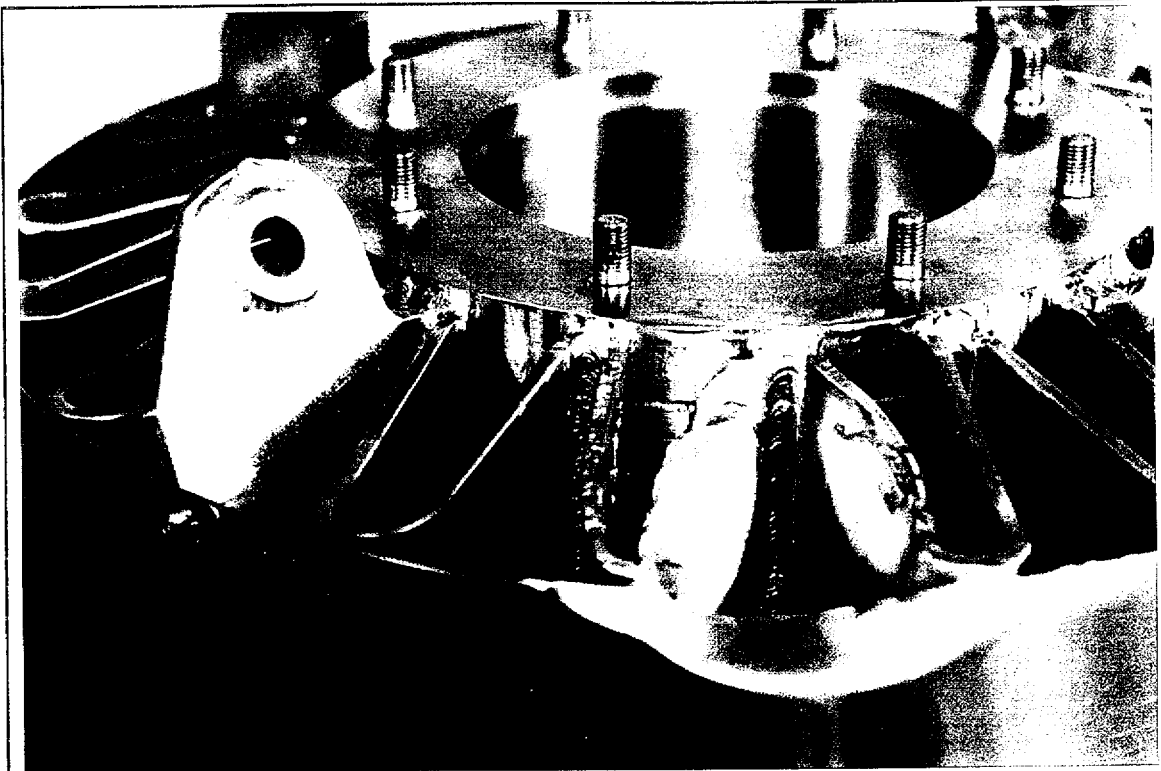


Figure 6: Cooling fin and jacket damage from punch

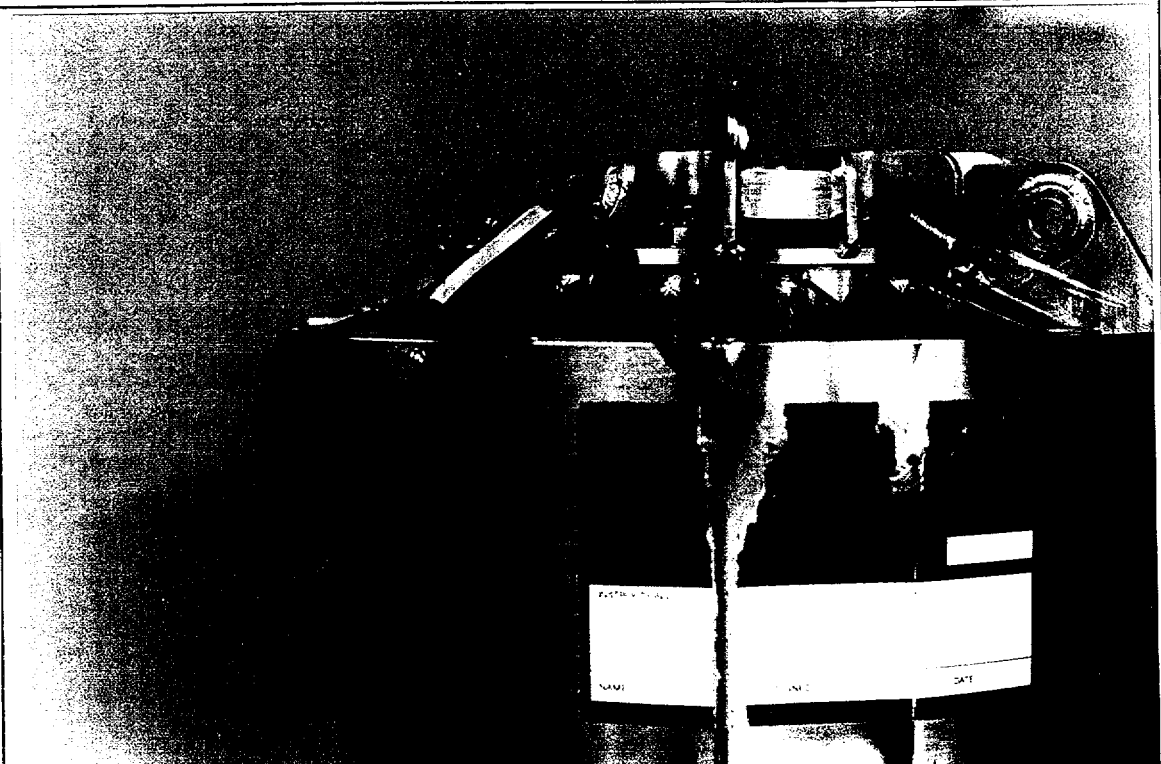


Figure 7: Cask and closure showing plane of 9.0m drop impact

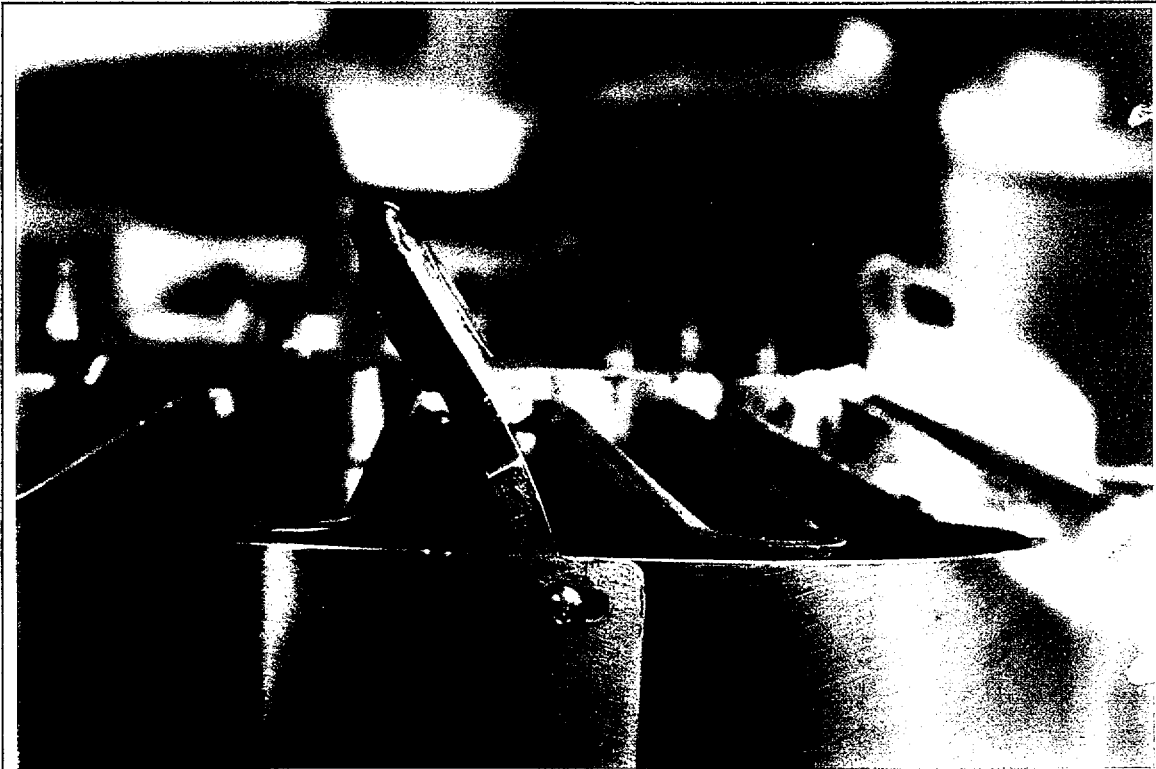


Figure 8: Lifting point distortion



Figure 9 Lifting point distortion



Figure 10: Crack in fin near jacket screw

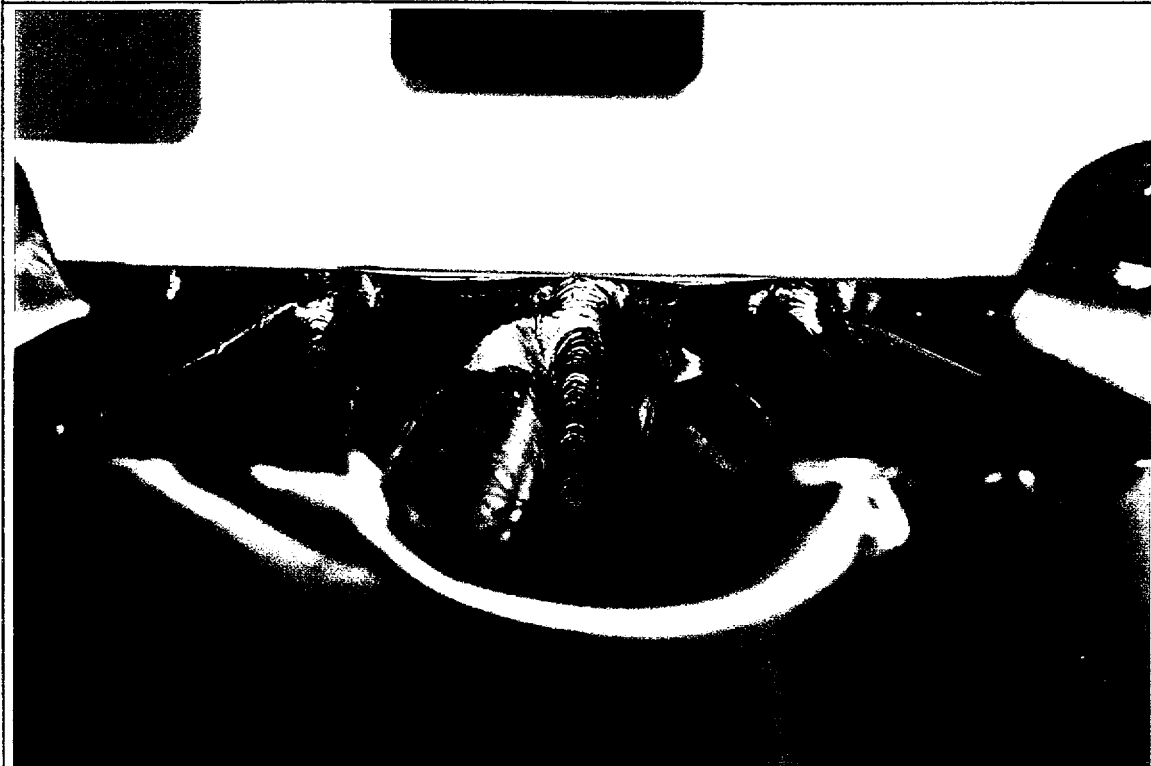


Figure 11: Cask body flange face showing bruising

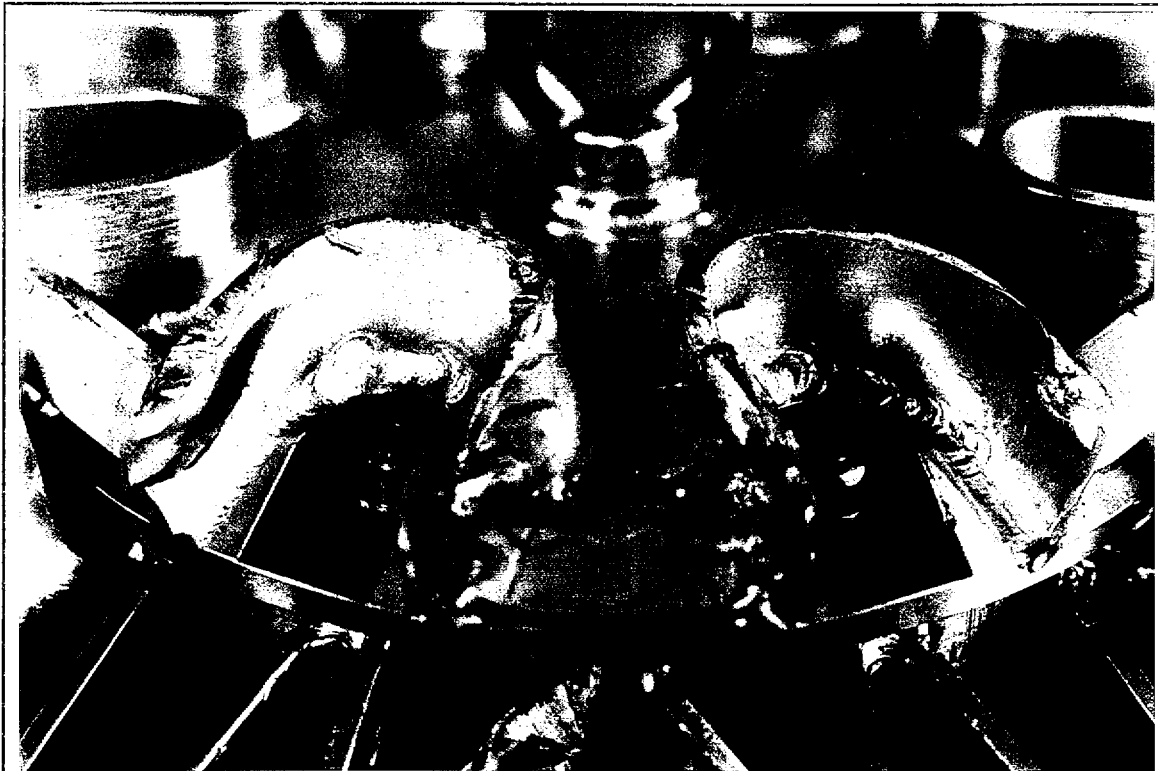


Figure 12: Crushed closure shock absorbers

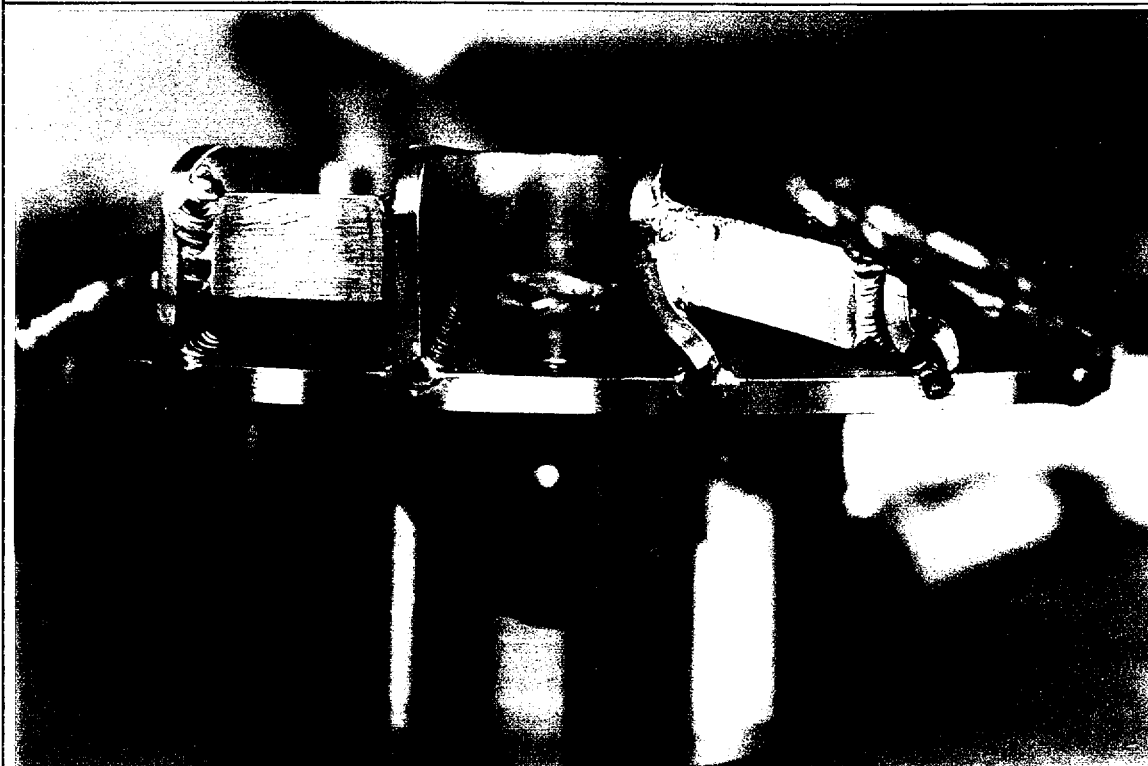


Figure 13: Distortion to adjacent shock absorber

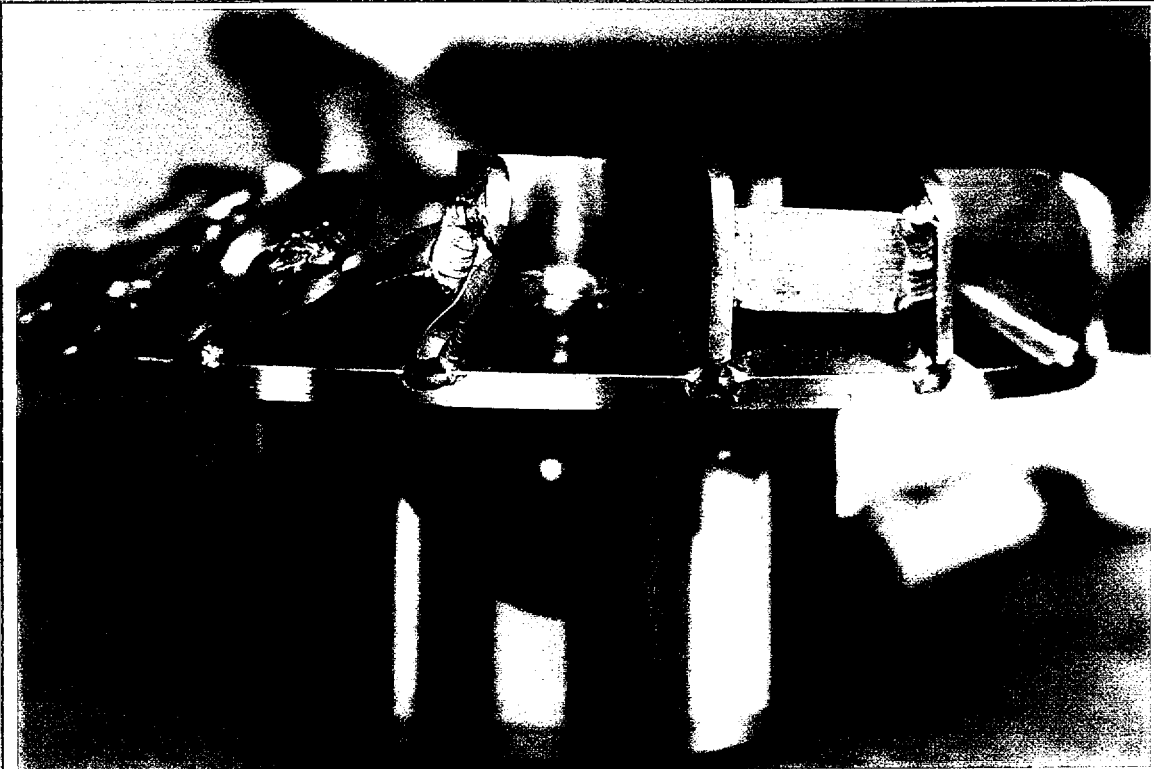


Figure 14: Distortion to adjacent shock absorber



Figure 15: Underside of closure flange showing rippled lip

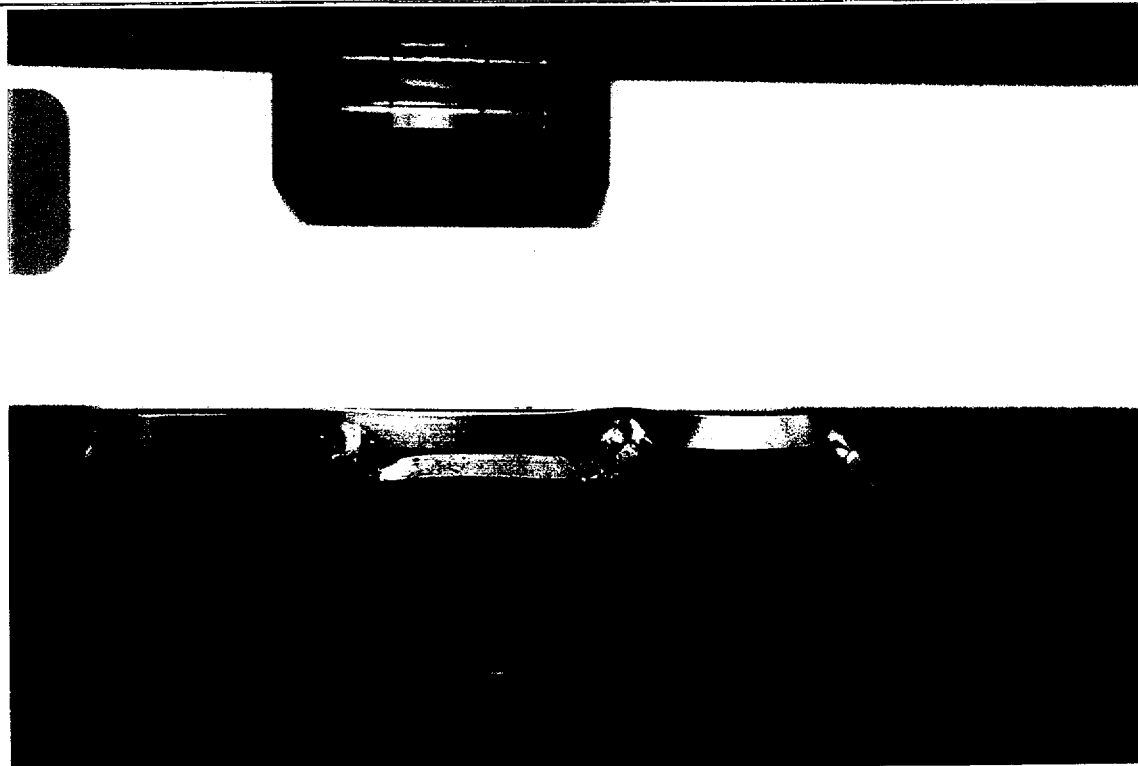


Figure 16: Profile of ripple in edge of closure flange

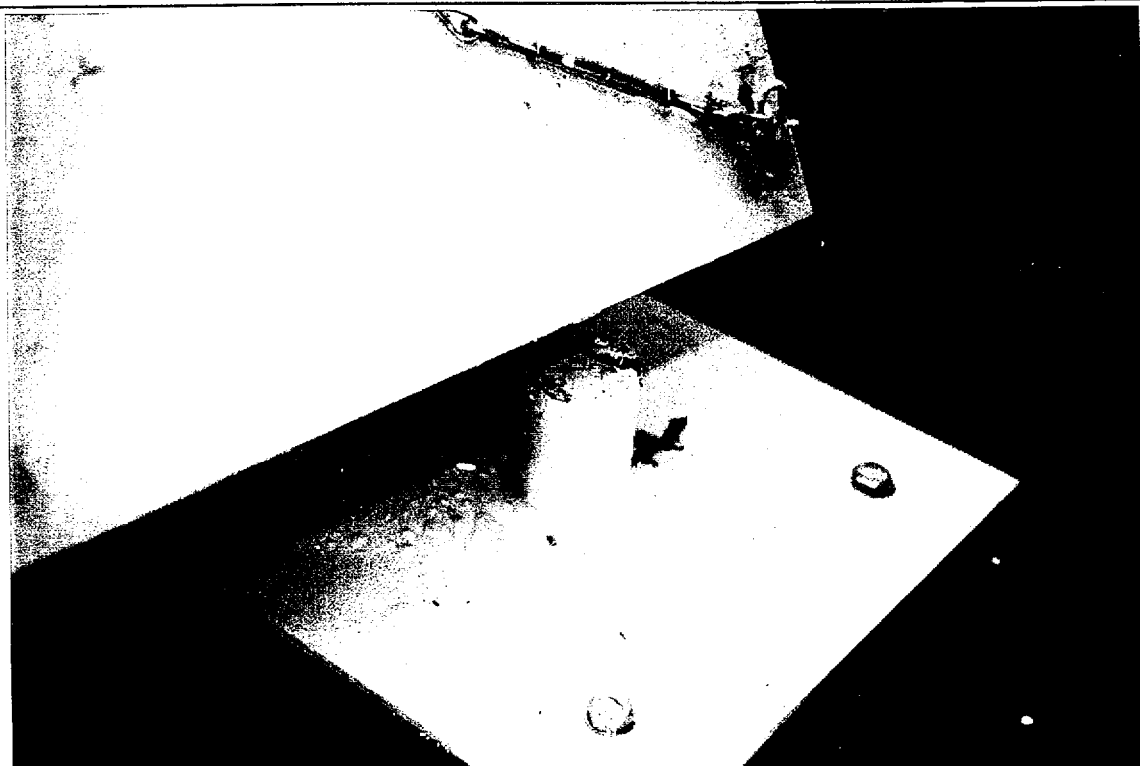


Figure 17: Punch after impact



Figure 18: Punch face

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Puncture Test Check List

Test No: 1905

Date: 24/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 55, Packaging Group Procedure for Puncture Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm punch is rigidly mounted	✓
6	Confirm sample is correctly orientated	✓
7	Photograph sample just over punch (optional)	✓
8	Raise sample to test height	✓
9	Record height between punch and impact point	1.00 metre
10	Remove all non-essential personnel from compound	✓
11	Start video	✓
12	Drop sample	✓
13	Confirm impact point is correct	✓
14	Record damage to sample with video	✓
15	Take still photographs (optional)	✓

