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TECHNICAL STUDY 67

CONTAINERS FOR CHEMICAL/BIOLOGICAL AGENTS DROP-TESTED FROM AIRCRAFT

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MARCH 1969

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INDUSTRIAL HEALTH & SAFETY DIRECTORATE

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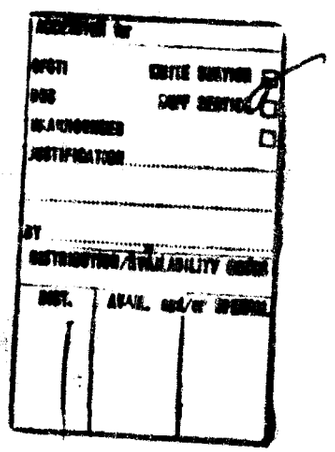

ACKNOWLEDGMENT

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ABSTRACT

Etiologic agent shipping containers with fluid volumes between 450 and 1,300 ml were prepared from readily available materials and dropped from 500 and 1,000 feet onto hard desert soil, concrete, and macadam. The purpose was to determine whether (i) the containers would be likely to withstand a severe impact during shipment, and (ii) such a container could be assembled from a general packaging instruction in the absence of explicit specification of container materials. All containers were prepared in accordance with the Interstate Quarantine Provisions of the U.S. Public Health Service in the Code of Federal Regulations, 42CFR72.25.

Materials evaluated were plastic, glass, and metal inner containers; cotton and vermiculite absorbent cushioning materials; and metal and cardboard outer containers.

The drop tests established that adherence to the packaging requirements of 42CFR72.25 will not assure a package that will not leak when dropped on a smooth surface at the velocities reached in these tests. However, packages prepared in accordance with 42CFR72.25 will not leak under "conditions ordinarily incident to transportation handling" as stated in 42CFR72.25.

For volumes of infectious fluid exceeding 500 ml, it is recommended that 42CFR72.25 be revised to include a performance standard, preferably "no leakage from the individual shipping container after an impact at 145 to 165 feet per second."

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I. INTRODUCTION

The packaging requirements of the Department of Transportation for shipment of chemicals include no rough handling or drop tests exceeding a 6-foot drop to determine whether the container might leak as a result of the shocks, pressure changes, or other conditions common to transportation handling. However, there are other drop requirements for other materials. Except for delivery by military aircraft, drop tests for other containers do not exceed 40 feet. A brief summary of these requirements is shown in Appendix A.

The packaging of etiologic agents is governed by the Interstate Quarantine provisions of the U.S. Public Health Service in the Code of Federal Regulations, 42CFR72.25. Briefly, these require that "the agent is packaged in a minimum of two sealed containers, and each such double container is enclosed in a third container." Between the inner two containers there must be sufficient absorbent material to absorb the entire contents in case of breakage; the maximum amount of etiologic agent permissible in this triple container is one U.S. gallon (3,785 ml). No rough handling tests or drop tests of the container are required. However, both the Army and federal regulatory authorities have been concerned about the public safety if such a container received an accidental crushing impact during transportation. As a result, prototype shipping containers have been tested in various drop and crash tests before being approved by the Army for use. Appendix B is a tabular summary of the results of these tests since 1953.

It is possible that 42CFR72.25 will be revised to require containers that do not leak after an impact test at a stated minimum impact speed, probably 145 to 165 feet per second. Drop tests, coordinated with timed film records, were done at Edgewood Arsenal, Maryland, on 13 October 1967 to determine impact speeds of representative containers and their resistance to leakage. A preliminary summary of these results is shown in Appendix C.

II. TESTS OF IMPROVISED CONTAINERS

A. BACKGROUND

On 20 July 1967 at Dugway Proving Ground, Utah, the Safety Director initiated a drop test program for shipping containers with a capacity of less than one gallon of chemical agents. The results of these tests will be published separately as a Dugway Proving Ground report, and a summary of the data are included as Appendix D of this report. These tests provided an opportunity to test the feasibility of meeting a hypothetical emergency shipping problem by improvising containers from readily available materials that still fulfilled all the requirements of the current 42CFR72.25. These improvised containers were dropped from an altitude of 500 or 1,000 feet above ground level onto dry baked desert soil, macadam, or concrete at Dugway Proving Ground.

B. FABRICATION

Six combinations of test containers were prepared as shown in Table 1. These were placed in crimp-sealed cans as secondary containers, then in either larger crimp-sealed cans or in fiberboard cartons.* The tops of the glass and plastic bottles and the fiberboard cartons were wrapped with cloth-backed adhesive tape.

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* Fiberboard container specification: 11½ inches outside diameter, 14 inches high, side wall test 600 lb/in^2, net weight limit 150 pounds. Construction and binding of the container shall be such that container shall remain intact and be leak-free after the following test: Place one 5-pound lead weight in bottom of container, fill container ¾ full with white pine shavings, add 3 quarts of water, place another 5-pound lead weight on top of shavings and steam sterilize for 2 hours at 240 F at 15 psig pressure.