** PACKAGE DAMAGED FROM SERIES 1 + TESTS 1902 - 1904

* Delete as appropriate

4. Notes:

TEST PLAN NO = PGM 921, ISSUE 3, PARA 8.3-4.
MODEL 3750A = GRN NO. 217554/04
25-5° MACHINED ANGLE = GRN NO. 215917/02
LEVEL = TOOL NO 34
HEIGHT GAUGE = TOOL NO 31
PUNCH SHORT = GRN NO. 212750/01
TEMP RECORDER = TOOL NO 27
FILM NO. 23, START TIME 150M 20S.
- TEMP. READINGS AT DROP

T/C NO1: -41.0
T/C NO2: -41.1
T/C NO3: -43.8
T/C NO4: -39.5
T/C NO5: -48.4
TIME OF DROP: 15.24
5. Personnel:

FILM NO 24, START TIME: 17M 39S.

Conducted:

P. W. Rogers

Posn: PKU ENGR.

Witnessed:

C. CALLINGTON

Posn: T.C.O.

Amersham International plc

Packaging Design Group

Test Report No. 1906

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.2m Free Drop.

1.3 Procedure PGP 15, Issue 5.

1.4 Orientation Flat on side (figs 1-3).

1.5 Notes

1.5.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The cask was not repaired in any way after Series 1 (Tests 1898, 1900 & 1901). After Series 2 (Tests 1902, 1904 & 1905) the only repair was to straighten the two bent lifting points. After Series 4 (Tests 1910, 1911 & 1913) the only repair was to replace the closure eyebolt. The principal damage from these tests was crushing of two of the closure shock absorbers, partial crushing of the remaining six and punch damage in two places on the top of the cooling fins. None of this was considered to be significant for the side drop series. This with the agreement of the DoT witnessing engineer.

(3) The cage was repaired for this test series after the crushing of the upper section in Series 4, the vertical inverted drops. The vertical cage sections were straightened as much as possible and the mesh panels made secure with wire ties (fig 2). In addition all the cage to pallet screws were replaced. This with the agreement of the DoT witnessing engineer.

(4) The pallet was not repaired in any way after Series 4 tests. The only damage from these tests was slight distortion of the underside at one corner which would not be on the impact face for any of the side drop series. The four small lugs that had been added to the underside of the pallet to facilitate slinging in the Series 4 (fig 2) were left in place. This with the agreement of the DoT witnessing engineer.

(5) Five thermocouples were added in readiness for the following Tests 1907 & 1899 and the cables lead out through a small hole cut in the lower right hand corner of the mesh panel on side No. 2 (fig 1). This with the agreement of the DoT witnessing engineer.

1.5.2 Orientation:

(1) Test order: Series 3, the side impact, was carried out after Series 4 as it was likely to damage the cask feet which would have made subsequent assembly to the pallet very difficult.

(2) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 1).

(3) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the package in the lateral axis and against the base of the pallet for longitudinal adjustment.

(4) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.5.3 Target:

The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall mass is in excess of 8,000 kg.

2 Pass/Fail Criteria

2.1 Pallet

The pallet must remain attached to the cage.

2.2 Cask

The cask must remain attached to the pallet.

2.3 Closure

The cask closure must remain attached to the cask body.

2.4

Notes
The criteria above are based on what was readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before, during and after the mechanical test programme. The additional tests measure each parameter and sentence it against quantified criteria (see Ref 6.3).

3

Quality Assurance

3.1

Materials and equipment

3.1.1

Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC No.
One third scale 3750A cask	217554/04	01	-	-	-
One third scale 3750A pallet	217554/04	02	-	-	-
One third scale 3750A cage	217554/04	02	-	-	-
Cask closure studs	217554/04	01-08	-	-	-
Torque wrench: Norbar Model SLO	-	-	30	10/01/97	-
Height gauge: 1.2m	-	-	32	08/01/97	-
Level: RS Stock No. 651-428	-	-	34	08/01/97	-

- 3.1.2

Notes:

(1)

The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.

(2)

The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3)

The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.

(4)

The Calibration Due Date is required for any other measuring equipment used.

(5)

The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The third scale 3750A package was assembled in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. None of the damage from the previous tests prevented the package being assembled correctly.

3.3 Records

3.3.1 Photographic See Appendix A.

3.3.2 Video: (1) Film No. 23, Start time 53min 30sec. (2) Film No. 24, Start time 29min 30sec.

3.3.3 Operational: See Appendix B.

4 Results

4.1 Orientation and impact

The video recordings confirmed the assembly dropped correctly. It landed square on the side of the cage, bounced to a height of 25-50 mm and came to rest on its side (figs 4 & 5).

4.2 Pass/Fail criteria

The cask closure, cask, pallet and cage all remained securely attached.

4.3 General observations

4.3.1 Note: The inspection was limited to an external examination as the package was to not to be disturbed before the last test in the series, Test 1899, the punch test.

4.3.2 Cage: The upper section of the cage was displaced laterally by 10 mm at the top. The tie-down lugs under the impact were bent down flat (fig 6-8). Other than this the lower half of the cage was undamaged. All twelve of the pallet screws were undamaged.

4.3.3 Pallet: The pallet showed no significant damage. It supported the cask centrally and almost upright. A slight distortion around the cask feet pads gave the cask a slight tilt leading to a maximum lateral displacement of 5 mm at the top of the jacket. All twelve of the cask feet screws were undamaged. All twelve of the jacket screws were undamaged.

4.3.4 Cask body: The cask showed no additional damage. All eight of the closure studs and nuts were undamaged. The combination of cage and pallet distortions brought the cage mesh to within 32 mm (from 49 mm) of the top of the cask jacket (fig 9).

4.3.5 Cask closure: The closure showed no additional damage.

5 **Conclusions**

5.1 **Pass/Fail**

The package passed the test

5.2 **Other**

None.

6 **References**


6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 622.

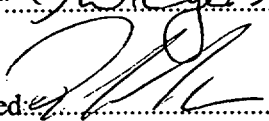
6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 71.7.

6.3 3750A Test Plan, PGM 921, Issue 3, paragraph 8.4.2.

6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author:  Position: PKG ENG'Z Date: 16/02/96

7.1 Checked:  Position: PKG ENG'Z Date: 16-02-96

Appendix A

Photographs

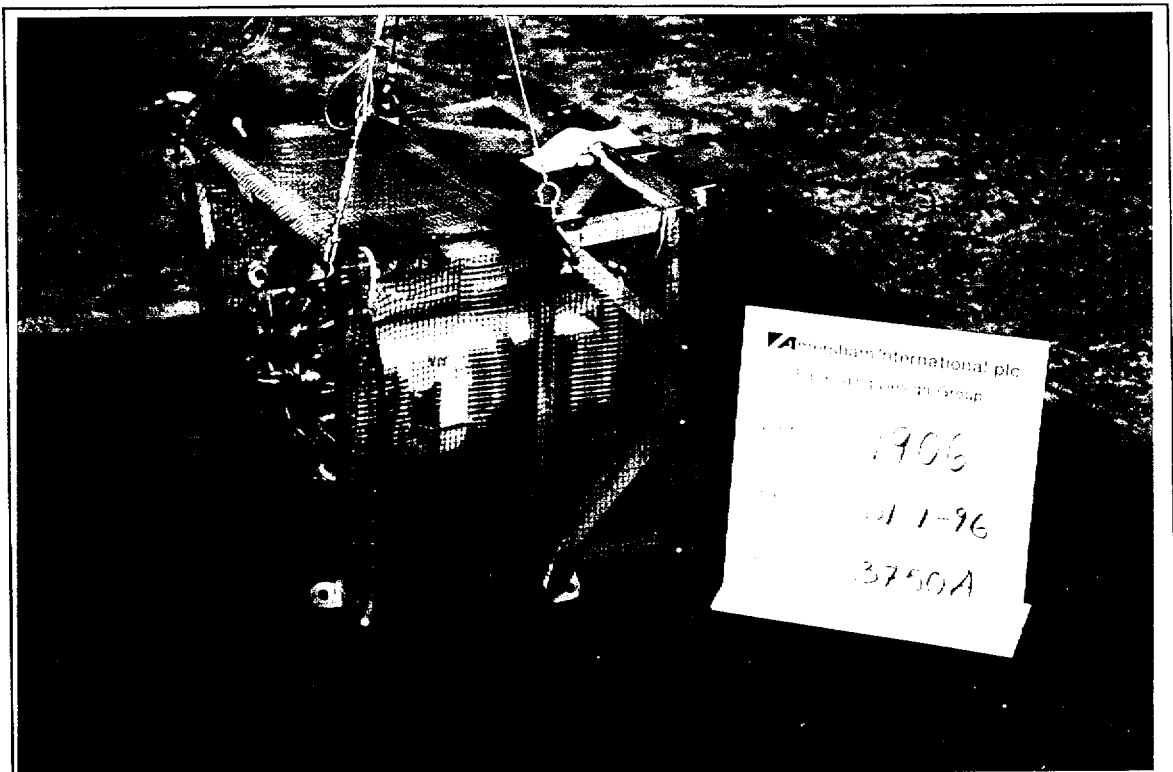


Figure 1: Test orientation

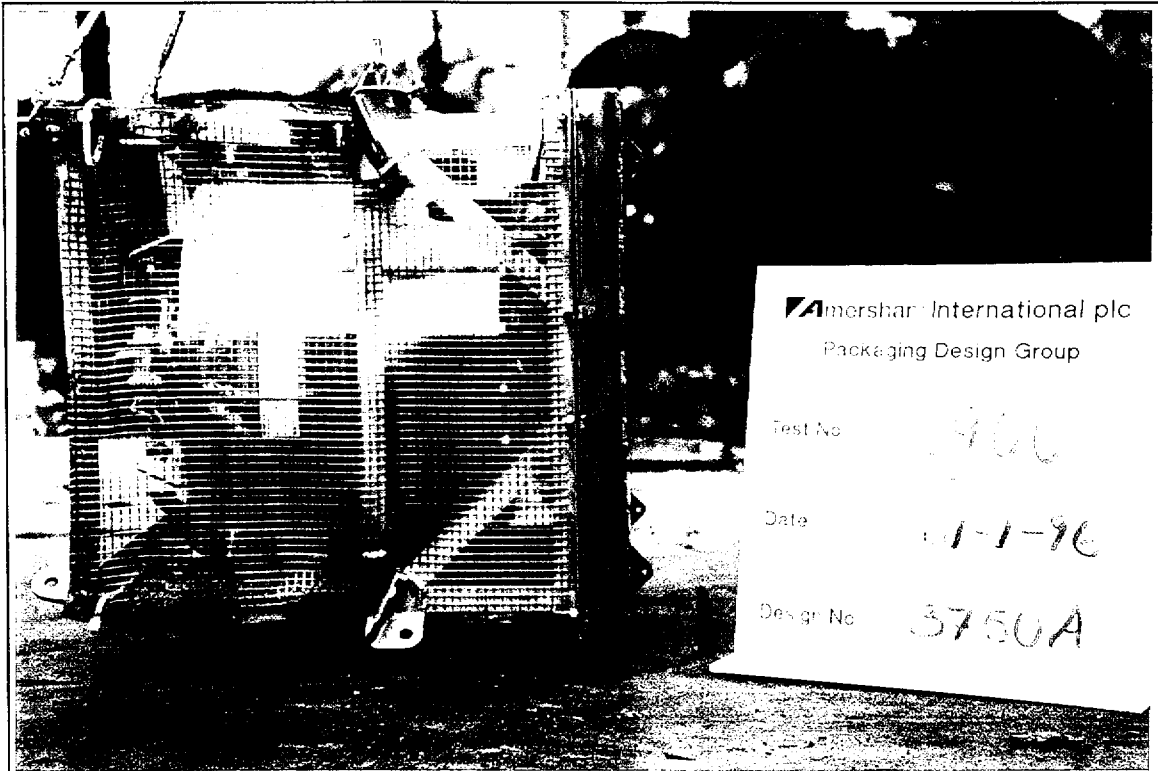


Figure 2: Test orientation



Figure 3: Test set-up

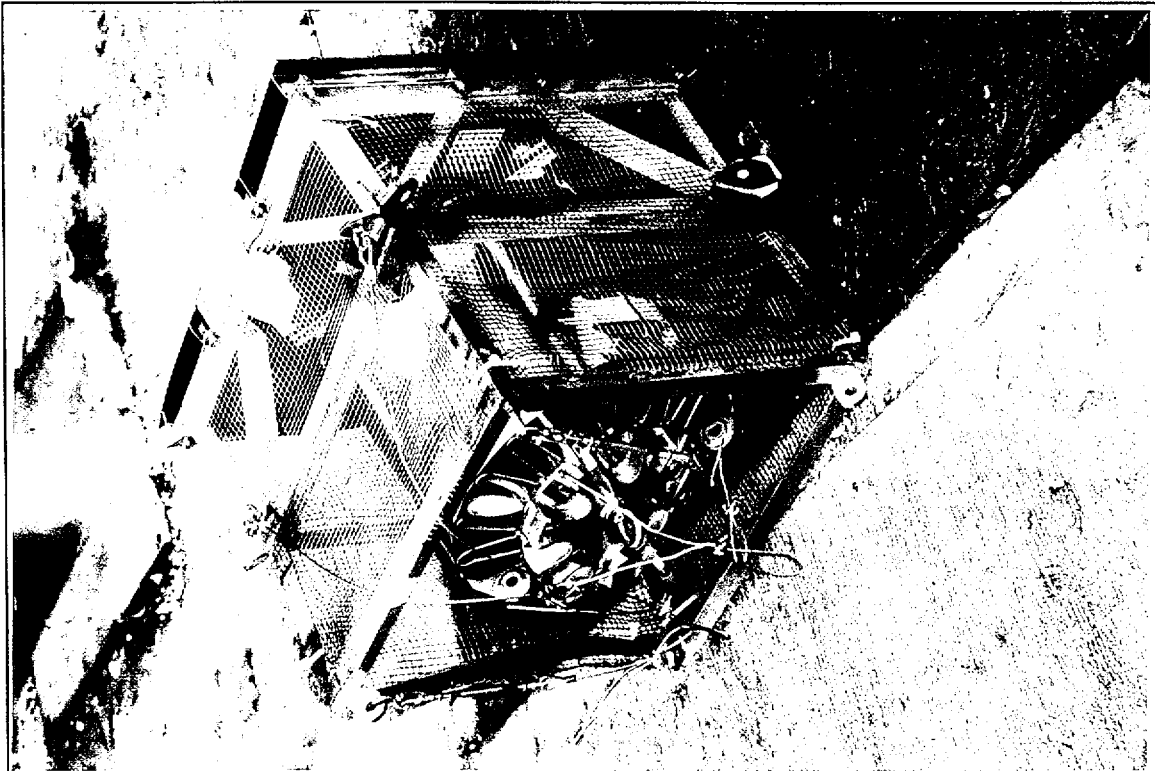


Figure 4: After impact

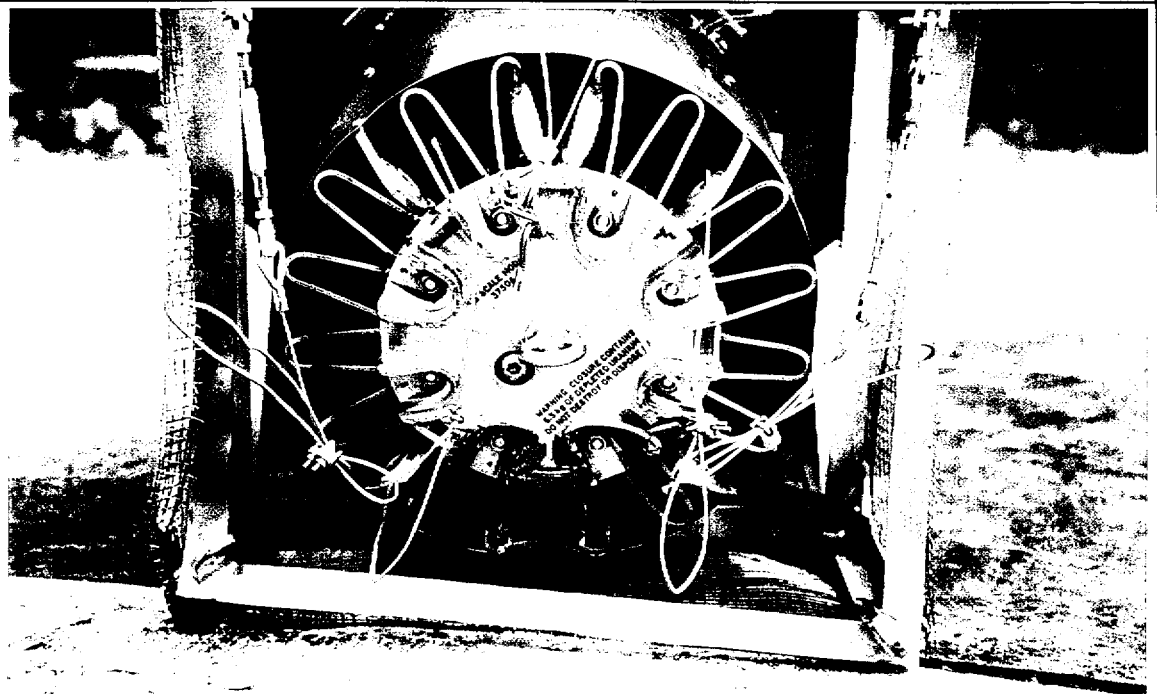


Figure 5: After impact

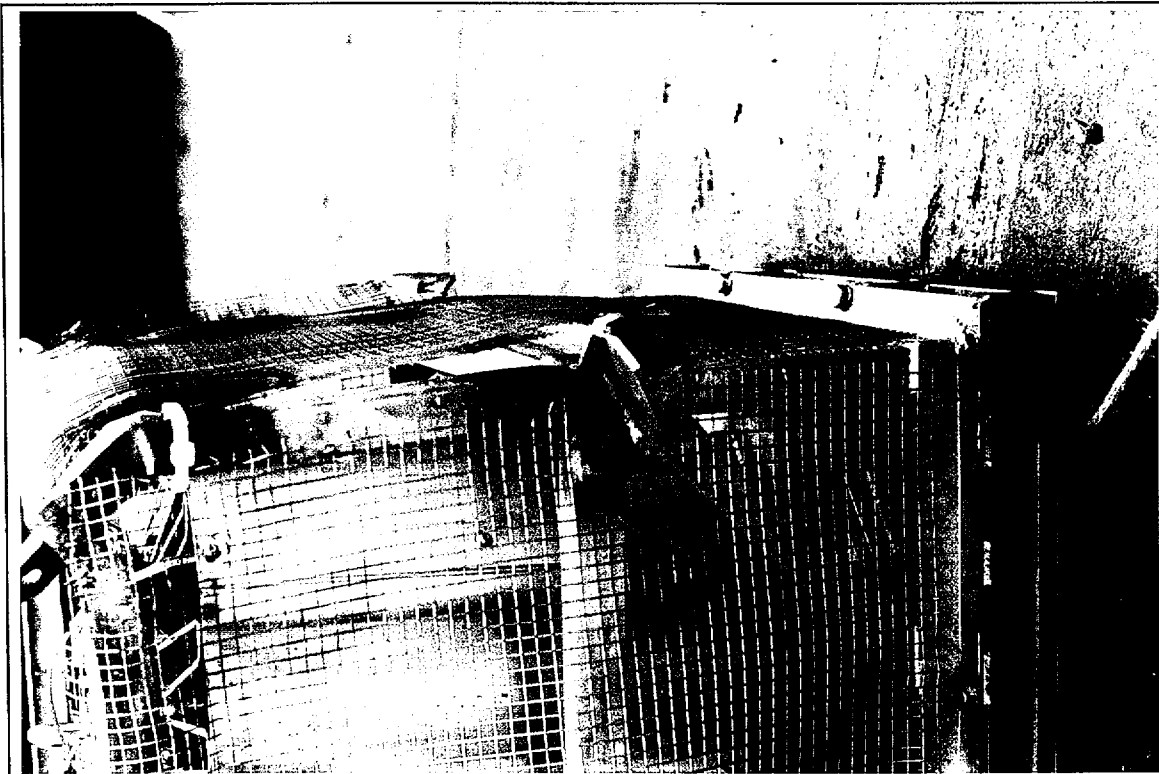


Figure 6: Cage impact face

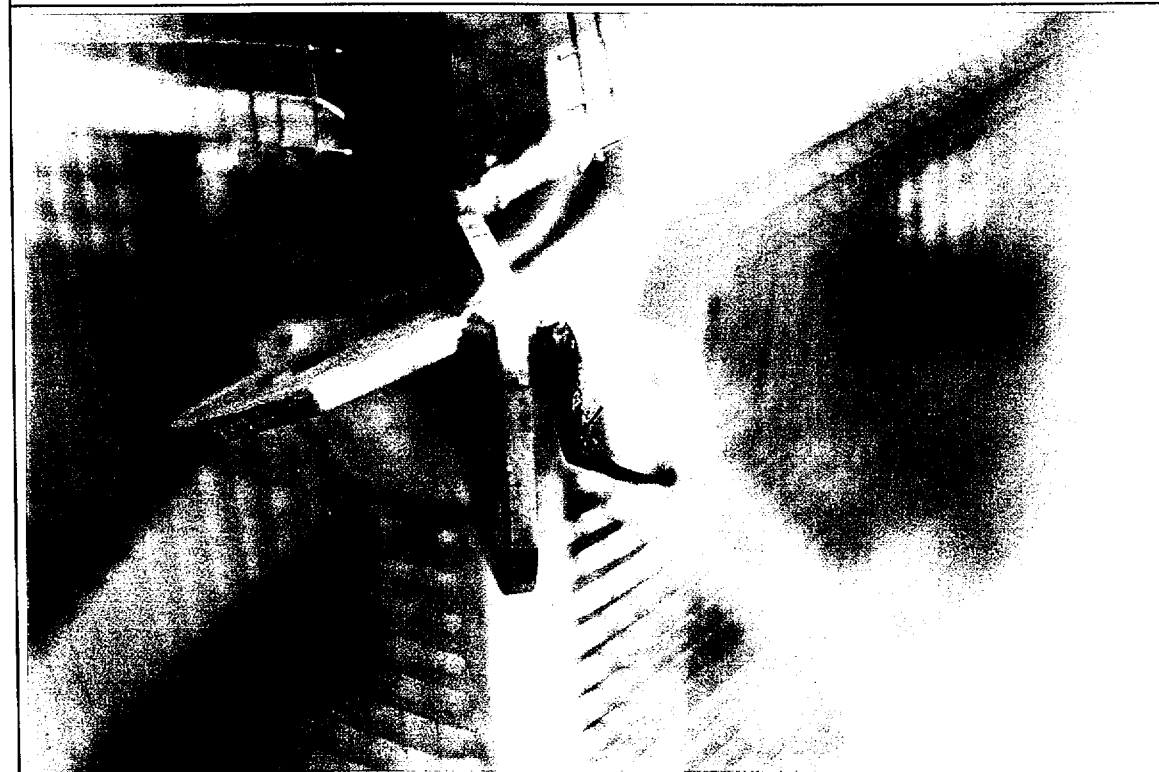


Figure 7: Cage tie-down lug



Figure 8: Cage tie-down lug

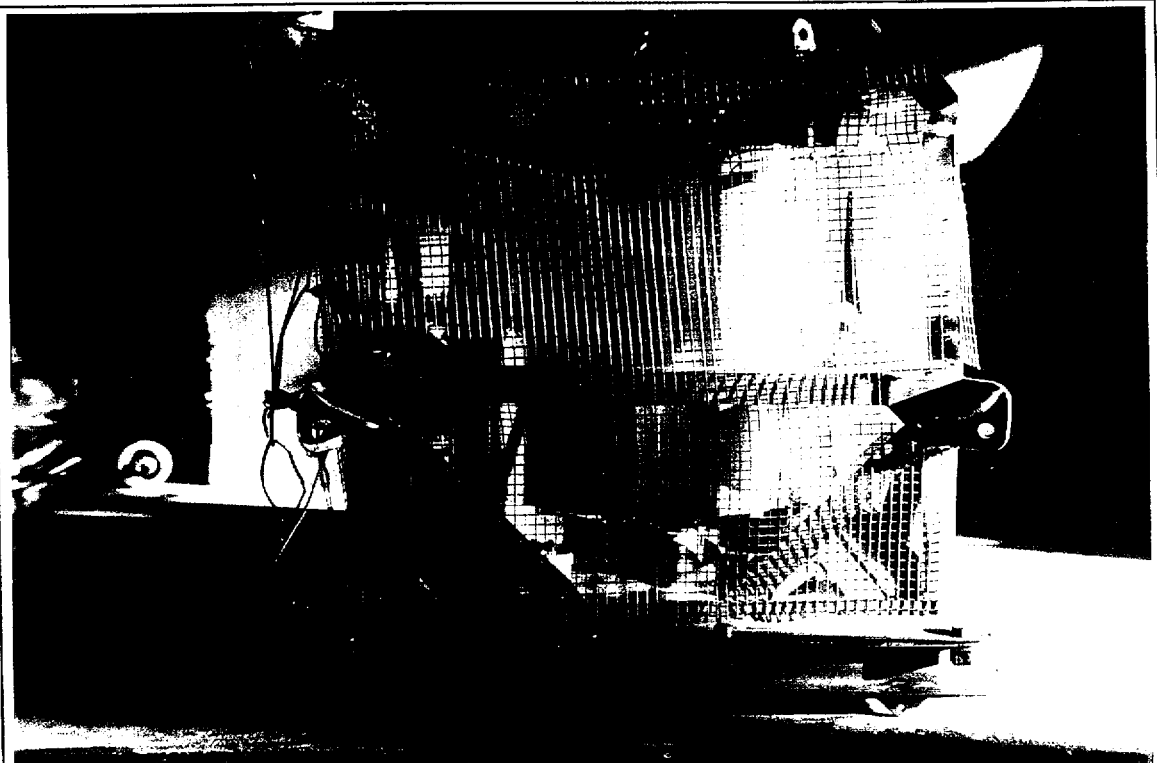


Figure 9: Package elevation

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1906

Date: 31/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height.	<div><div>0.9m</div><div>1.2m*</div><div>9.1m</div></div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	

- * Delete as appropriate

** CASK DAMAGED FROM TESTS 1900, 1901, 1902, 1904, 1905, 1910, 1911 & 1913.
PALLET DAMAGED FROM TESTS 1910, 1911 & 1913.
CAGE DAMAGED FROM TESTS 1910, 1911 & 1913. TOP MEMBERS STRAIGHTENED.
CAGE TO PALLET SCREWS REPLACED.
4. Notes: TEST PLAN NO. PGM 921, ISSUE 3, PARA 8.4.2.
MODEL 3750A : GRN NO. 217554/04. STUD NOS. 1-8.
LEVEL : TOOL NO. 34. PALLET NO. 02.
TORQUE WRENCH : TOOL NO 30. CAGE NO. 02.
HEIGHT GAUGE : TOOL NO 32.
FILM NO: 23, START TIME 53 MIN 30 SEC.
FILM NO: 24, START TIME 29 MIN 30 SEC.

5. Personnel:
- Conducted:

DWR

DWROGERS

Posn: PKG ENGR.
- Witnessed:

M.P. WHEATLEY

M.P. WHEATLEY

Posn: QA ENGINEER.

Amersham International plc

Packaging Design Group

Test Report No. 1908

1 Introduction

1.1 Package Design No. 3750A.

1.2 Test 9.0m Free Drop (Drop I).

1.3 Procedure PGP 15, Issue 5.

1.4 Orientation Flat on side (figs 1 & 2).

1.5 Special conditions The Test Plan (ref 6.3) specifies a test temperature of -40°C.

1.6 Notes

1.6.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The pallet had four small lugs welded to its underside to facilitate slinging. This with the agreement of the DoT engineer.

(3) The cask was not repaired in any way after Series 1, Tests 1898, 1900 & 1901. After Series 2, Tests 1902, 1904 & 1905, the only repair was to straighten the two bent lifting points. After Series 4 (Tests 1910, 1911 & 1913) the only repair was to replace the closure eyebolt. The principal damage from these tests was crushing of two of the closure shock absorbers, partial crushing of the remaining six and punch damage in two places on the top of the cooling fins. None of this was considered to be significant for the side drop series. This with the agreement of the DoT witnessing engineer.

(4) The cage was repaired for this test series after the crushing of the upper section in Series 4, the vertical inverted drops. The vertical cage sections were straightened as much as possible and the mesh panels made secure with wire ties (fig 1). In addition all the cage to pallet screws were replaced. This with the agreement of the DoT witnessing engineer.

(5) The pallet was not repaired in any way after Series 4 tests. The only damage from these tests was slight distortion of the underside at one corner which would not be on the impact face for any of the side drop series. The four small lugs that had been added to the underside of the pallet to facilitate slinging in the Series 4 (fig 1) were left in place. This with the agreement of the DoT witnessing engineer.

(6) The package had been damaged in the 1.2m drop, Test 1906, as required by the Test Plan (ref 6.3).

(7) The package had five thermocouples added to monitor temperature.

1.6.2 Orientation:

(1) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 2).

(2) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the pallet in the lateral axis and along the top of the cask for the longitudinal axis.

(3) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.6.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature (fig 2). Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure. A small section of mesh was cut out of the lower right panel on side No. 2 to allow the cables and connectors to be lead out.

Note: The thermocouples were installed prior to Test 1906 to avoid disturbance of the package assembly during the test series.

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

1.6.4 Target:

The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

2 Pass/Fail Criteria

2.1 Closure

The cask closure must remain attached to the cask body.

2.2 Jacket

The jacket must remain attached to the cask.

2.3 Notes

The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
One third scale 3750A pallet	217554/04	02	-	-
One third scale 3750A cage	217554/04	02	-	-
Cask closure studs	217554/04	01-08	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Level: RS Stock No. 651-428	-	-	34	08/01/97
Height gauge: 9.0m	-	-	35	15/01/97

3.1.2 Notes:

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any measuring equipment used.

3.2 Assembly

The third scale 3750A package was assembled prior to Test 1906 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. The existing damage did not prevent it being properly assembled.

3.4 Records

3.4.1 Photographic:

See Appendix A.

- 3.4.2 Video:
(1) Film No. 23, Start time 54min 20sec.
(2) Film No. 24, Start time 33min 10sec.

- 3.4.3 Operational:
See Appendix B.

4 Results

4.1 Temperature

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-42.5
2	-44.6
3	-45.7
4	-40.1
5	-44.0

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed flat on the side, bounced to a height of approximately 200 mm and landed and came to rest on its side (figs 3 & 4).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached to the cask body.

4.4 General observations

- 4.4.1 Note: Inspection was limited to an external examination. It was not permitted to dismantle the package before the following punch test, Test 1899 the last test of Series 3, when more detailed observations could be made.

- 4.4.2 Cage: The cage showed relatively little additional damage. The tie-down lugs under the impact were a little more bent over. The half height cross member under the impact was slightly flattened in its centre. There was a small degree of general distortion in the lower half of the cage resulting in yielding around several of the pallet fixing points (figs 5-7). Otherwise the cage was intact. All twelve of the pallet screws were in place and appeared undamaged.

- 4.4.3 Pallet: The pallet was distorted slightly around some of the cage fixings and to a greater degree around the cask mounting points. The six screws holding the lower two cask feet appeared undamaged and secure. The upper six screws had failed (fig 8). The cask was secure to the pallet but was leaning against the cage impact face above the cross member.
- 4.4.4 Cask body: The cask body showed crushing of the jacket and cooling fins over an area best described as an inverted triangle extending at its broadest along the top of the jacket almost the full quadrant between two lifting points and downwards to a point midway between and half way down the jacket (fig 9). The lifting points were undamaged. The cooling fins were distorted away from the centreline of the impact. The jacket had a triangular split (fig 10) 20 mm wide at the top extending 85 mm down from the top edge which appeared to have been initiated by the indentation caused by the jacket being compressed between the tips of the cooling fins and the cage mesh. There were several such indentations and the split clearly followed one of them. The jacket was corrugated and folded to each side. All twelve jacket screws were in place and appeared undamaged. All eight closure studs and nuts were in place and appeared undamaged.
- 4.4.5 Cask closure: The closure appeared free from additional damage.


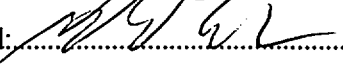
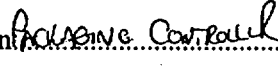
5 Conclusions

- 5.1 Pass/Fail
The package passed the test.
- 5.2 Other
None.

6 References

- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(a).
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(1).
- 6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.4.3.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 Signatures

- 7.1 Author:  Position: PKG ENGR Date: 19/02/96
- 7.1 Checked:  Position: ~~PKG ENGR~~  Date: 19/2/96