TABLE 1. TEST CONTAINERS

Container Designation	Inner Container[a]	Volume of Fill, ml	Middle Container	Packing between Containers	Outer Container	Total Weight, g	Impact Surface	Leakage: Inner	Leakage: Middle	Leakage: Outer	Container Suitable
				Dropped from 500 feet above ground level[b]							
MA-5	1-pint brown glass bottle w/ hard black plastic screw cap	473	No. 3 can[c]	cotton[d]	No. 12 can[e]	2,021.4	soil	yes	no	no	yes
MB-5	clear glass bottle w/hard plastic screw cap	500	No. 12 can	vermiculite[f]	fiberboard[g]	6,581.5	soil	yes	yes	yes	no
MC-5	1-pint polyethylene bottle, plastic screw cap	473	No. 3 can	cotton	No. 12 can	1,630.4	soil	yes	no	no	yes
MD-5	1-pint polyethylene bottle	473	No. 12 can	vermiculite	fiberboard	6,147.4	soil	no	no	no	yes
ME-5	No. 3 can	1,400	No. 12 can	cotton	fiberboard	5,672.6	concrete	yes	yes	yes	no
MF-5	No. 3 can	1,400	No. 12 can	vermiculite	fiberboard	7,073.0	concrete	yes	yes	yes	no
				Dropped from 1,000 feet above ground level[h]							
MA	1-pint brown glass bottle w/hard black plastic screw cap	473	No. 3 can	cotton	No. 12 can	6,581.5	macadam	yes	yes	yes	no
MB	clear glass bottle w/hard plastic screw cap	1,000	No. 12 can	vermiculite	fiberboard	8,179.0	soil	yes	yes	yes	no
MC	1-pint polyethylene bottle, plastic screw cap	473	No. 3 can	cotton	No. 12 can	1,670.5	soil[i]	yes	yes	yes	no
MD	1-pint polyethylene bottle	473	No. 12 can	vermiculite	fiberboard	6,187.5	soil	yes	no	no	yes
ME	No. 3 can	1,400	No. 12 can	cotton	fiberboard	5,672.0	macadam	yes	yes	yes	no
MF	No. 3 can	1,400	No. 12 can	vermiculite	fiberboard	7,073.0	macadam	yes	no	no	yes

a. All inner containers were filled with Oil Red dye dissolved in carbon tetrachloride.
b. Atmospheric conditions: temperature, 89.1 F; RH, 19%; barometric pressure, 25.7 in. Hg; pressure altitude, 4,146 ft; density altitude, 7,100 ft; ground-level altitude, 4,349 ft.
c. Crimp-seal tin can 404-700, capacity 51.7 ounces (1,529 ml).
d. Absorbent cotton.
e. Crimp-seal tin can 603-812, capacity 138.3 ounces (4,109.5 ml).
f. Zonolite, construction grade, size IV, treated for moisture resistance.
g. See text.
h. Atmospheric conditions: temperature, 92.4 F; RH, 14%; barometric pressure, 25.66 in. Hg; pressure altitude, 4,178 ft; density altitude, 7,125 ft; ground-level altitude, 4,349 ft.
i. Container first struck metal fence rail.

III. RESULTS

A. RESULTS OF THE 500-FOOT DROP

The MA-5 container landed on its bottom on the sunbaked hardpacked desert soil. The pint glass bottle was intact except that its screw cap broke. Approximately 100 ml of the Oil Red dye was absorbed by the cotton within the No. 3 can. The remainder of the dye was in the glass bottle. There was no leakage from the No. 3 can.

The MB-5 container landed on its bottom edge on the soil. The glass 500-ml bottle shattered, the No. 12 can ruptured, the bottom of the fiberboard container was torn off, and dye spilled onto the ground.

The MC-5 container landed on its side on the soil. The side of the pint plastic bottle ruptured near the top shoulder and its plastic cap broke. Dye was absorbed by the cotton in the No. 3 can, which bulged at the top but did not leak. The top of the No. 12 can bulged, but there was no leakage.

The MD-5 container landed on its bottom corner on the soil. The pint plastic bottle was intact, with no leakage. The No. 12 can was intact with a small dent on the bottom corner. The bottom of the fiberboard container ruptured.

The ME-5 container landed on its bottom on concrete. The seam on the bottom of the No. 3 can ruptured, and the bottom of the No. 12 can ruptured. The bottom of the fiberboard container was torn off and dye was spilled on the concrete.

The MF-5 container landed on its side on concrete The No. 3 can ruptured at the seams on the side, top and bottom; dye spread throughout the vermiculite. The No. 12 can bottom seam ruptured, and dye spread throughout the vermiculite. The top and bottom of the fiberboard container ruptured and dye was spread on the concrete.

B. RESULTS OF THE 1,000-FOOT DROP

The MA container landed on its bottom edge on the macadam road. The glass bottle shattered. The No. 3 can ruptured at its bottom seam. A 1/8" rupture occurred in the bottom seam of the No. 12 can and a trace of dye appeared at the rupture (Fig. 1).

The MB container landed on its side on the soil. The glass bottle shattered, the No. 12 can bottom seam ruptured, the top and bottom were torn off the fiberboard container, and a trace of dye appeared on its outside (Fig. 2).