Appendix A

Photographs

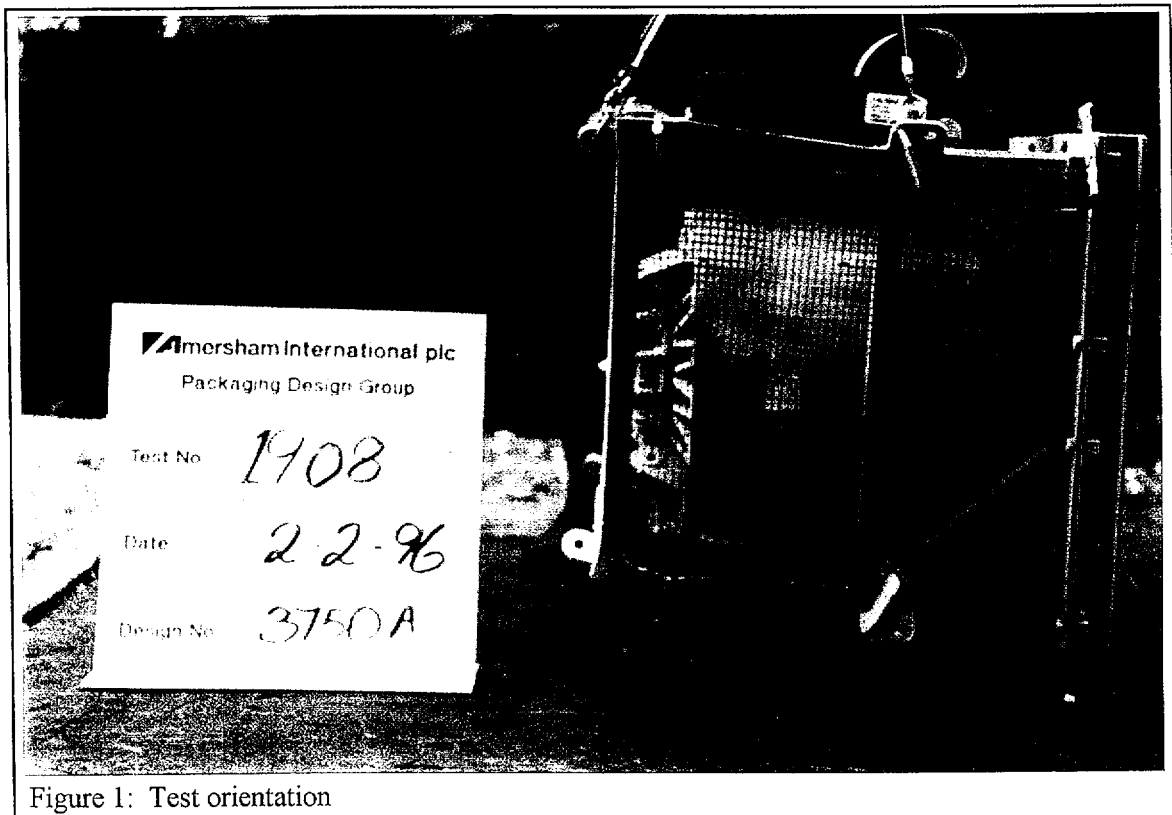


Figure 1: Test orientation

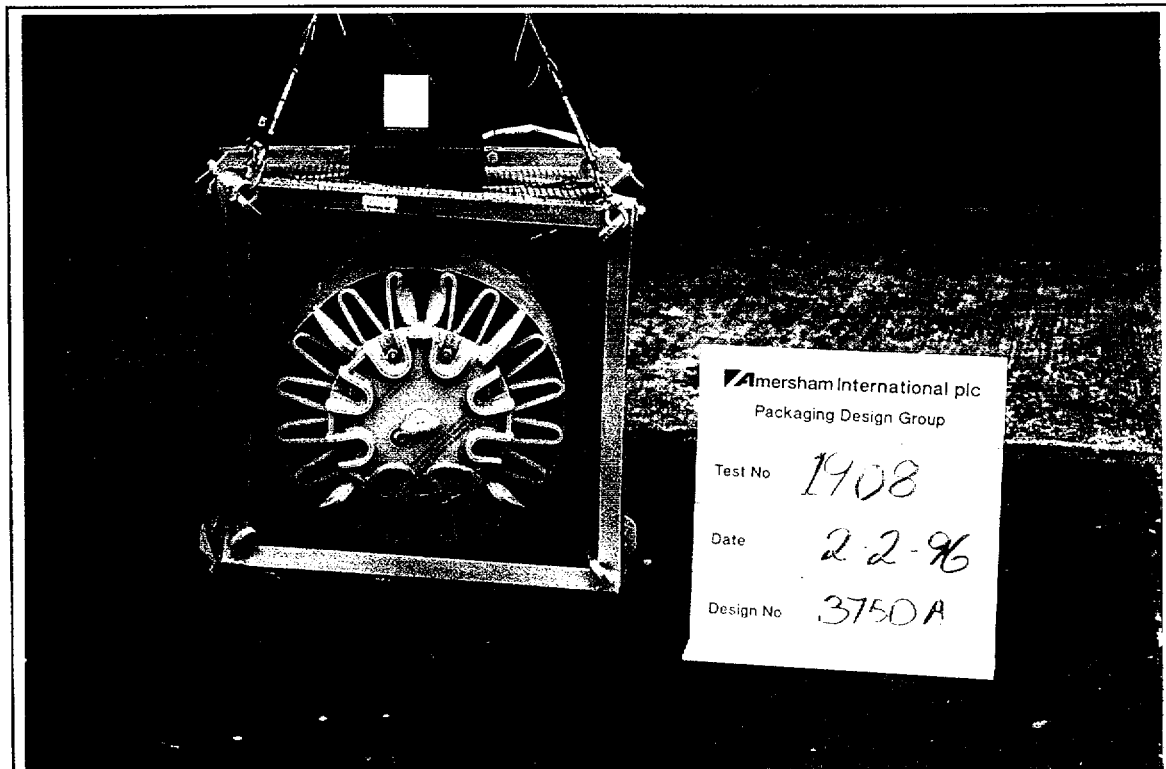


Figure 2: Test orientation

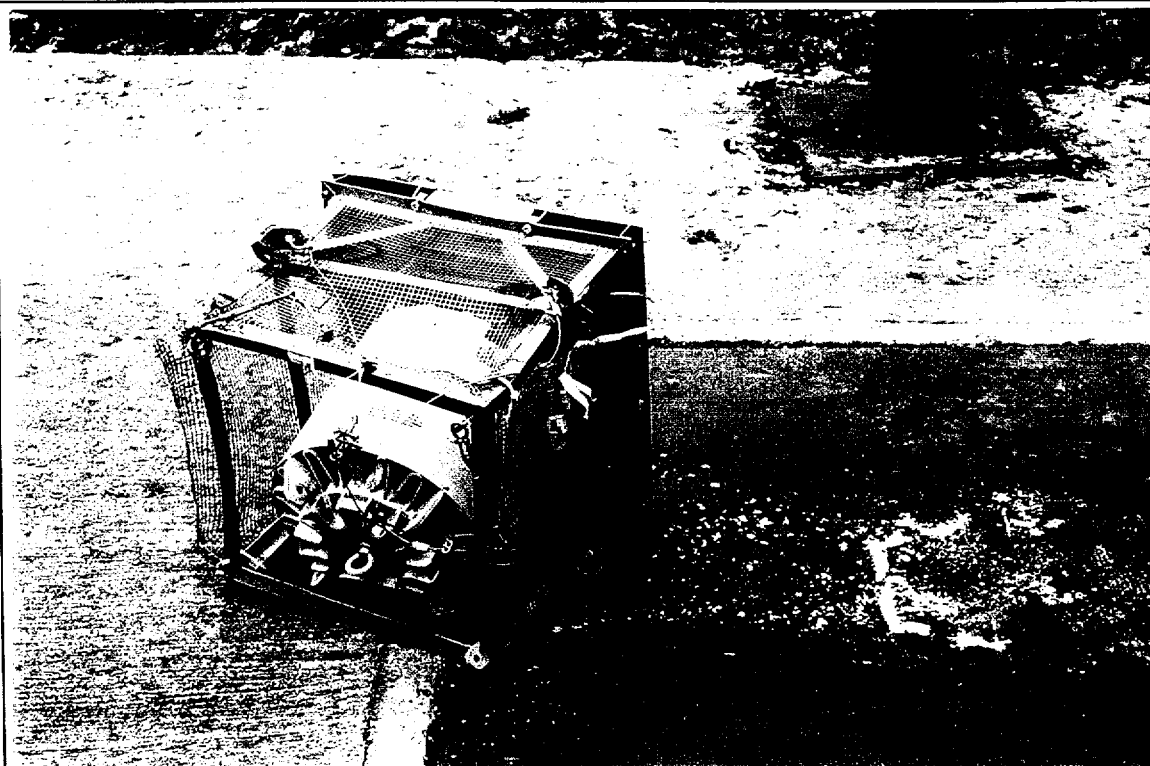


Figure 3: After impact

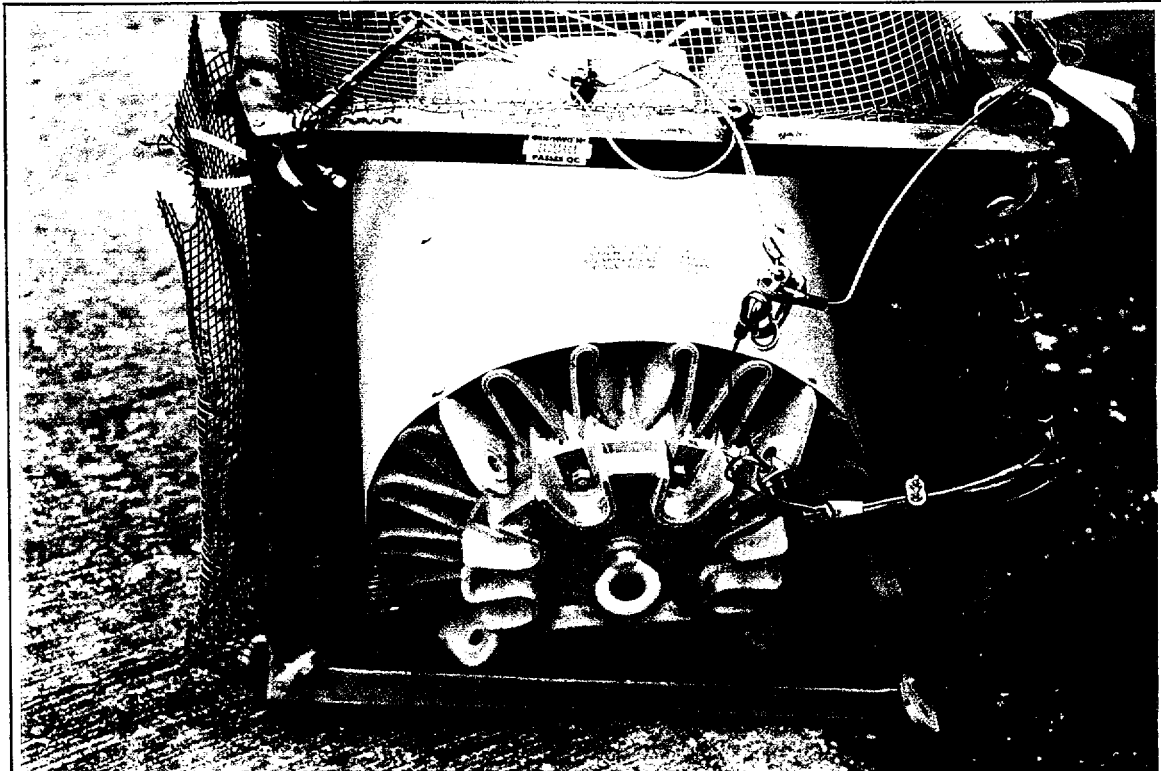


Figure 4: After impact

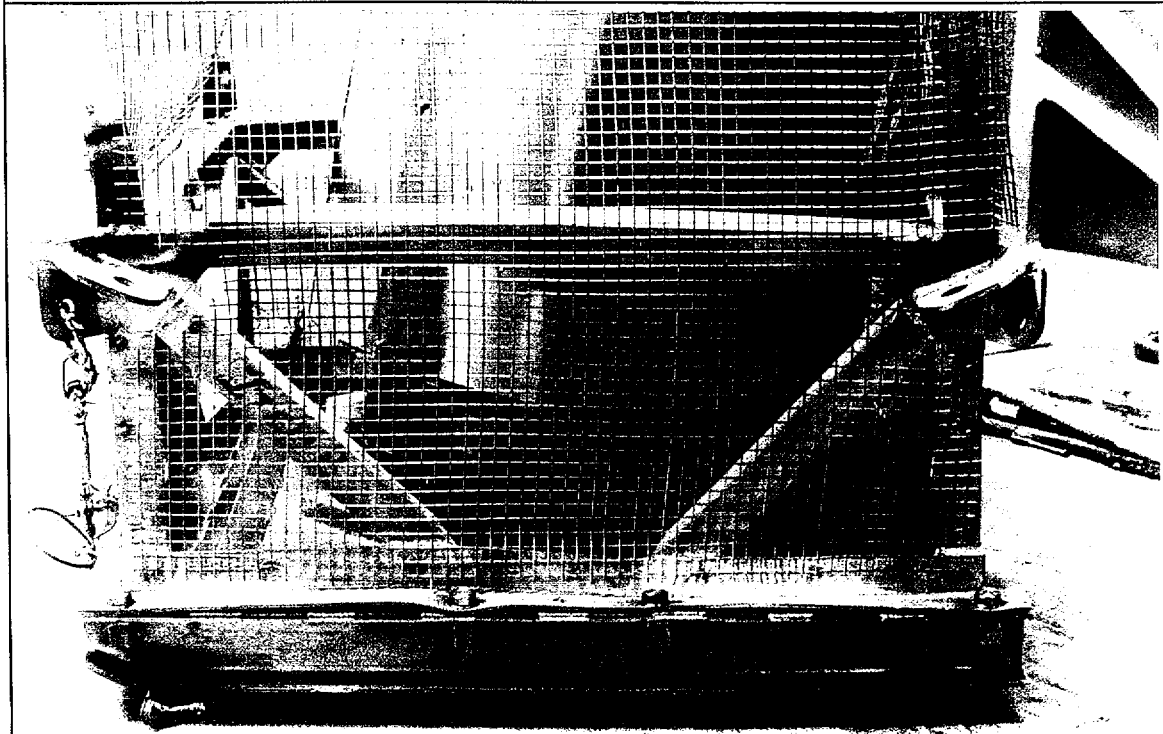


Figure 5: Cage showing yielding around pallet fixings

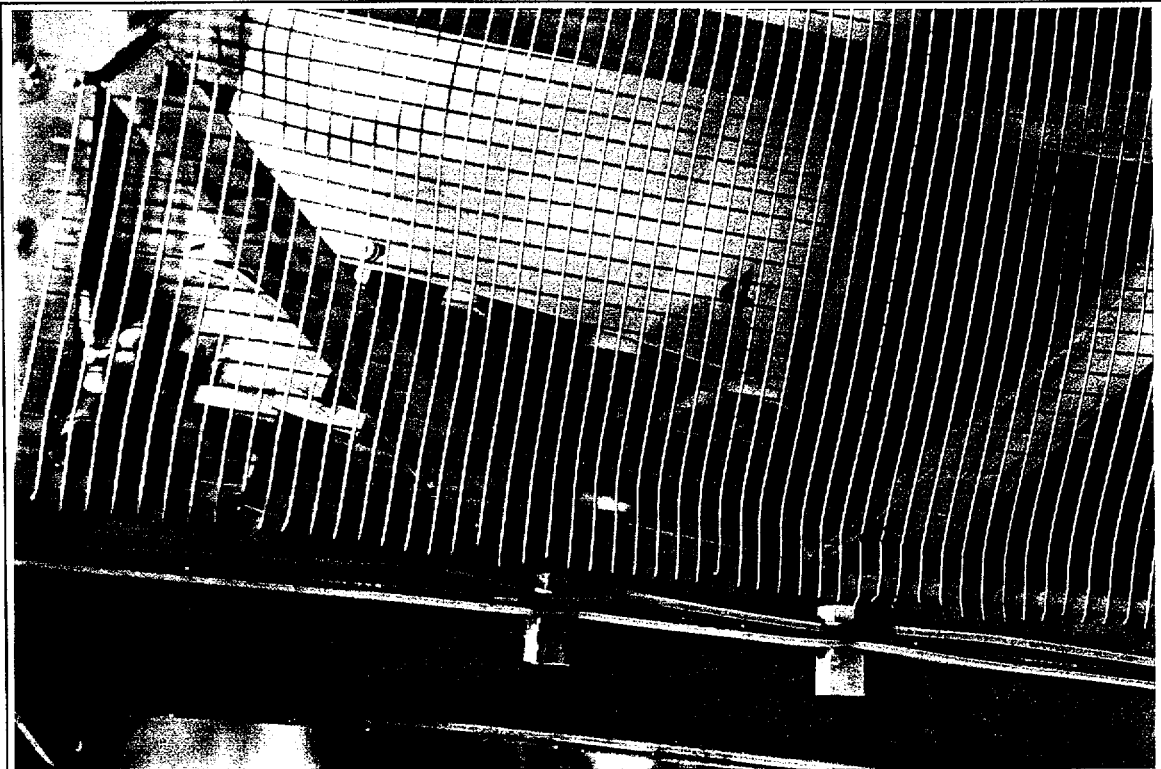


Figure 6: Cage showing yielding around pallet fixings



Figure 7: Cage showing yielding around pallet fixings



Figure 8: Failed cask feet screws

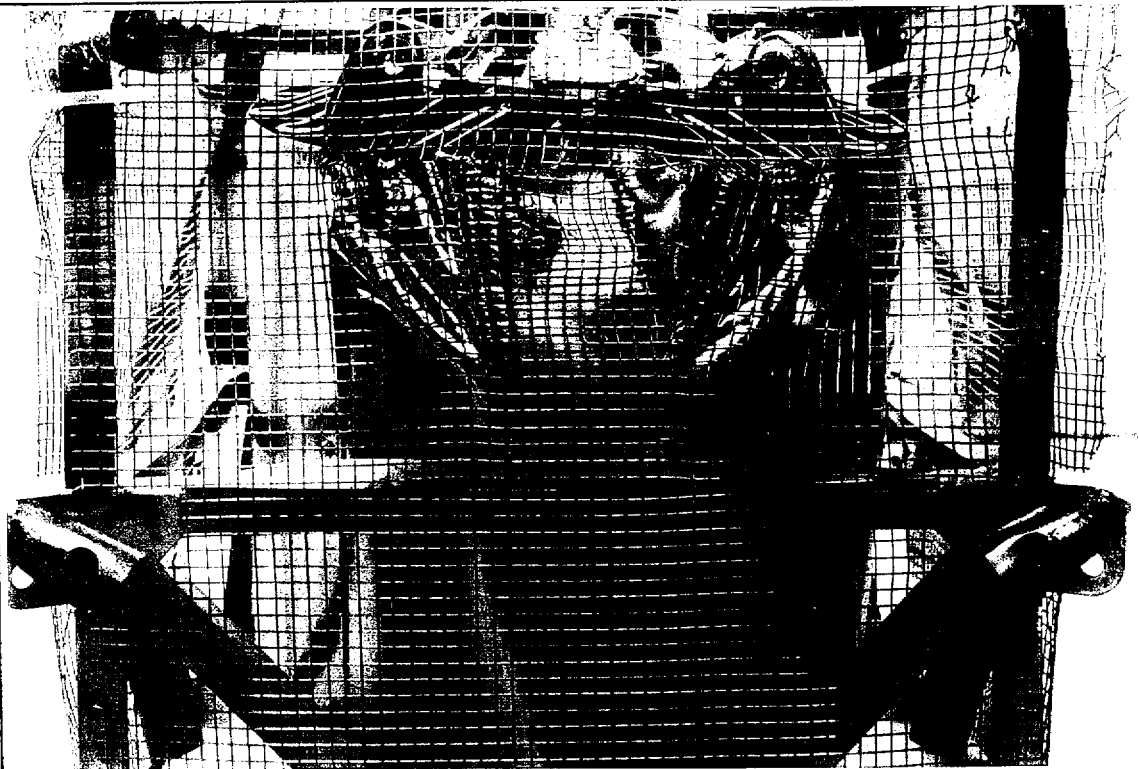


Figure 9: Crush damage to upper cask

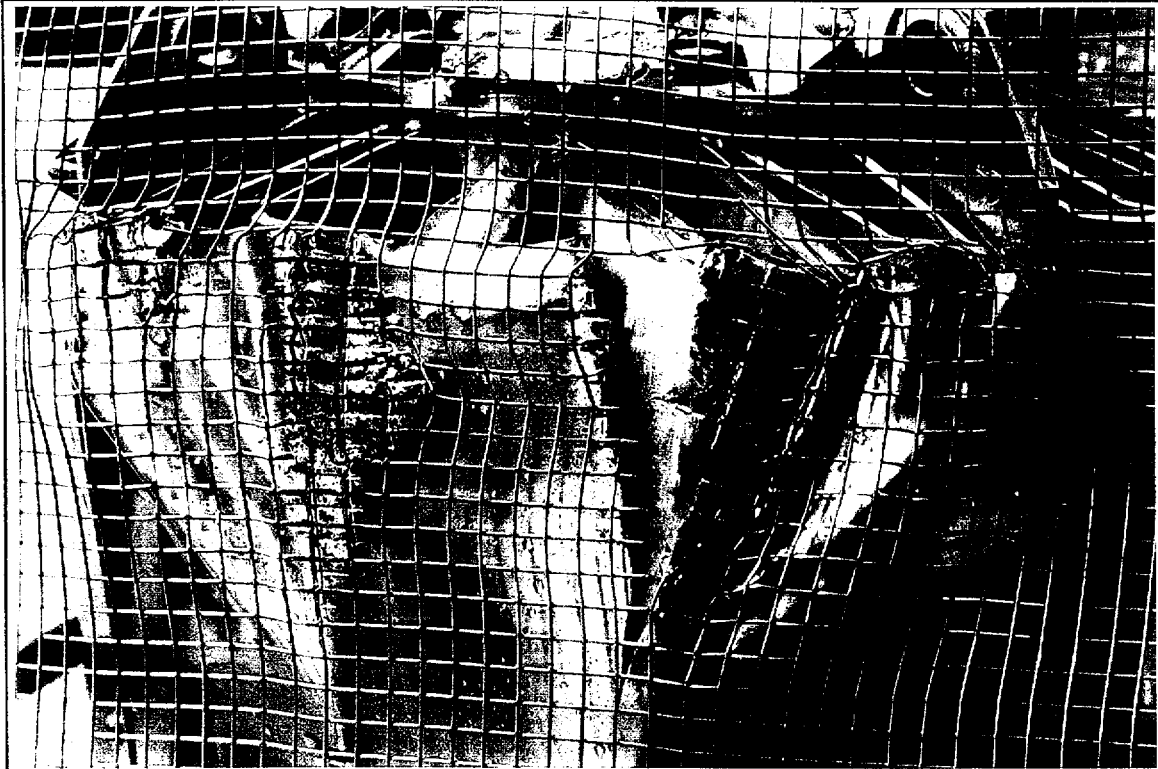


Figure 10: Crush damage to upper cask

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1908

Date: 02/02/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.

2. Check List:

Step	Operation	Check
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height.	<div>0.3m✓</div> <div>1.2m✓</div> <div>9.0m* ✓</div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	✓

* Delete as appropriate ** PACKAGE DAMAGED FROM TEST 1906.

4. Notes:
- TEST PLAN: P&M 921, ISSUE 3, PARA 8.4.3

3750A MODEL: GRN NO. 217554/04

LEVEL: TOOL NO. 34

HEIGHT GAUGE: TOOL NO. 35

TEMPERATURE RECORDER: TOOL NO 27

FILM NO 23 = START TIME 54 MIN 20 SEC

FILM NO 24 = START TIME 33 MIN 10 SEC
- TEMP. READINGS AT DROP (°C)

T/C NO. 1: -42.5

T/C NO. 2: -44.6

T/C NO. 3: -45.7

T/C NO 4: -40.1

T/C NO 5: -44.0

TIME OF DROP: 12.20

5. Personnel:
- Conducted:

DJ Rogers

D.L. ROGERS

Posn: PKE ENGR.
- Witnessed:

M. P. WILKINSON

M. P. WILKINSON

Posn: QA ENGINEER.

Amersham International plc

Packaging Design Group

Test Report No. 1909

1 Introduction

1.1 Package Design No 3300A.

1.2 Test 1.0m Penetration (refs 6.1 & 6.2).

1.3 Procedure PGP 17, Issue 3.

1.4 Orientation Upright (figs 1, 2 & 4).

1.5 Location of impact The impact point was the edge of the top mesh panel, just inside and at the mid point of the supporting angle section framework (fig 3).

1.6 Special conditions None.

1.7. Notes The penetration bar was a 32 mm diameter stainless steel bar weighing 6.0 kg with a hemispherical end.

2 Pass/Fail Criteria

The bar must not make a hole in the mesh greater than 100 mm in diameter (ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
3300A cage: Drg No. A23901, Issue D	-	09	-	-
Penetration bar	-	-	28	09/01/98
Height gauge: 1.0m	-	-	31	08/01/97

3.1.2 Notes:

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any measuring equipment used.

3.2 Assembly

Not applicable as only one component is being tested.

3.3 Records

3.3.1 Photographic:

See Appendix A.

3.3.2 Video:

Film No. 23, Start time 57min 00sec.

3.3.3 Operational:

See Appendix B.

4 Results

4.1 Orientation and impact

The video recordings and damage confirmed the penetration bar dropped correctly.

4.2 **Pass/Fail Criteria**

The bar did not penetrate the mesh.

4.3 **General observations**

The bar made a circular impression in the mesh (figs 5 & 6) approximately 10 mm deep in the centre. The distortion was entirely plastic. All the wires were intact and attached to each other. None of the mesh attachment welds were affected or the angle section supporting frame.

5 **Conclusions**

5.1 **Pass/Fail**

The package passed the test.

5.2 **Other**

None.

6 **References**

6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 624.

6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 71.71(10).

6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.2.2.

7 **Signatures**

7.1 Author: DDRye & DWROGERS Position: PRG ENGR Date: 12/03/96

7.1 Checked: Alex A. Lewis Position: Pkg Designer Date: 13/3/96

Appendix A

Photographs

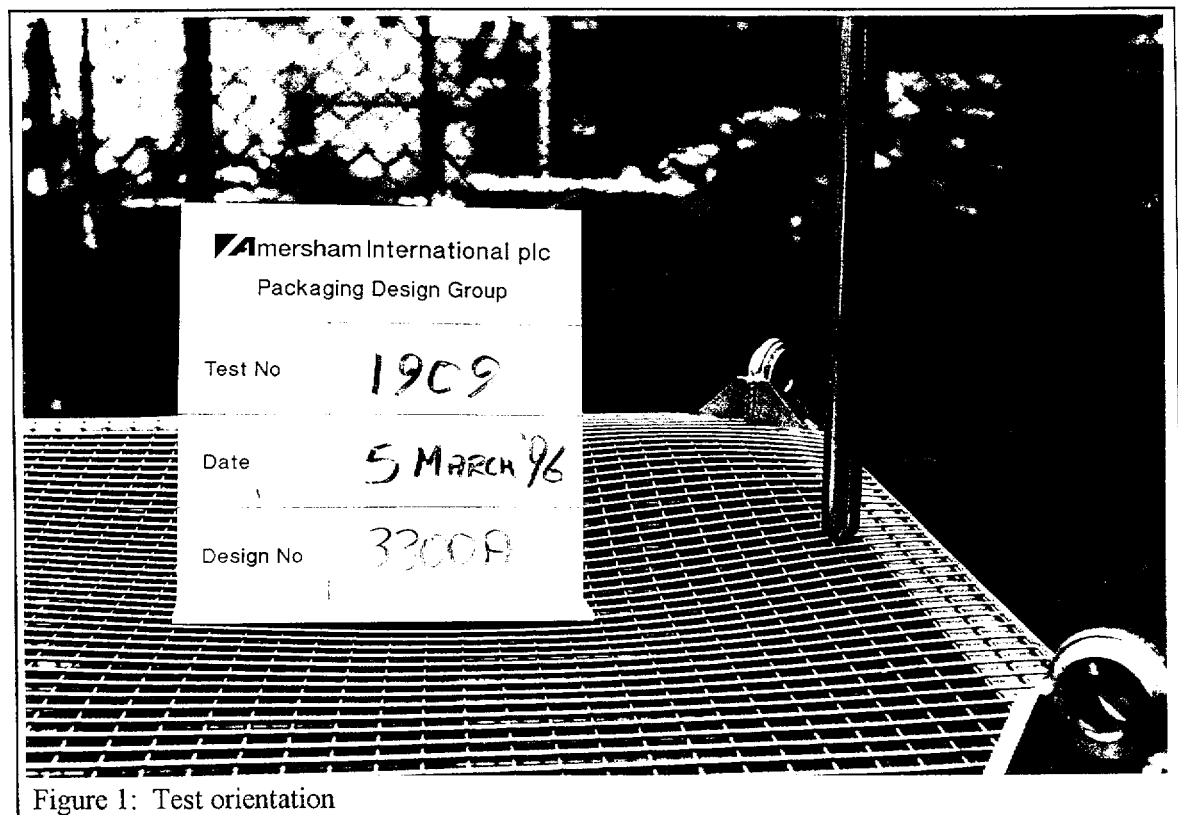


Figure 1: Test orientation



Figure 2: Test orientation



Figure 3: Test set-up

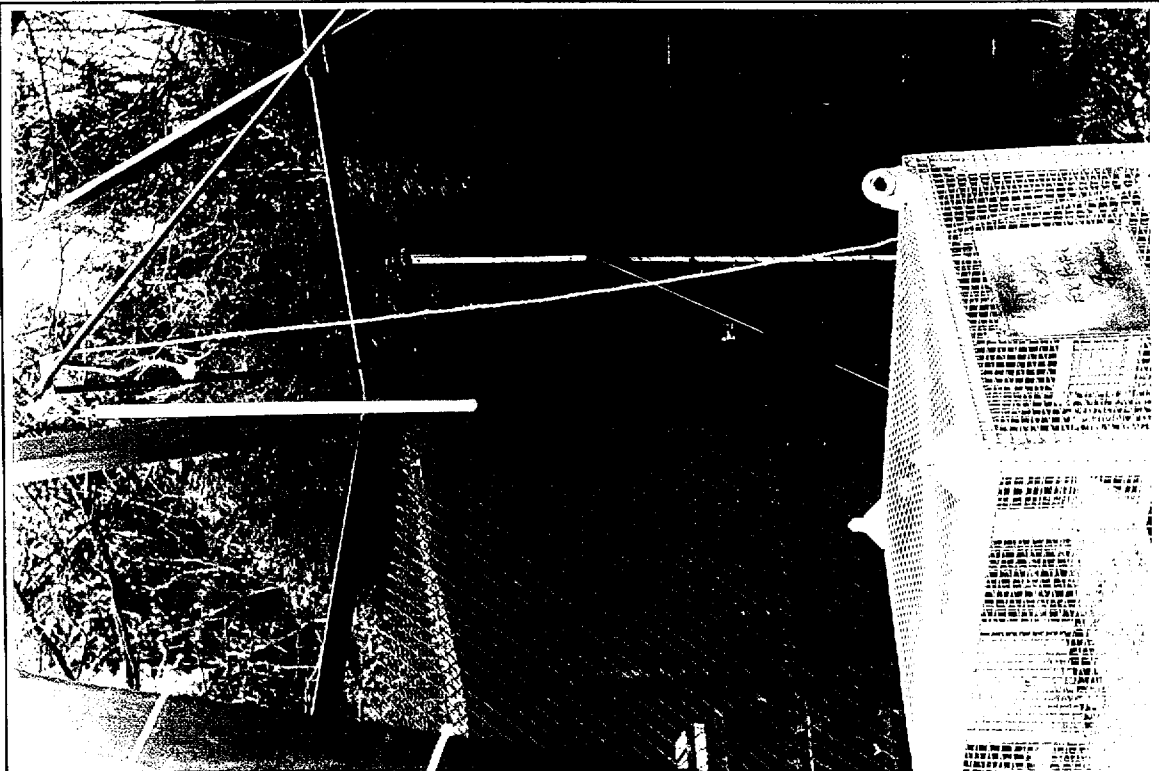


Figure 4: Test set-up



Figure 5: Bar impression

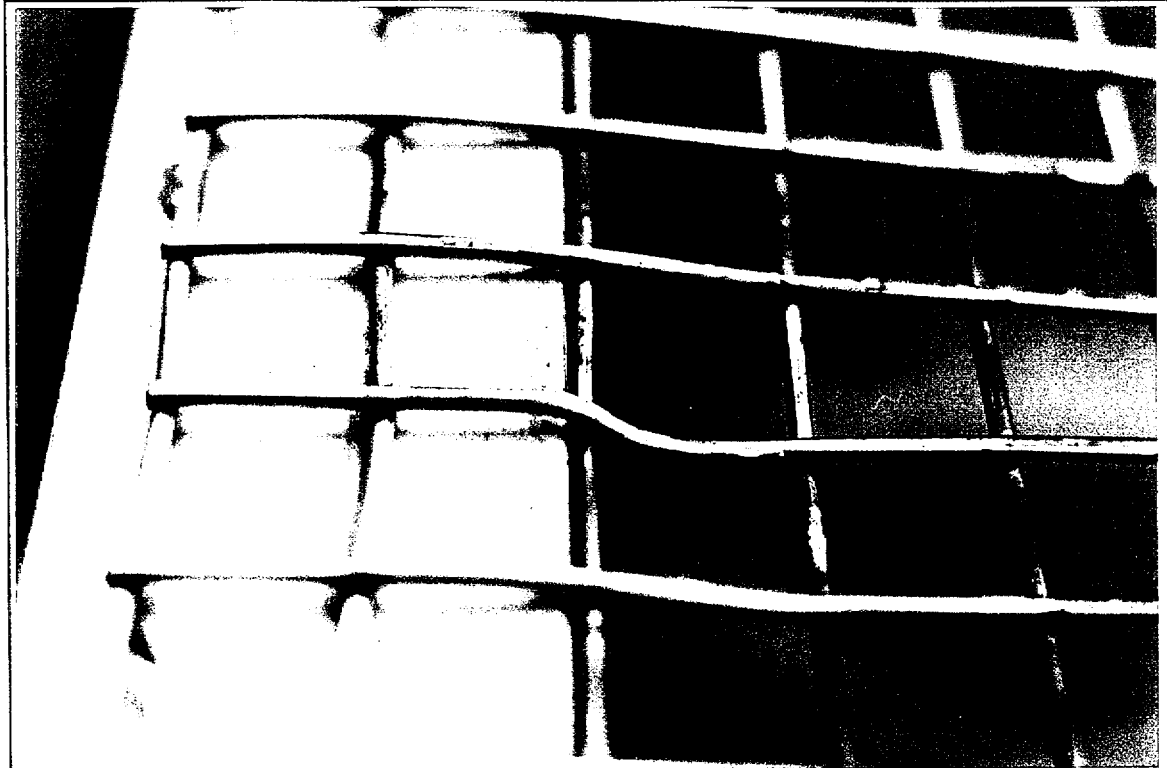


Figure 6: Bar impression

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Penetration Test Check List

Test No:	1909
Date:	05/03/96

1. Notes:
- a) This checklist forms the operations section of PGP 17, Packaging Group Procedure for Penetration Testing. If in doubt ask.
 - b) A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
 - c) Check hoist cable weight is lowered onto the target plate before entering compound.

2. Check List:

Step	Operation	Check ✓	
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓	
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓	
3	Record video film number and start time	✓	
4	Confirm sample is correctly assembled	✓	
5	Confirm sample is correctly orientated	✓	
6	Confirm test bar is correctly aligned	✓	
7	Confirm test bar is correct weight	6 kg*	7 kg*
8	Confirm height between guide tube base and impact point is correct	1.2m*	1.0m*
9	Remove all non-essential personnel from compound	✓	
10	Start video	✓	
11	Drop penetration bar	✓	
12	Confirm impact point is correct	✓	
13	Record damage to sample with video	✓	
14	Take still photographs (optional)	✓	

* Delete as appropriate

4. Notes: TEST PLAN PGM 921, ISSUE 3, PARA 8.2.2 APPLIES.
- CAGE = 3300/09
- PALLET: 3300/01
- PENETRATION BAR: TOOL NO: 28
- HEIGHT GAUGE : TOOL NO: 31
- TAPE NO 23: START TIME 57 MIN 00 SEC.

5. Personnel:

Conducted: DW Rogers Posn: 05/03/96

Witnessed: A. Lewis Posn: 5/3/96

Amersham International plc

Packaging Design Group

Test Report No. 1910

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.2m Free Drop.

1.3 Procedure PGP 15, Issue 5.

1.4 Orientation Vertical inverted (figs 1-3).

1.5 Notes

1.5.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The cask was not repaired in any way after Series 1, Tests 1898, 1900 & 1901. After Series 2, Tests 1902, 1904 & 1905, the only repair was to straighten the two bent lifting points. The principal damage from these tests was crushing of two of the closure shock absorbers thus reducing the number from eight to six. This was considered to give a harder impact and therefore additional conservatism to the results. This with the agreement of the DoT witnessing engineer.

(3) The pallet and cage were replaced for this test series. Although the cage was not required by the Test Plan it was added to make it more representative. This with the agreement of the DoT witnessing engineer.

(4) Four small lugs were added to the underside of the pallet to facilitate slinging (fig 2). This with the agreement of the DoT witnessing engineer.

(5) Five thermocouples were added in readiness for the following Tests 1911 & 1913 and the cables lead out through a small hole cut in the lower right hand corner of the mesh panel on side No. 2 (fig 5). This with the agreement of the DoT witnessing engineer.

1.5.2 Orientation:

(1) Test order: The inverted orientation is Series 4. This was brought in front of Series 3, the side impact, to avoid damaging the cask feet as otherwise this would have made assembly to the pallet very difficult for Series 4.

(2) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 2).

(3) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the package in both axis.

(4) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.5.3 Target:

The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall mass is in excess of 8,000 kg.

2 Pass/Fail Criteria

2.1 Pallet

The pallet must remain attached to the cage.

2.2 Cask

The cask must remain attached to the pallet.

2.3 Closure

The cask closure must remain attached to the cask body.

2.4 Notes

The criteria above are based on what was readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before, during and after the mechanical test programme. The additional tests measure each parameter and sentence it against quantified criteria (see Ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC No.
One third scale 3750A cask	217554/04	01	-	-	-
One third scale 3750A pallet	217554/04	02	-	-	-
One third scale 3750A cage	217554/04	02	-	-	-
Cask closure studs	217554/04	09-16	-	-	-
Torque wrench: Norbar Model SLO	-	-	30	10/01/97	-
Height gauge: 1.2m	-	-	32	08/01/97	-
Level: RS Stock No. 651-428	-	-	34	08/01/97	-

3.1.2 Notes

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any other measuring equipment used.
- (5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The third scale 3750A package was assembled in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. None of the damage from the previous tests prevented the package being assembled correctly.

3.3 Records

3.3.1 Photographic See Appendix A.

- 3.3.2 Video:
(1) Film No. 23, Start time 60min 00sec.
(2) Film No. 24, Start time 20min 07sec.

- 3.3.3 Operational:
See Appendix B.

4 Results

4.1 Orientation and impact

The video recordings confirmed the assembly dropped correctly. It landed square on the top of the cage with very little bounce. The cage gave way and the package remained inverted (fig 4).

4.2 Pass/Fail criteria

The cask closure, cask, pallet and cage all remained securely attached.

4.3 General observations

- 4.3.1 Note: The inspection was limited to an external examination as the package was not permitted to be disturbed before the the last test in Series 4, Test 1913.

- 4.3.2 Cage: The upper section of the cage was compressed downwards to the height of the closure eyebolt (fig 6). All four uprights had buckled just below the lifting points. The lower half of the cage was undamaged. All twelve pallet screws were in place and appeared undamaged.

- 4.3.3 Pallet: The pallet showed no damage. It supported the cask centrally and upright. All twelve cask feet screws were in place and appeared undamaged.

- 4.3.4 Cask body: The cask showed no additional damage. All twelve jacket screws were in place and appeared undamaged. All eight closure studs and nuts were in place and appeared undamaged.

- 4.3.5 Cask closure: The closure, including the eyebolt, appeared undamaged (fig 7).

5 Conclusions

5.1 Pass/Fail

The package passed the test

5.2 Other

None.

6 **References**

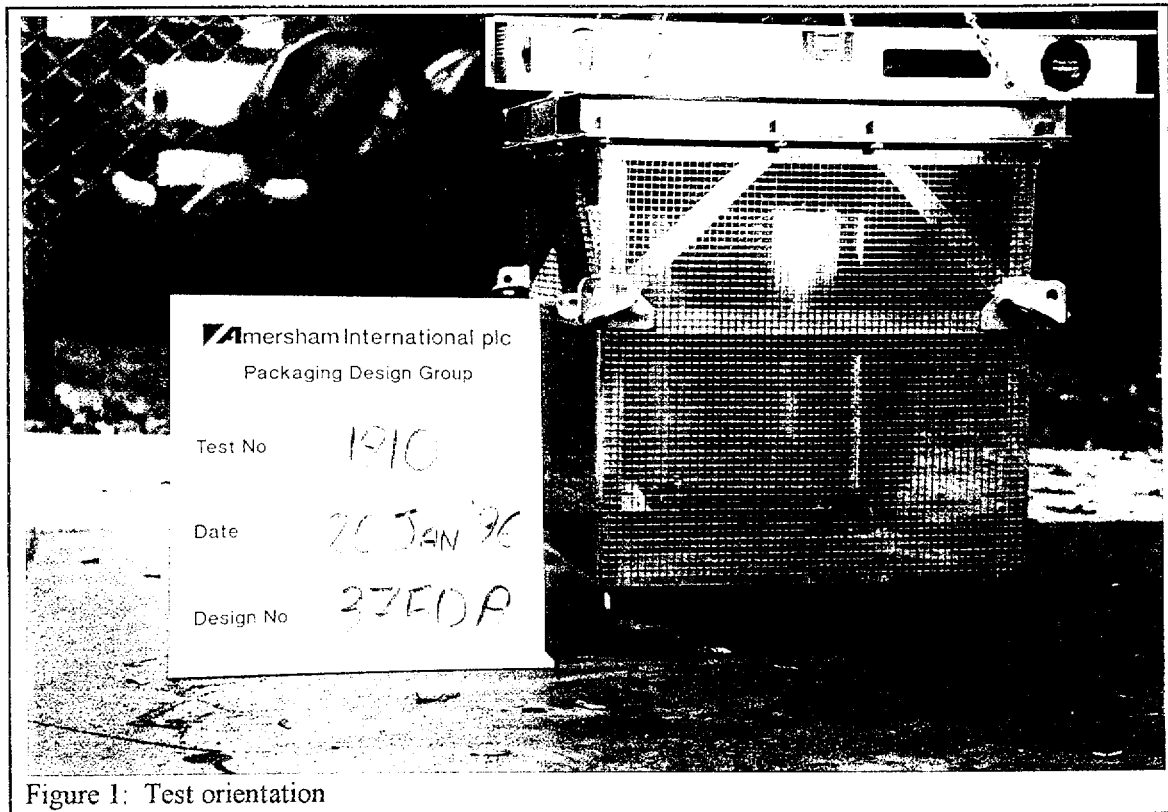
- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 622.
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 71.7.
- 6.3 3750A Test Plan, PGM 921, Issue 3, paragraph 8.5.2.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

- 7.1 Author: DWR Position: PIG ENGR Date: 16/02/96
- 7.1 Checked: [Signature] Position: Phenolic Carburizer Date: 16 02 96

Appendix A

Photographs



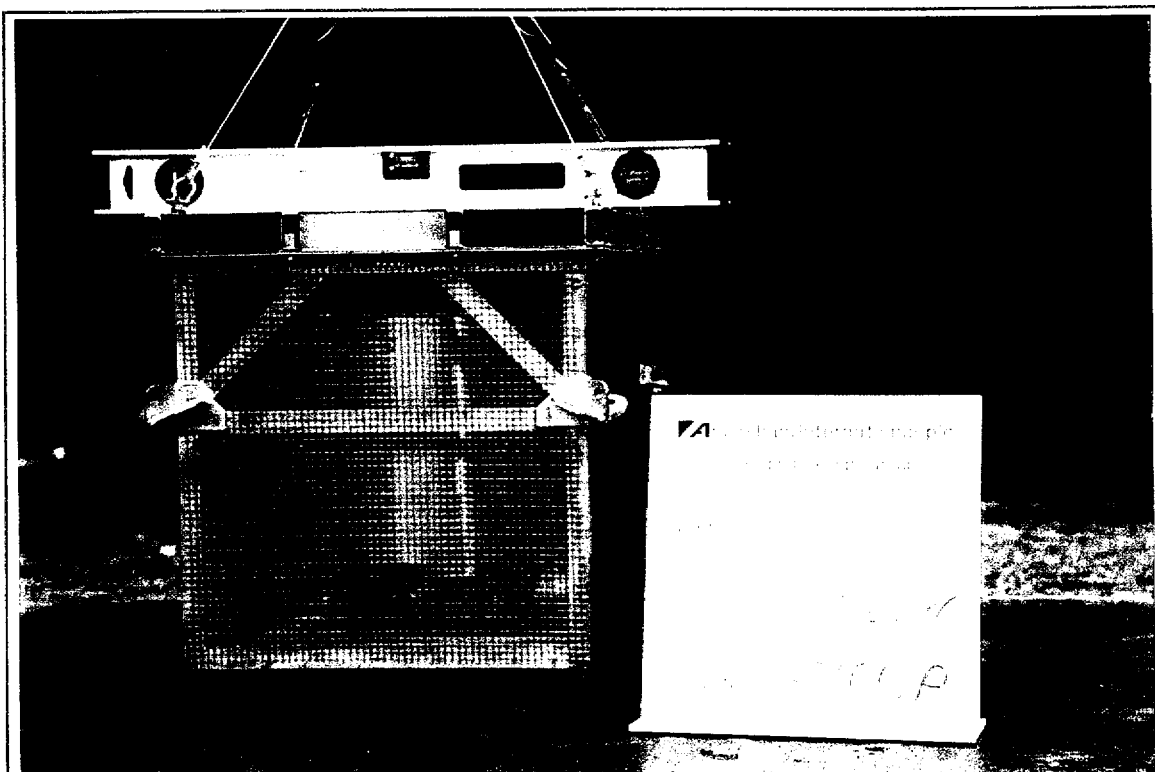


Figure 2: Test orientation



Figure 3: Test set-up

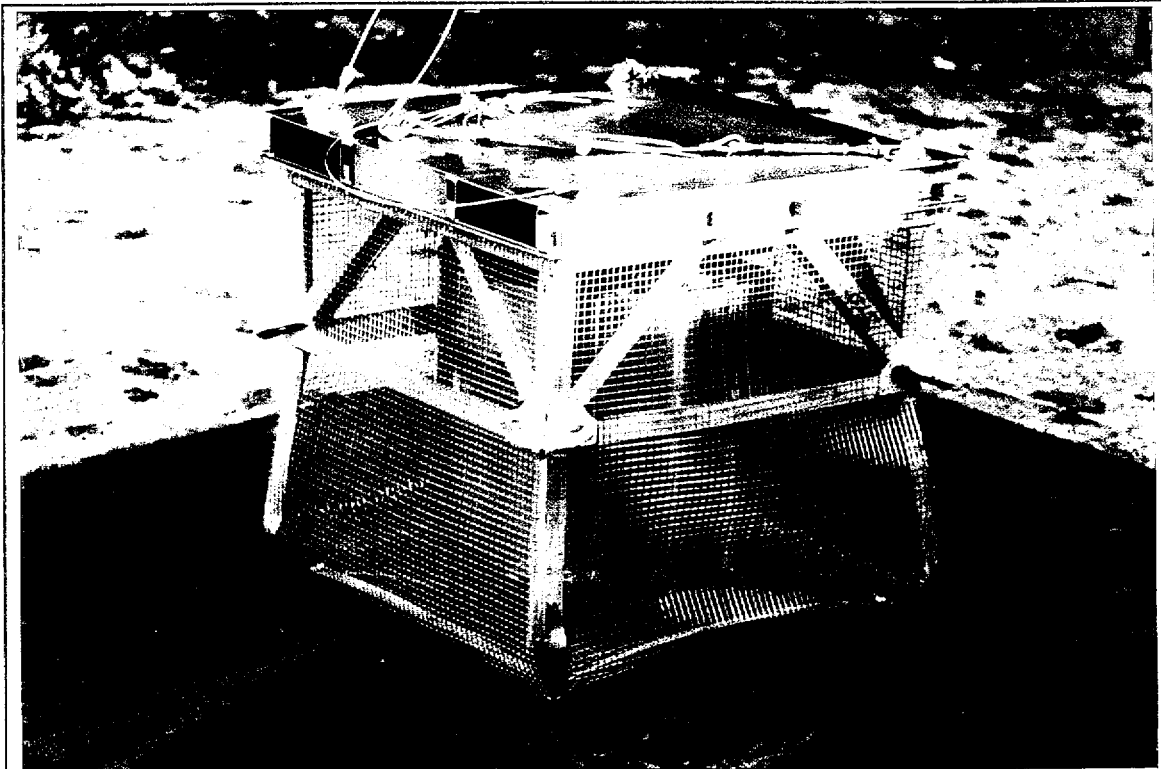


Figure 4: After impact

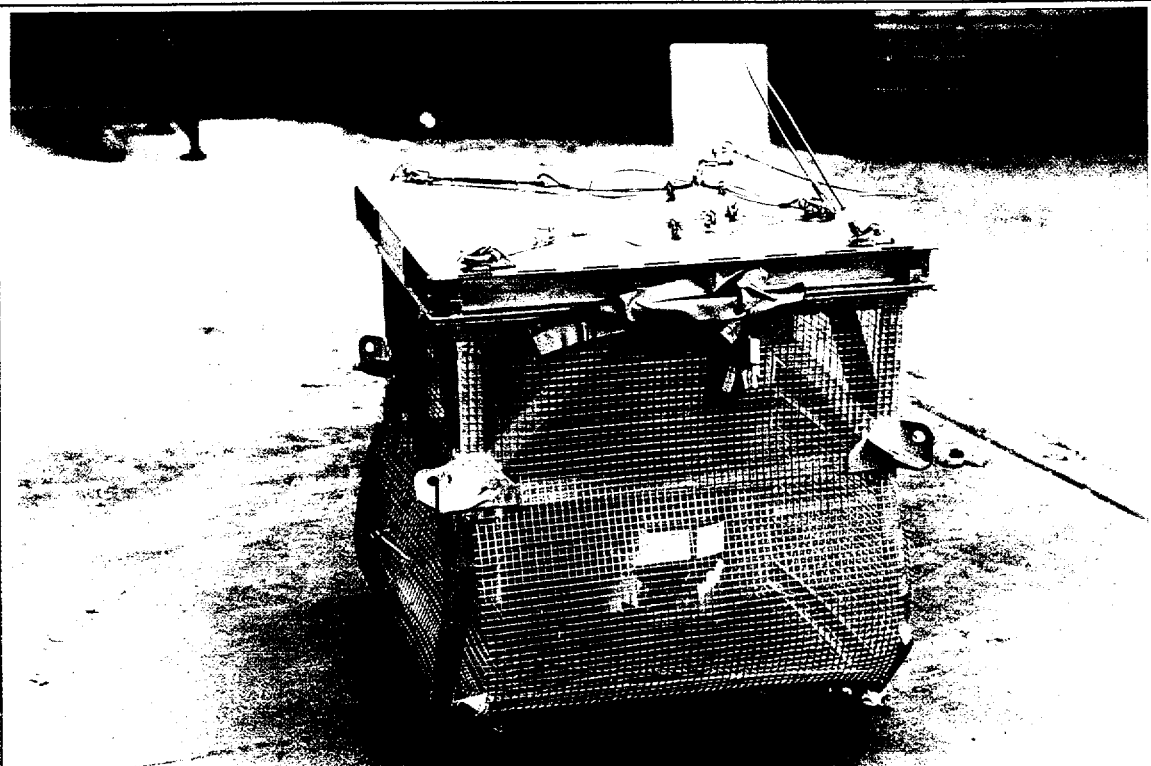


Figure 5: After impact

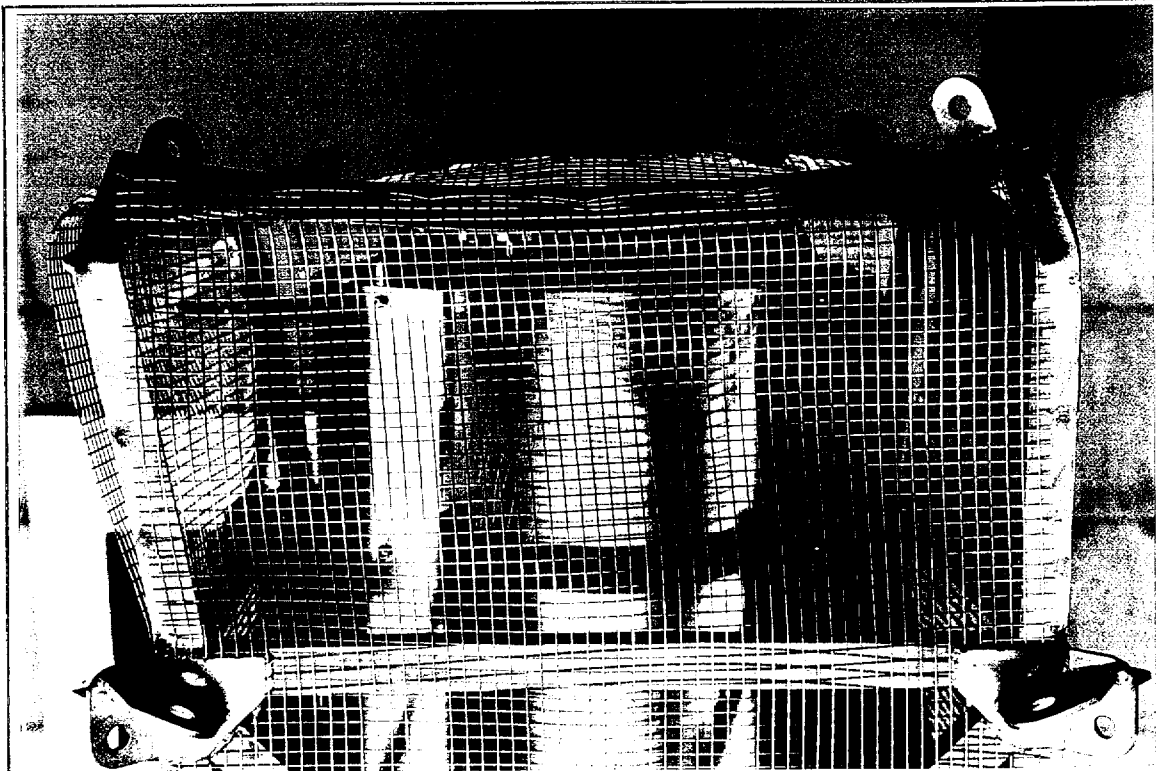


Figure 6: Upper half of cage

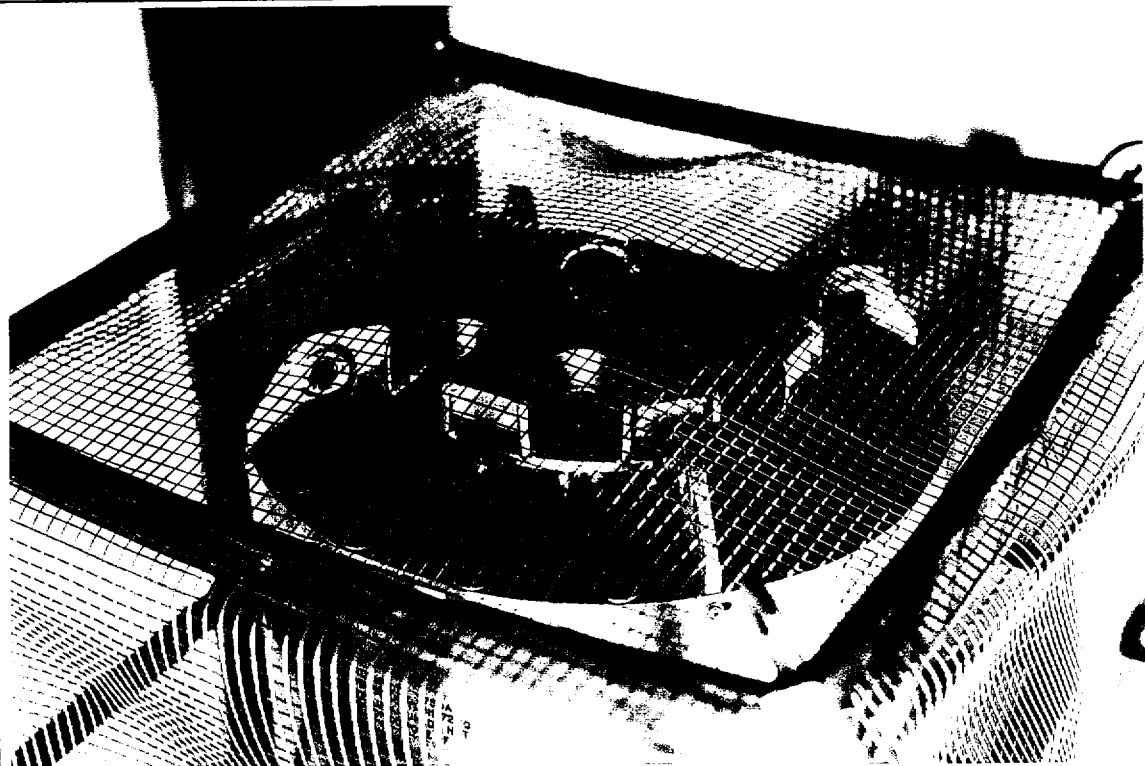


Figure 7: Closure and eyebolt

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1910

Date: 26/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height.	<div><div>0.3m</div><div>1.2m*</div><div>0.9m</div></div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	✓

- * Delete as appropriate

** TWO FINS ON CLOSURE FLATTENED FROM TEST NO 1904.
TWO BENT LIFTING POINTS STRAIGHTENED.
ASSEMBLED AS ILLUSTRATION BUT WITH CAGE.
FOUR SMALL LUGS WELDED TO BASE OF PALLET FOR SLINGING.
4. Notes: TEST PLAN NO PGM 921, ISSUE 3, PARA 8.5.2 APPLIES,
MODEL 3750A: GRN No. 217554/04, STUD NOS. 9-16.
LEVEL: TOOL No. 34 PALLET NO. 02
TORQUE WRENCH: TOOL NO. 30 CAGE NO. 02
HEIGHT GAUGE: TOOL NO. 32
FILM NO: 23, START TIME: 60 MIN 00 SEC
FILM NO: 24, START TIME: 20 MIN 07 SEC.

5. Personnel:
- Conducted:

D.W. Rogers

DW ROGERS

Posn: PKG ENGR.
- Witnessed:

jt

C. CARRINGTON

Posn: T.C.O.

Amersham International plc
Packaging Design Group
Test Report No. 1911

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
9.0m Free Drop (Drop I).

1.3 **Procedure**
PGP 15, Issue 5.

1.4 **Orientation**
Vertical inverted (figs 1 & 2).

1.5 **Special conditions**
The Test Plan (ref 6.3) specifies a test temperature of -40°C.

1.6 **Notes**

1.6.1 **Package:**

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The pallet had four small lugs welded to its underside to facilitate slinging. This with the agreement of the DoT engineer.

(3) The cask was not repaired in any way after Series 1, Tests 1898, 1900 & 1901. After Series 2, Tests 1902, 1904 & 1905, the only repair was to straighten the two bent lifting points. The principal damage from these tests was crushing of two of the closure shock absorbers thus reducing the number from eight to six. This was considered to give a harder impact and therefore additional conservatism to the results. This with the agreement of the DoT witnessing engineer.

(4) The pallet and cage were replaced for this test series. Although the cage was not required by the Test Plan it was added to make it more representative. This with the agreement of the DoT witnessing engineer.

(5) The package had been damaged in the 1.2m drop, Test 1910, as required by the Test Plan (ref 6.3).

(6) The package had five thermocouples added to monitor temperature.

1.6.2 Orientation:

(1) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg (fig 1).

(2) Measurement: Immediately prior to the test the orientation was checked by placing a spirit level across the top of the package in both axis.

(3) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.6.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature (fig 2). Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure. A small section of mesh was cut out of the lower right panel on side No. 2 to allow the cables and connectors to be lead out.

Note: The thermocouples were installed prior to Test 1910 to avoid disturbance of the package assembly during the test series.

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

- 1.6.4 **Target:**
The target is 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

2 **Pass/Fail Criteria**

- 2.1 **Closure**
The cask closure must remain attached to the cask body.

- 2.2 **Jacket**
The jacket must remain attached to the cask.

- 2.3 **Notes**
The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 **Quality Assurance**

3.1 **Materials and equipment**

3.1.1 **Identification:**

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
One third scale 3750A pallet	217554/04	02	-	-
One third scale 3750A cage	217554/04	02	-	-
Cask closure studs	217554/04	09-16	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Level: RS Stock No. 651-428	-	-	34	08/01/97
Height gauge: 9.0m	-	-	35	15/01/97

3.1.2 Notes:

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any measuring equipment used.

3.2 **Assembly**

The third scale 3750A package was assembled prior to Test 1910 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C.

3.4 **Records**

3.4.1 Photographic:

See Appendix A.

3.4.2 Video:

- (1) Film No. 23, Start time 51min 30sec.
- (2) Film No. 24, Start time 23min 00sec.

3.4.3 Operational:

See Appendix B.

4 **Results**

4.1 **Temperature**

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-44.4
2	-43.1
3	-46.5
4	No reading
5	-53.4

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed square the top face, bounced to a height of approximately 400 mm, rotated through approximately 270° to land on its side and rolled a further 90° to come to rest inverted (fig 3 & 4).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached to the cask body.

4.4 General observations

4.4.1 Note: Inspection was limited to an external examination. It was not permitted to dismantle the package before the following puncture test, Test 1913, the last test of Series 4, after which more detailed observations could be made.

4.4.2 Cage: The cage showed relatively little additional damage. The verticals in the upper half of the cage were bent over some more (figs 5 & 6). Otherwise the cage was undamaged. All twelve pallet screws were in place and appeared undamaged.

4.4.3 Pallet: The pallet was distorted 10 mm upwards towards one corner where it had landed after the first bounce (fig 6). Otherwise the pallet showed no additional damage. It supported the cask centrally and upright. All twelve cask feet screws were in place and appeared undamaged.

4.4.4 Cask body: The cask body showed no additional damage. All eight closure studs and nuts were in place and appeared undamaged. All twelve jacket screws were in place and appeared undamaged.

4.4.5 Cask closure: The central eyebolt was crushed onto its mounting boss (fig 7). The six shock absorbers remaining after Test 1904 were indented on their top edges with the pattern of the mesh. Other than this the closure appeared free from damage.

5 Conclusions

5.1 Pass/Fail

The package passed the test.

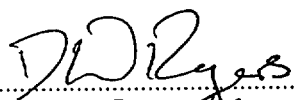
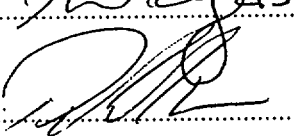
5.2 Other

The closure shock absorbers performed their function and also protected the closure leak test point from all damage.

6 **References**

- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(a).
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(1).
- 6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.5.3.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

- 7.1 Author:  Position: PKG ENGR Date: 19/02/96
- 7.1 Checked:  Position: P. K. M. C. C. C. Date: 19-2-96

Appendix A

Photographs

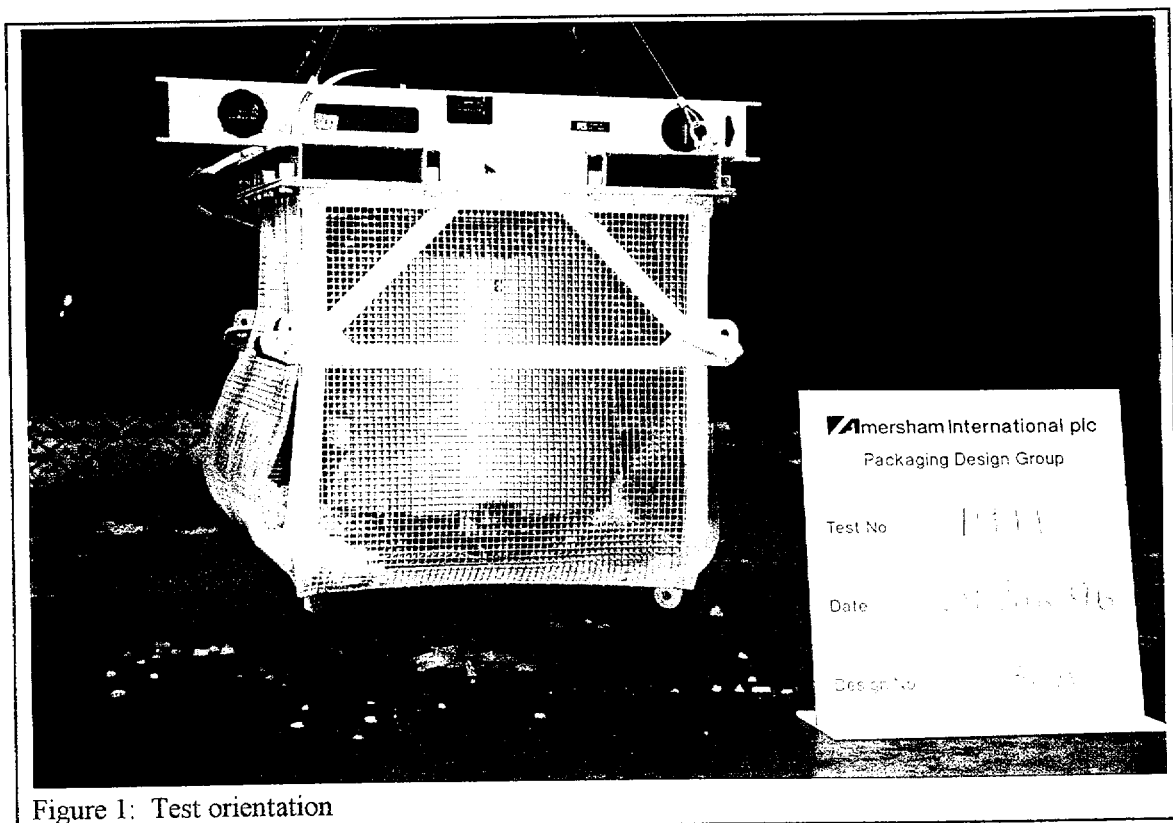


Figure 1: Test orientation

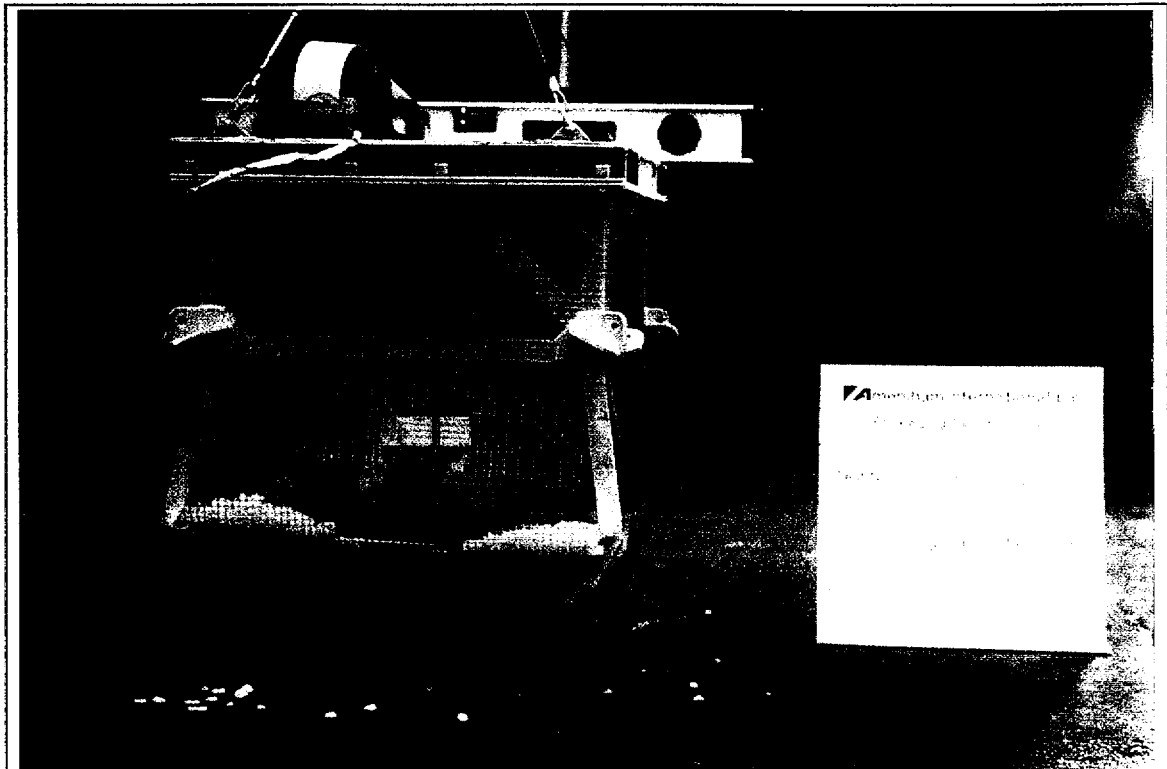


Figure 2: Test orientation

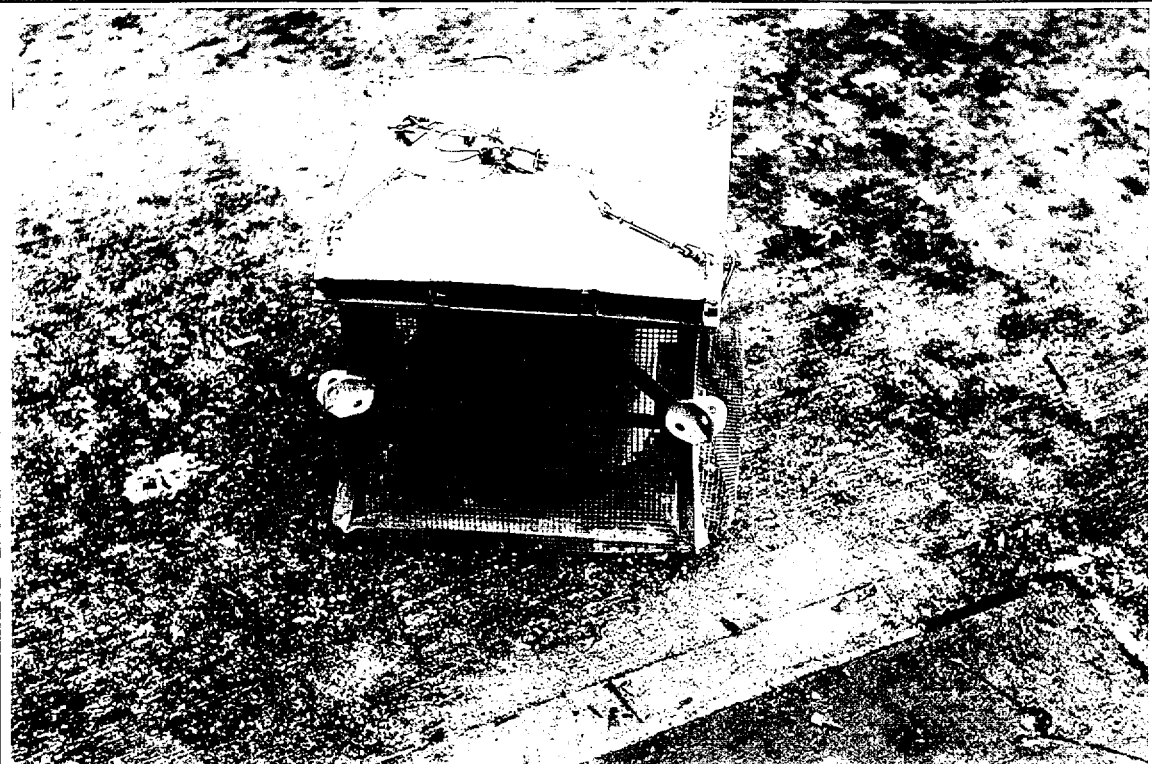


Figure 3: After impact

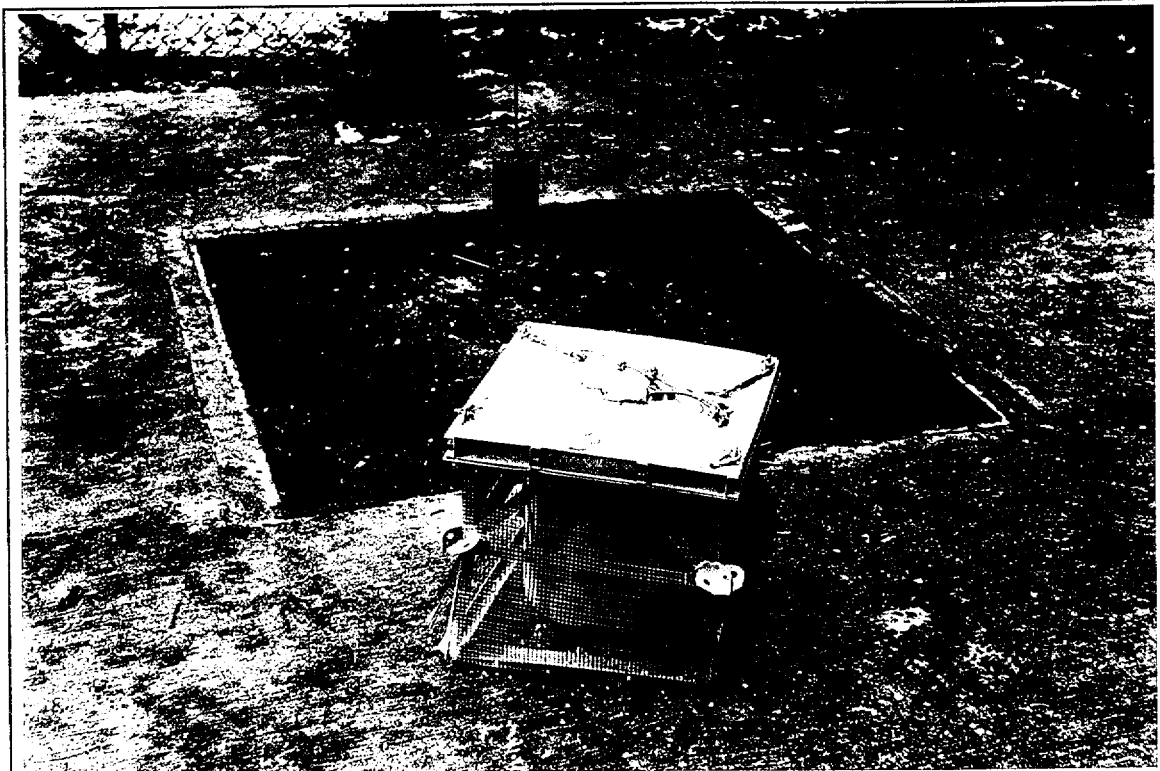


Figure 4: After impact

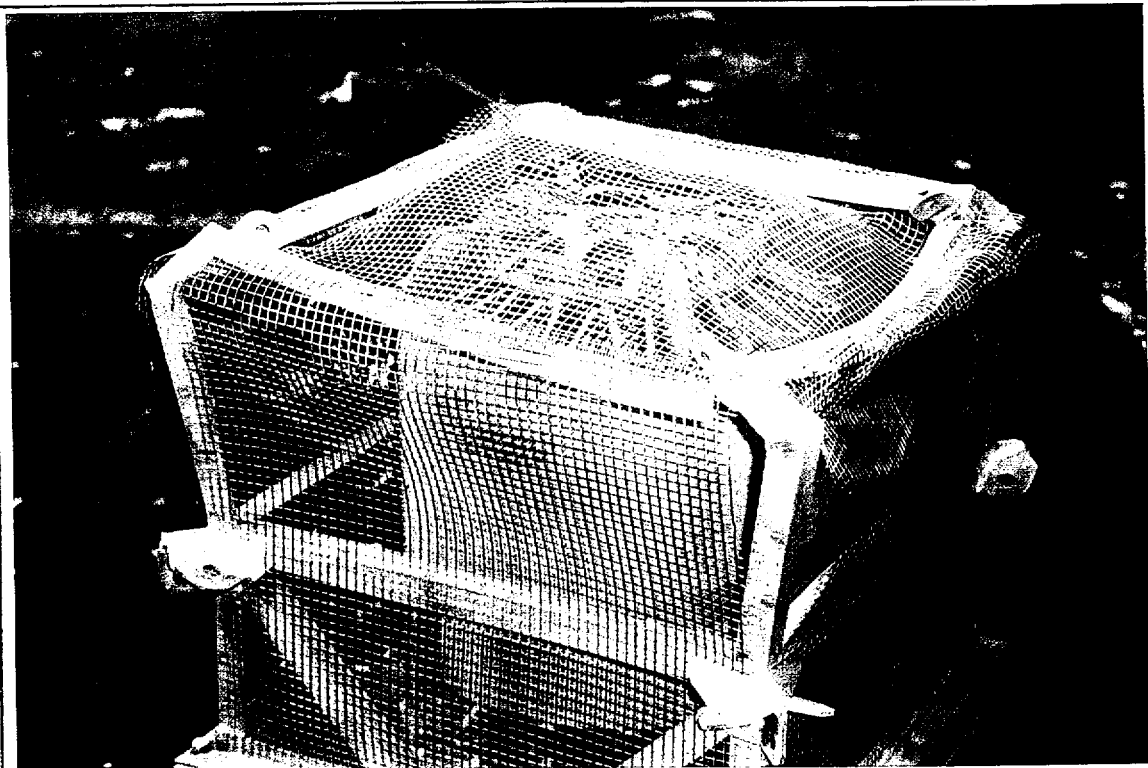


Figure 5: Cage showing compression damage

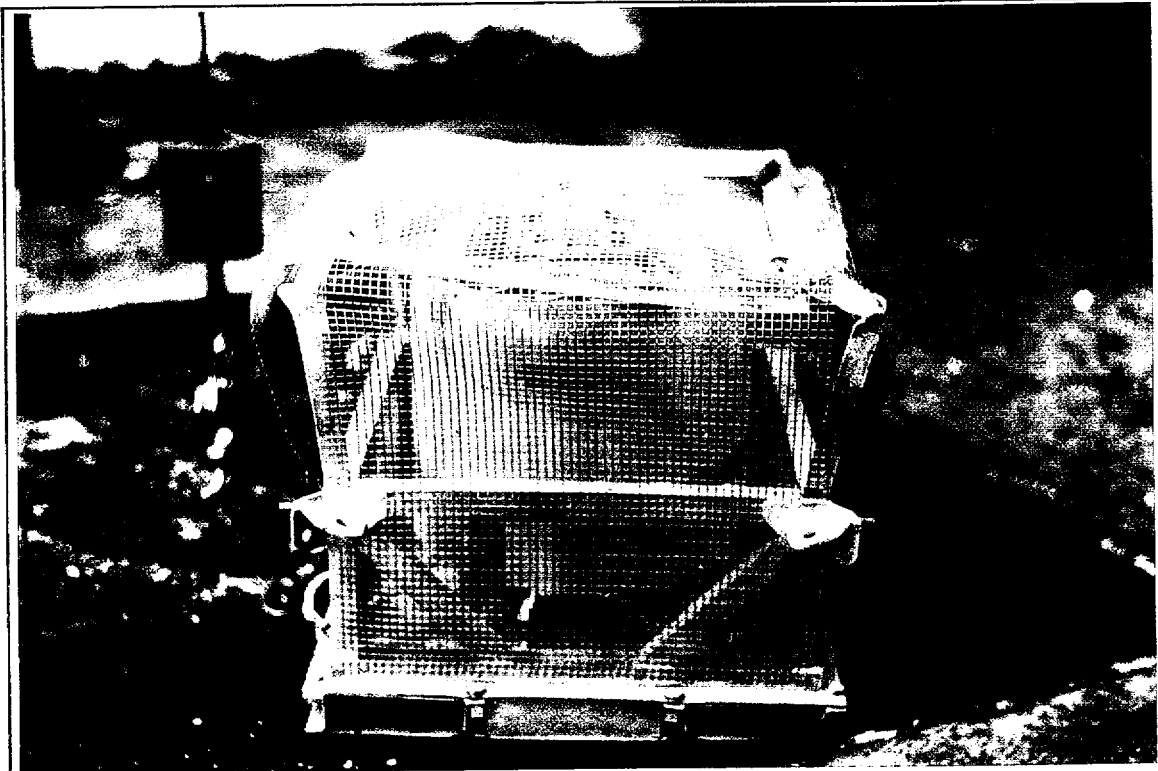


Figure 6: Cage damage and pallet distortion

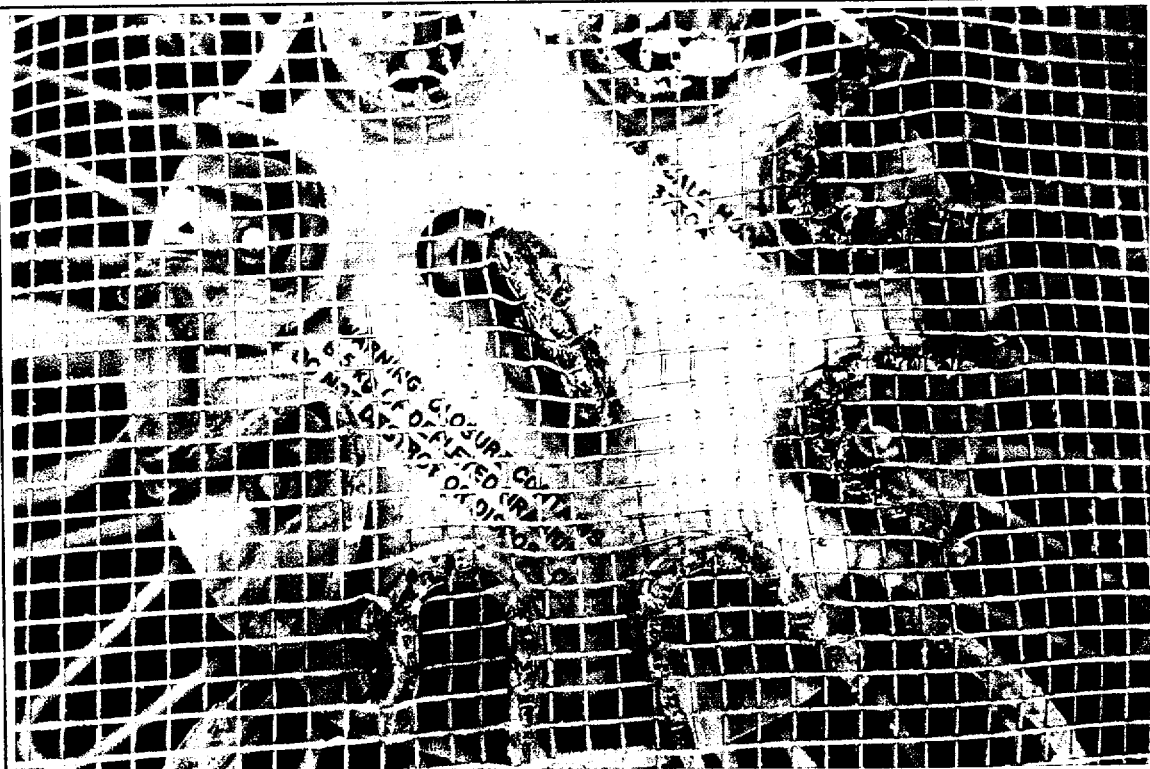


Figure 7: Closure from above

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Drop Test Check List

Test No: 1911

Date: 29/01/96

1. Notes:
- a)

This checklist forms the operations section of PGP 15, Packaging Group Procedure for Drop Testing. If in doubt ask.
- b)

A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
- c)

Check hoist cable weight is lowered onto the target plate before entering compound.
- d)

Safety helmets must be worn by all personnel if anyone uses the gantry walkway.
2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm sample is correctly orientated	✓
6	Photograph just above target (optional)	✓
7	Raise to correct height	<div><div>0.5m</div><div>1.0m</div><div>9.0m*</div></div>
8	Remove all non-essential personnel from compound	✓
9	Start video	✓
10	Release sample	✓
11	Confirm impact attitude is correct	✓
12	Record damage to sample with video	✓
13	Photograph damage (optional)	✓

- * Delete as appropriate

** TWO FINS ON CLOSURE FLATTENED FROM TEST NO 1904
TWO BENT LIFTING POINTS STRAIGHTENED
ASSEMBLED AS ILLUSTRATION BUT WITH CAGE.
4. Notes: TEST PLAN NO: PGM 921, ISSUE 3 (PARA 8.5.3).
- MODEL 3750A : GRN NO. 217554/04

TEMP READINGS AT DROP:
- LEVEL : TOOL NO 34

T/C NO 1 : - 44.4°C
- HEIGHT GAUGE : TOOL NO 35

T/C NO 2 : - 43.1°C
- TEMP. RECORDER : TOOL NO 27

T/C NO 3 : - 46.5°C
- FILM NO : 23, START TIME : 51 MIN 30 SEC

T/C NO 4 : - NOT WORKING.
- FILM NO : 22, START TIME : 23 MIN 00 SEC.

T/C NO 5 : - 53.4°C
- TIME OF DROP : 11.42 AM

5. Personnel:
- Conducted:

DWROGERS

Posn: PKG ENGR
- Witnessed:

C. CARRINGTON

Posn: TCO

Amersham International plc

Packaging Design Group

Test Report No. 1913

1 Introduction

1.1 Package Design No 3750A.

1.2 Test 1.0m Puncture (Drop II).

1.3 Procedure PGP 55, Issue 1.

1.4 Orientation The package was slung at an angle of 25.5° from the inverted vertical placing the centre of gravity over the point of impact (figs 1 & 2).

1.5 Location of impact The impact point was the upper edge of the cooling fins, midway between two lifting points and avoiding the closure (fig 2).

1.6 Special conditions The Test Plan (ref 6.3) required the package to be tested at -40°C.

1.7. Notes

1.7.1 Package:

(1) A one third scale 3750A package was used to demonstrate its performance (see also ref 6.4).

(2) The pallet had four small lugs welded to its underside to facilitate slinging. This with the agreement of the DoT engineer.

(3) The cask was not repaired in any way after Series 1, Tests 1898, 1900 & 1901. After Series 2, Tests 1902, 1904 & 1905, the only repair was to straighten the two bent lifting points. This with the agreement of the DoT witnessing engineer.

(4) The pallet and cage were replaced for this test series. Although the cage was not required by the Test Plan it was added to make it more representative. This with the agreement of the DoT witnessing engineer.

(5) The package had been damaged in the 1.2m and 9.0m drops, Test 1910 & 11, as required by the Test Plan (ref 6.3).

1.7.2 Orientation:

(1) Angle: The orientation required in the test plan was vertical. It was decided to change this to bring the centre of gravity over the point of impact thereby imparting the maximum deceleration to the package and the maximum tensile load to the closure studs. This at the request of the witnessing DoT engineer.

(2) Control: The orientation of the package was controlled by a four leg sling adjusted by means of a turnbuckle on each leg.

(3) Measurement: Immediately prior to the test the orientation was checked laterally with a spirit level placed across the top of the pallet and longitudinally with it placed on a machined angle plate aligned along the inclined axis on the pallet base.

(4) Verification: The orientation was verified after the test by reference to video recordings. Two cameras were used, set at 90° to each other, with a minimum shutter speed of 1/1,000sec.

1.7.3 Temperature:

(1) Measurement: Five type K, twisted pair, individually PTFE insulated, 0.2 mm wire diameter thermocouples (range: -50°C to 200°C) and a five channel temperature recorder (range: -100°C to 1,100°C) were used to monitor the cask temperature (fig 2). Nos. 1-4 thermocouples were positioned at the mid-height in the north, south, east and west positions of the four main cask fins. The tips were epoxied into the bottom of the Vee formed by each fin and its neighbouring cooling fin. No. 5 thermocouple was fastened inside the cask cavity with adhesive tape, again at the mid-height, and led out under the closure.

(2) Procedure: The package was cooled in an insulated container using dry ice (solid carbon dioxide) pellets. Before the test the package was at a temperature of approximately -80°C. It was then removed from the container and allowed to warm naturally until it reached the required temperature. This ensured that the inside of the cask was cooler than the surface. The drop was carried out when the highest reading thermocouple approached the test temperature.

1.7.4 Target:

The target was 1.6m square, 50mm thick plate of structural carbon steel grouted and bolted down onto a 1.6 x 1.6 x 1.5m block of steel reinforced, high compressive strength concrete (see also Drg No. A25187, Issue A). The overall weight is in excess of 8,000kg.

1.7.5 Punch:

The punch was a third scale, carbon steel bar welded vertically to a plate bolted at each corner to the target. A 150 mm long bar was used to ensure a positive impact. The bar protruded slightly below the plate to ensure positive contact with the target plate (see Drg No. A25239, Issue A).

1.7.6 Secondary impact:

Two plywood sheets were placed next to the punch to avoid unnecessary distortion of the package tie-down points which would be used for slinging in the next test series. Normally secondary damage would be considered part of the test but, as the package was to be subjected to a 9.0 m side drop in Test 1908, the protection was considered acceptable. This with the agreement of the DoT witnessing engineer.

2 Pass/Fail Criteria

2.1 Closure

The cask closure must remain attached to the cask body.

2.2 Jacket

The jacket must remain attached to the cask.

2.3 Notes

The criteria above are based on what is readily achievable by a visual inspection. Other elements of design performance such as shielding efficiency and surface dose rate, rupture or cracking of the cask structural shells and closure stud yield are all addressed in separate tests conducted before and after the mechanical tests. The additional tests measure each parameter and sentencing is performed against quantified criteria (see ref 6.3).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification:

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date
One third scale 3750A cask	217554/04	01	-	-
One third scale 3750A pallet	217554/04	02	-	-
One third scale 3750A cage	217554/04	02	-	-
Cask closure studs	217554/04	09-16	-	-
Punch (long)	212750/02	-	-	-
Thermocouples: RS Stock No. 158-913	098425/02	-	-	-
Temperature recorder: Kane Int. KM1202	-	1327	27	18/09/96
Height gauge: 1.0m	-	-	31	08/01/97
Level: RS Stock No. 651-428	-	-	34	08/01/97

3.1.2 Notes:

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records for items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of any calibrated measuring equipment or tools taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any measuring equipment used.
- (5) The QC No. is the identify of specific measurements records made by the Packaging Design Group.

3.2 Assembly

The third scale 3750A package was assembled prior to Test 1910 in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C.

3.3 Records

3.3.1 Photographic:
See Appendix A.

3.3.2 Video:
(1) Film No. 23, Start time 52min 30sec.
(2) Film No. 24, Start time 27min 55sec.

3.3.3 Operational:
See Appendix B.

4 Results

4.1 Temperature

Immediately prior to package release the thermocouples gave the following readings:

Thermocouple No.	Reading (°C)
1	-44.2
2	-42.9
3	-46.0
4	Not reading
5	-53.2

4.2 Orientation and impact

The video recordings confirmed the package dropped correctly. It landed on the punch, bounced upwards approximately 25mm and landed just next to it on its side (figs 4 & 5).

4.3 Pass/Fail Criteria

The cask closure and jacket remained securely attached.

4.4 General observations

4.4.1 Note: Some of the observations relate to damage caused in the previous 9.0m drop test, Test 1911, when it was not permitted to dismantle the package for examination.

4.4.2 Cage: The punch made a circular impression in the mesh (figs 6 & 7). The twelve pallet screws were secure. Four of the screws were bent 5°-10° near the head and unscrewed with some initial difficulty. The remaining eight were undamaged and unscrewed freely.

4.4.3 Pallet: The pallet showed no additional damage. It supported the cask centrally and upright. All twelve cask feet screws were secure, undamaged and unscrewed freely.

- 4.4.4 Cask body: The inner edges of the two fins hit by the punch were bent over away from each other (fig 8). There was no other damage to the cask body or jacket. All twelve jacket screws were secure, undamaged and unscrewed freely. All eight closure studs and nuts were secure, undamaged and unscrewed freely.
- 4.4.5 Cask closure: The closure disengaged freely from the body. It showed a small mark where the punch had just nicked it (fig 8). Otherwise it was completely undamaged by the punch. The 9.0m drop had crushed the central eyebolt down to a height of 12 mm (from 36 mm) onto its mounting boss (figs 9 & 10). The six shock absorbers undamaged from Test 1904 were indented on their top edges with the pattern of the mesh and crushed down to a height of 17 mm (from 20.4 mm). Other than this top of the closure was free from damage.
- 4.4.6 Punch: The punch carried two indentations from the cooling fins (fig 11) indicating a good impact.

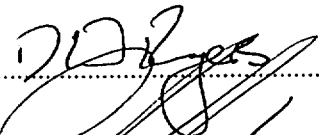
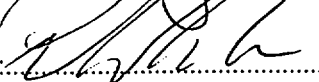
5 Conclusions

- 5.1 **Pass/Fail**
The package passed the test.
- 5.2 **Other**
None.

6 References

- 6.1 IAEA, Safety Series No. 6, 1985 Edition (as amended 1990), paragraph 627(b).
- 6.2 Code of Federal Regulation, 10 CFR 71, 01-01-94 Edition, paragraph 73.(2).
- 6.3 Package Design No. 3750A Test Plan, PGM 921, Issue 3, paragraph 8.5.4.
- 6.4 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 Signatures

- 7.1 Author:  Position: PKG ENGR Date: 19/02/96
- 7.1 Checked:  Position: PACKAGE CONTROLLER Date: 19/2/96.

Appendix A

Photographs

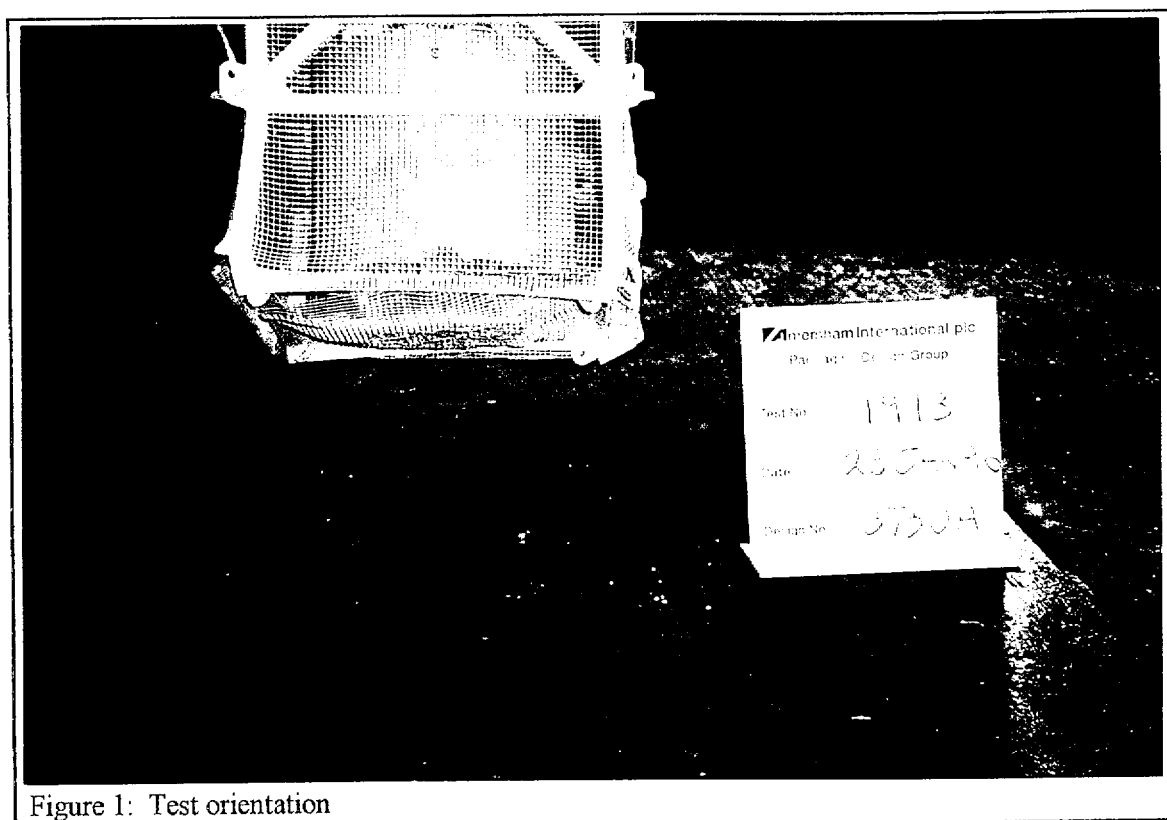


Figure 1: Test orientation

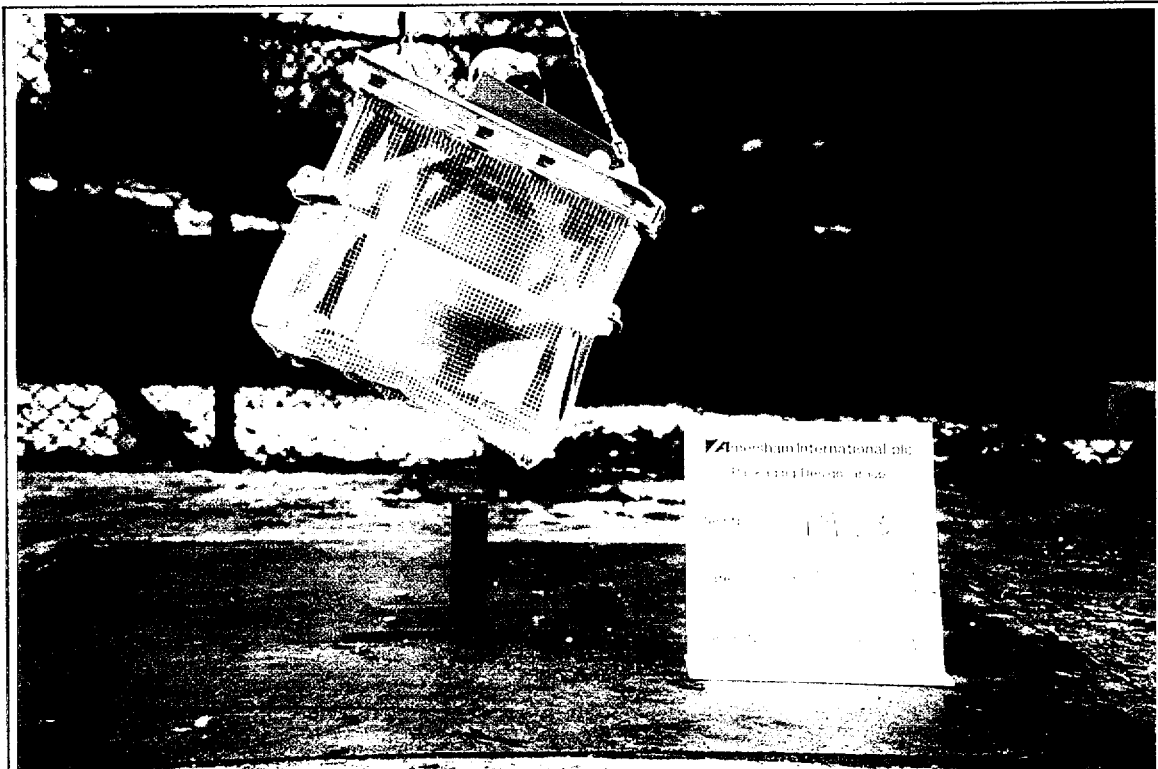


Figure 2: Test orientation



Figure 3: Test set-up

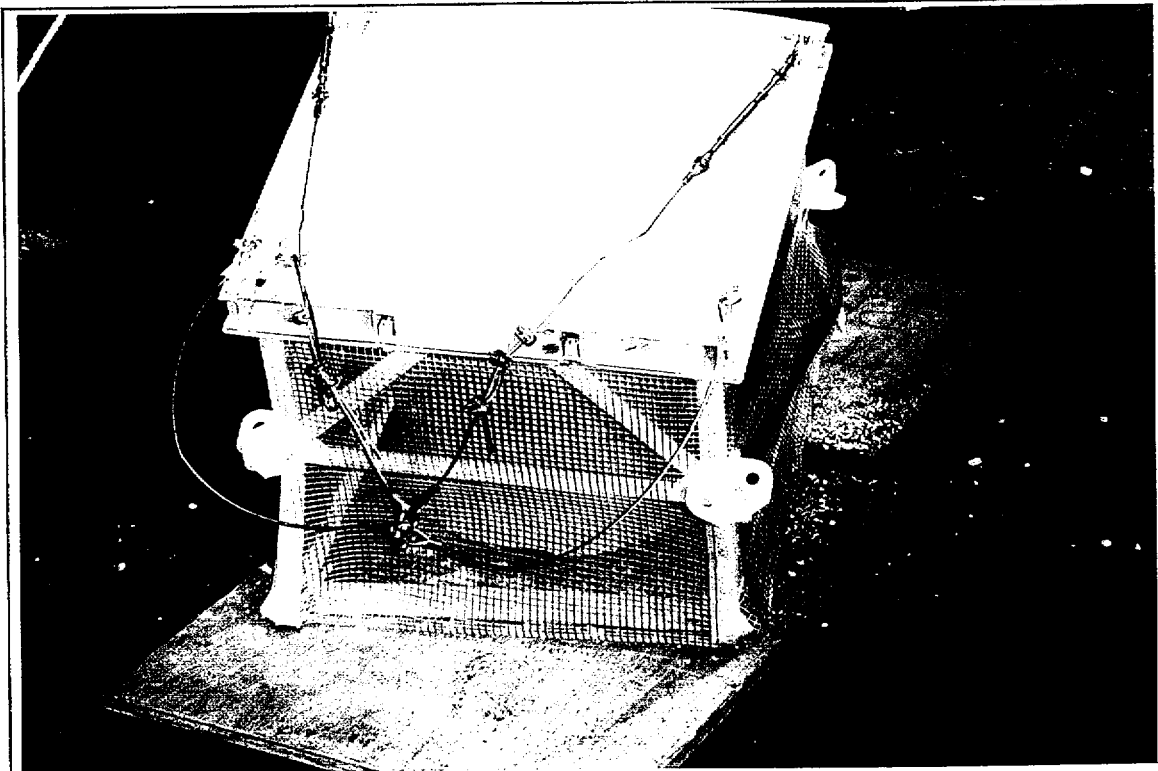


Figure 4: After impact



Figure 5: After impact

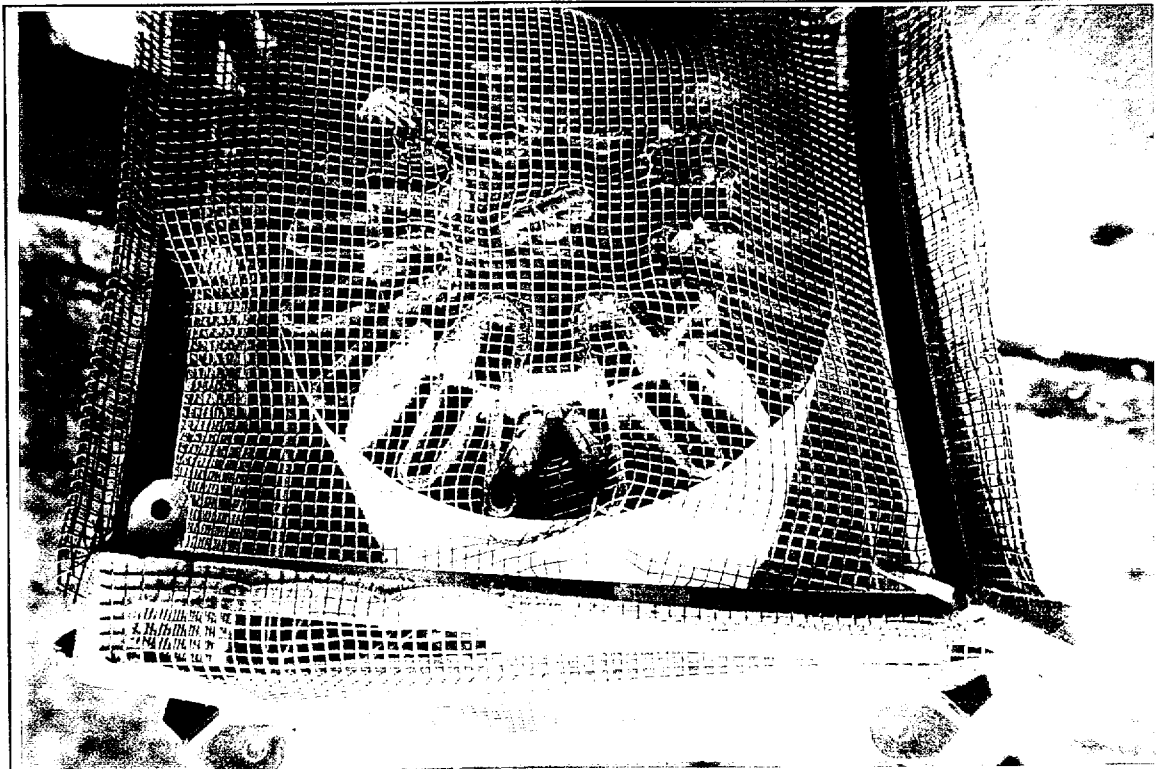


Figure 6: Package showing punch indentation

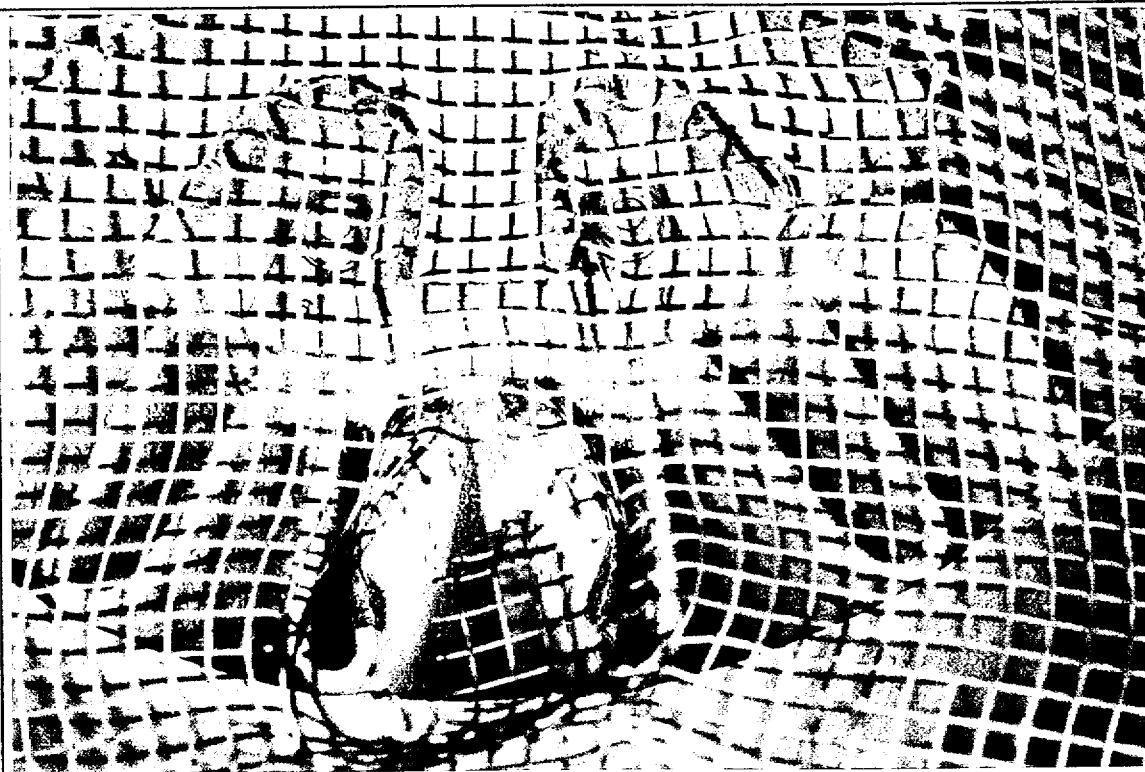


Figure 7: Cooling fin distortion

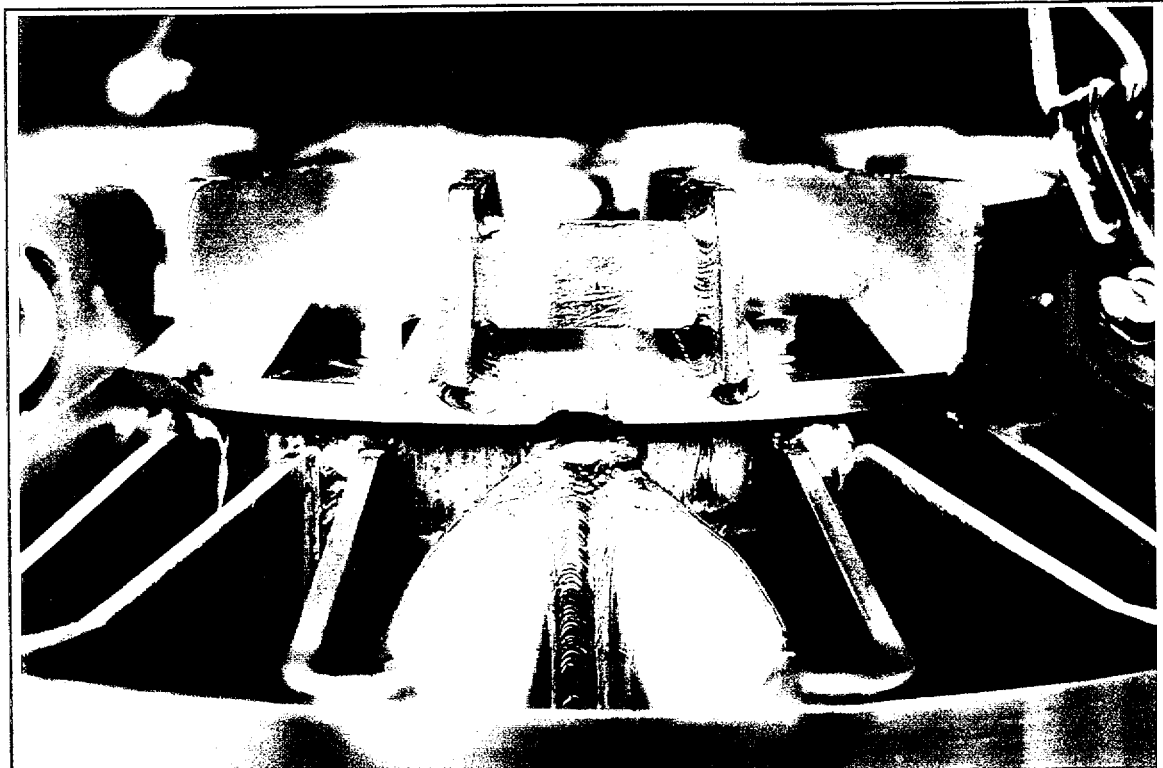


Figure 8: Cooling fin distortion

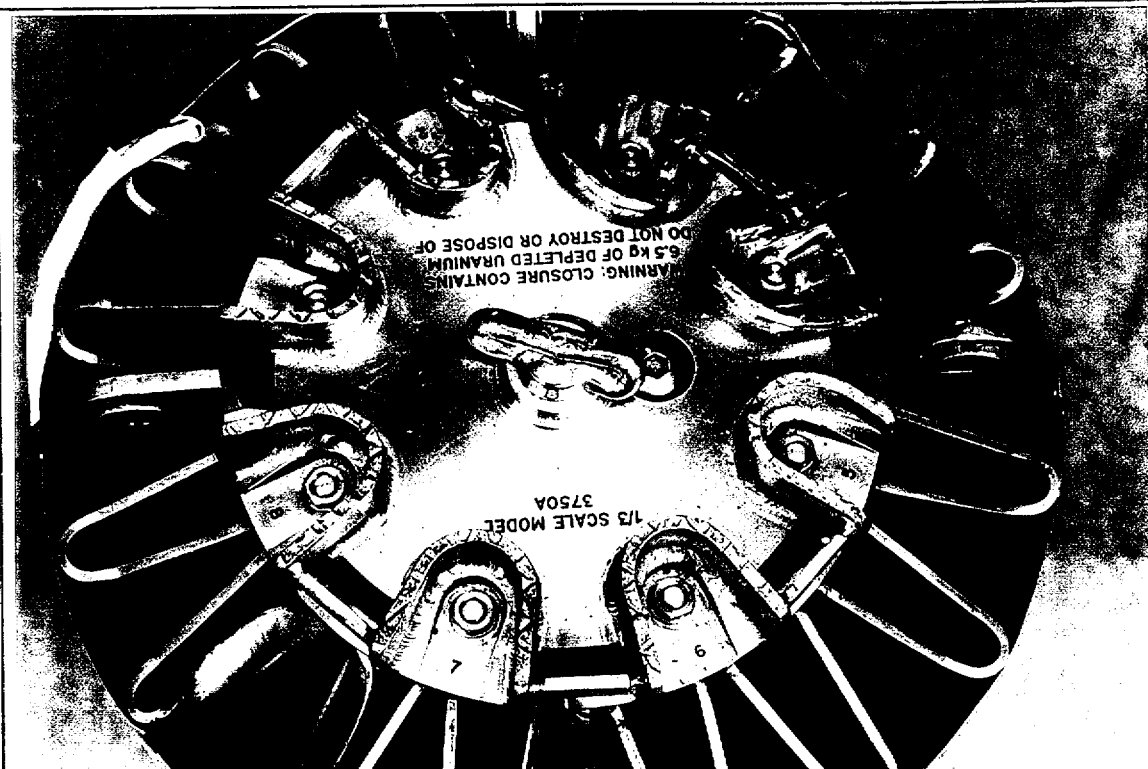


Figure 9: Closure top face



Figure 10: Eyebolt crushed



Figure 11: Punch face

Appendix B

Test Checklist

The attached document is the form used to record details of the procedure, equipment and test specimen employed in performing this test. It is completed at the time of the test and must be witnessed by personnel from either the Packaging Design Group or Quality Assurance or by the Transport Container Officer.

Puncture Test Check List

Test No: 1913
Date: 29/01/96

1. Notes:
- a) This checklist forms the operations section of PGP 55, Packaging Group Procedure for Puncture Testing. If in doubt ask.
 - b) A minimum of two personnel must be present to carry out a test - both must wear safety shoes.
 - c) Check hoist cable weight is lowered onto the target plate before entering compound.

2. Check List:

Step	Operation	Check ✓
1	Record GRN Nos/Serial Nos/QC Register Nos of sample as appropriate	✓
2	Record GRN Nos/Tool Nos of equipment used as appropriate	✓
3	Record video film number and start time	✓
4	Confirm sample is correctly assembled **	✓
5	Confirm punch is rigidly mounted	✓
6	Confirm sample is correctly orientated	✓
7	Photograph sample just over punch (optional)	✓
8	Raise sample to test height	✓
9	Record height between punch and impact point	1.00 metre
10	Remove all non-essential personnel from compound	✓
11	Start video	✓
12	Drop sample	✓
13	Confirm impact point is correct	✓
14	Record damage to sample with video	✓
15	Take still photographs (optional)	✓

* Delete as appropriate ** ASSEMBLED AS IN TEST NO 1911.
DROP ANGLE ALTERED TO 25.4°
LONG PUNCH SUBSTITUTED FOR SHORT PUNCH

4. Notes: TEST PLAN NO: PGM 921, ISSUE 3 (PARA 8.5.4)
- MODEL 3750A: GRN NO. 217554/04
LEVEL: TOOL NO. 34.
HEIGHT GAUGE: TOOL NO. 31
PUNCH (LONG): GRN NO. 212750/02
TEMP. RECORDER: TOOL NO 27
FILM NO 23, START TIME: 52 MIN 30 SEC
FILM NO 24, START TIME: 27 MIN 55 SEC.

TEMP READINGS AT DROP:
TIC NO 1 = 44.2°C
TIC NO 2 = 42.9°C
TIC NO 3 = -46.0°C
TIC NO 4 = NOT WORKING
TIC NO 5 = -53.2°C
TIME OF DROP: 2.23 PM

5. Personnel:
- Conducted: DW EYRE DW ROGERS Posn: PRG ENGR;

Witnessed: Jt C. CARRINGTON Posn: T.C.O.

Amersham International plc

Packaging Design Group

Test Report No. 1915

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
Stud extension.

1.3 **Procedure**
PGP 21, Issue 2.

1.4 Notes

1.4.1 **Purpose:** The purpose of the extension test is to measure the degree of plastic strain in the closure studs after each series of tests in a programme of normal and accident conditions mechanical tests (ref 6.1). It is being used to demonstrate an adequate margin of structural safety.

1.4.2 **Package:** A one third scale 3750A package was used to demonstrate its mechanical performance (see also ref 6.2).

1.4.3 **Procedure:** The length of each stud was measured before Test Series 1 and again upon completion.

2 Pass/Fail Criteria

The length of any stud must not increase by more than 0.25 mm (ref 6.1).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC Nos.
Cask closure studs	217554/04	01 - 08	-	-	85 & 86
Vernier calipers	-	502	6	19/07/96	-

3.1.2 Notes

- (1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.
- (2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.
- (3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.
- (4) The Calibration Due Date is required for any other measuring equipment used.
- (5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The studs, Drg. No. A25227, Issue B, were manufactured as part of the third scale 3750A package in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. The stud numbers 01 - 16 identify each stud. Nos. 01 - 08 were installed in correspondence with the engraved identity (1-8) of each of the tapped holes in the cask body top flange.

3.3 QC records

See Appendix A.

4 **Results**

4.1 **Pass/Fail criteria**

Stud No.	Original length (mm)	Length after tests (mm)	Extension (mm)
01	24.87	24.87	0.00
02	24.85	24.85	0.00
03	24.79	24.78	-0.01
04	24.82	24.82	0.00
05	24.77	24.78	+0.01
06	24.81	24.80	-0.01
07	24.84	24.84	0.00
08	24.89	24.88	-0.01

5 **Conclusions**

5.1 **Pass/Fail**

The studs passed the test.

5.2 **Other**

The discrepancies between the two sets of readings are within the vernier manufacturer's quoted repeatability figures of +/- 0.03 mm. It is reasonable to assume therefore that there is no evidence of any permanent strain in the studs.

6 **References**

6.1 3750A Test Plan, PGM 921, Issue 3, paragraphs 8.2.1 & 8.2.6.

6.2 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author: DWZ Position: PKG ENGR Date: 16/02/96

7.1 Checked: [Signature] Position: PACKAGING CONTROLLER Date: 16-02-96

Appendix A

QC Inspection Records

The attached inspection records, Nos. 85 & 86, are the forms used to record certain measurements required for this test.

Amersham International plc

Packaging Design Group

Test Report No. 1916

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
Stud extension.

1.3 **Procedure**
PGP 21, Issue 2.

1.4 Notes

1.4.1 **Purpose:** The purpose of the extension test is to measure the degree of plastic strain in the closure studs after each series of tests in a programme of normal and accident conditions mechanical tests (ref 6.1). It is being used to demonstrate an adequate margin of structural safety.

1.4.2 **Package:** A one third scale 3750A package was used to demonstrate its mechanical performance (see also ref 6.2).

1.4.3 **Procedure:** The length of each stud was measured before Test Series 2 and again upon completion.

2 Pass/Fail Criteria

The length of any stud must not increase by more than 0.25 mm (ref 6.1).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC Nos.
Cask closure studs	217554/04	01 - 08	-	-	86 & 87
Vernier calipers	-	502	6	19/07/96	-

3.1.2 Notes

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any other measuring equipment used.

(5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The studs, Drg. No. A25227, Issue B, were manufactured as part of the third scale 3750A package in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. The stud numbers 01 - 16 identify each stud. Nos. 01 -08 were installed in correspondence with the engraved identity (1-8) of each of the tapped holes in the cask body top flange.

3.3 QC records

See Appendix A.

4 **Results**

4.1 **Pass/Fail criteria**

Stud No.	Original length (mm)	Length after tests (mm)	Extension (mm)
01	24.87	24.88	+0.01
02	24.85	24.85	0.00
03	24.78	24.79	+0.01
04	24.82	24.83	+0.01
05	24.78	24.79	+0.01
06	24.80	24.79	-0.01
07	24.84	24.84	0.00
08	24.88	24.89	+0.01

5 **Conclusions**

5.1 **Pass/Fail**
The studs passed the test.

5.2 **Other**
The discrepancies between the two sets of readings are within the vernier manufacturer's quoted repeatability figures of +/- 0.03 mm. It is reasonable to assume therefore that there is no evidence of any permanent strain in the studs.

6 **References**

- 6.1 3750A Test Plan, PGM 921, Issue 3, paragraphs 8.3.1 & 8.3.5.
- 6.2 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author: DW Ryers Position: PKG ENGR Date: 16/02/96

7.1 Checked: [Signature] Position: PACKAGING COORDINATOR Date: 16-02-96

Appendix A

QC Inspection Records

The attached inspection records, Nos. 86 & 87, are the forms used to record certain measurements required for this test.

Amersham International plc

Packaging Design Group

Test Report No. 1917

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
Stud extension.

1.3 **Procedure**
PGP 21, Issue 2.

1.4 Notes

1.4.1 **Purpose:** The purpose of the extension test is to measure the degree of plastic strain in the closure studs after each series of tests in a programme of normal and accident conditions mechanical tests (ref 6.1). It is being used to demonstrate an adequate margin of structural safety.

1.4.2 **Package:** A one third scale 3750A package was used to demonstrate its mechanical performance (see also ref 6.2).

1.4.3 **Procedure:** The length of each stud was measured before Test Series 3 and again upon completion.

2 Pass/Fail Criteria

The length of any stud must not increase by more than 0.25 mm (ref 6.1).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC Nos.
Cask closure studs	217554/04	01 - 08	-	-	87 & 88
Vernier calipers	-	502	6	19/07/96	-

3.1.2 Notes

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any other measuring equipment used.

(5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The studs, Drg. No. A25227, Issue B, were manufactured as part of the third scale 3750A package in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. The stud numbers 01 - 16 identify each stud. Nos. 01 - 08 were installed in correspondence with the engraved identity (1-8) of each of the tapped holes in the cask body top flange.

3.3 QC records

See Appendix A.

4 **Results**

4.1 **Pass/Fail criteria**

Stud No.	Original length (mm)	Length after tests (mm)	Extension (mm)
01	24.88	24.88	0.00
02	24.85	24.85	0.00
03	24.79	24.80	+0.01
04	24.83	24.83	0.00
05	24.79	24.80	+0.01
06	24.79	24.79	0.00
07	24.84	24.84	0.00
08	24.89	24.88	-0.01

5 **Conclusions**

5.1 **Pass/Fail**

The studs passed the test.

5.2 **Other**

The discrepancies between the two sets of readings are within the vernier manufacturer's quoted repeatability figures of +/- 0.03 mm. It is reasonable to assume therefore that there is no evidence of any permanent strain in the studs.

6 **References**

6.1 3750A Test Plan, PGM 921, Issue 3, paragraphs 8.4.1 & 8.4.5.

6.2 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 **Signatures**

7.1 Author: DW Egles Position: PUG. ENGR Date: 16/02/96

7.1 Checked: [Signature] Position: Benjamin Carroll Date: 16.02.96

Appendix A

QC Inspection Records

The attached inspection records, Nos. 87 & 88, are the forms used to record certain measurements required for this test.

C:\123\FILES\PGP21/2

Amersham International plc

Packaging Design Group

Test Report No. 1918

1 Introduction

1.1 **Package Design No.**
3750A.

1.2 **Test**
Stud extension.

1.3 **Procedure**
PGP 21, Issue 2.

1.4 **Notes**

1.4.1 **Purpose:** The purpose of the extension test is to measure the degree of plastic strain in the closure studs after each series of tests in a programme of normal and accident conditions mechanical tests (ref 6.1). It is being used to demonstrate an adequate margin of structural safety.

1.4.2 **Package:** A one third scale 3750A package was used to demonstrate its mechanical performance (see also ref 6.2).

1.4.3 **Procedure:** The length of each stud was measured before Test Series 4 and again upon completion.

2 Pass/Fail Criteria

The length of any stud must not increase by more than 0.25 mm (ref 2.1).

3 Quality Assurance

3.1 Materials and equipment

3.1.1 Identification

Item	GRN No.	Serial No.	Tool No.	Calibration Due Date	QC Nos.
Cask closure studs	217554/04	09 - 16	-	-	85 & 89
Vernier calipers	-	502	6	19/07/96	-

3.1.2 Notes

(1) The Goods Received Note (GRN) No. identifies the manufacturing and inspection records of items manufactured specifically for the test.

(2) The Serial No. of an assembly or sub-assembly is the identification assigned to it upon manufacture.

(3) The Tool No. is the identity of calibrated measuring equipment or tools that are taken from the Packaging Design Group inventory.

(4) The Calibration Due Date is required for any other measuring equipment used.

(5) The QC No. is the identity of specific measurement records made by the Packaging Design Group.

3.2 Assembly

The studs, Drg. No. A25227, Issue B, were manufactured as part of the third scale 3750A package in accordance with the manufacturing drawings as specified in Drawing List DL 25169, Issue C. The stud numbers 01 - 16 identify each stud. Nos. 09 -16 were installed in correspondence with the engraved identity (1-8) of each of the tapped holes in the cask body top flange counting from 09 as 1.

3.3 QC records

See Appendix A.

4 Results

4.1 Pass/Fail criteria

Stud No.	Original length (mm)	Length after tests (mm)	Extension (mm)
09	24.76	24.75	-0.01
10	24.86	24.87	+0.01
11	24.76	24.76	0.00
12	24.76	24.75	-0.01
13	24.86	24.85	-0.01
14	24.79	24.78	-0.01
15	24.82	24.83	+0.01
16	24.86	24.85	-0.01

5 Conclusions

5.1 Pass/Fail

The studs passed the test.

5.2 Other

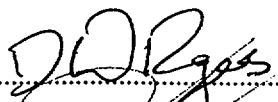
The discrepancies between the two sets of readings are within the vernier manufacturer's quoted repeatability figures of +/- 0.03 mm. It is reasonable to assume therefore that there is no evidence of any permanent strain in the studs.


6 References

6.1 3750A Test Plan, PGM 921, Issue 3, paragraphs 8.5.1 & 8.5.5.

6.2 The Modelling of Package Design No. 3750A, PGM 939, Issue 1.

7 Signatures

7.1 Author:  Position: PKG ENGR Date: 19/02/96

7.1 Checked:  Position: Package Controller Date: 19/2/96

Appendix A

QC Inspection Records

The attached inspection records, Nos. 85 & 89, are the forms used to record certain measurements required for this test.

85

^e M6.7 STUD

W9653

NO. A 25227

Issue

Manufacturer

W/A

PROJECT S944 D.W.R.

MEASUREMENT WITH VERNIER CALIPER (502)

[illegible]