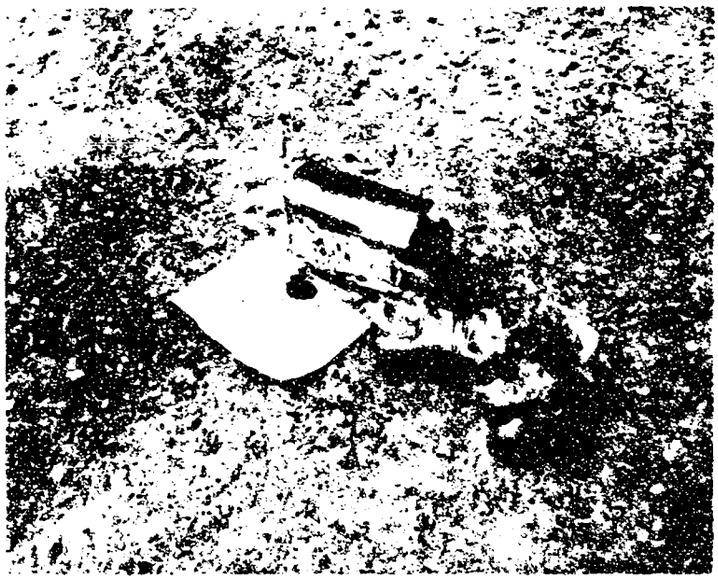

FIGURE 1. MA Container; All Vessels Ruptured with External Leakage.

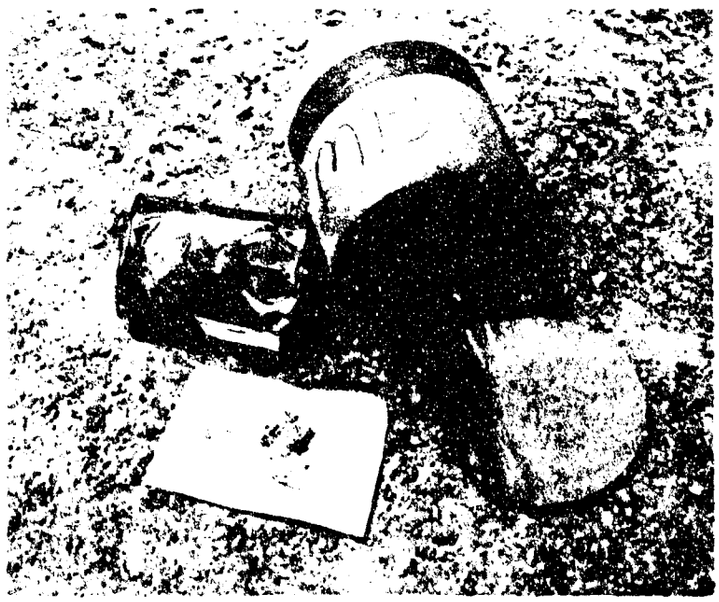

FIGURE 2. MB Container; All Vessels Ruptured with External Leakage.

The side of the MC container struck the top of a metal fence rail and then landed on the soil. The plastic bottle ruptured at three locations on its sides. The bottom seam of the No. 3 can ruptured. A small rupture occurred in the No. 12 can. Dye was absorbed by the cotton around the plastic bottle and No. 3 can, but a trace of dye appeared on the outside of the No. 12 can at its point of impact (Fig. 3).

The MD container landed on its bottom edge on the soil. The plastic bottle ruptured along its side. The No. 12 can was dented on its bottom edge; otherwise it was intact with no leakage. The bottom of the fiberboard container was torn off. The No. 12 can was 15 feet away from the fiberboard container. The vermiculite inside the No. 12 can absorbed all of the dye (Fig. 4).

The ME container impacted on the bottom edge on macadam. The top and bottom seams of the No. 3 can ruptured, and the No. 12 can bottom seam ruptured. The fiberboard container bottom was torn off. Dye was spread throughout the cotton surrounding No. 3 and 12 cans and on the macadam surface (Fig. 5).

The MF container impacted on its bottom edge on macadam. The No. 3 can bottom and side seams ruptured. The No. 12 can was dented on the bottom, but no seams ruptured. The bottom of the fiberboard container was ruptured, but without external dye leakage. All of the dye was absorbed by the vermiculite surrounding the No. 3 can (Fig. 6).

The results of the 500- and 1,000-foot drop tests are summarized in Table 1.

IV. DISCUSSION

Drops at the 500- and 1,000-foot levels were selected because a performance test standard such as a drop or impact test has not been established for etiologic agent shipping containers. However, drop tests conducted in May 1961 (Appendix B) had been used as the basis for standard specifications incorporated in US Army Materiel Command Regulation 385-101.

These present tests were conducted to demonstrate the need for exact specifications for the containers and for amounts of cushioning absorbent materials to be used if the container is expected to survive rough treatment approaching that encountered in a motor vehicle or aircraft crash. Our method was that of obtaining materials readily available in the laboratory and using these to make up containers. For example: In the 500-foot drop test, the pint and 500-ml glass bottles were one brown and one clear chemical reagent bottle. The plastic bottles were thin-walled

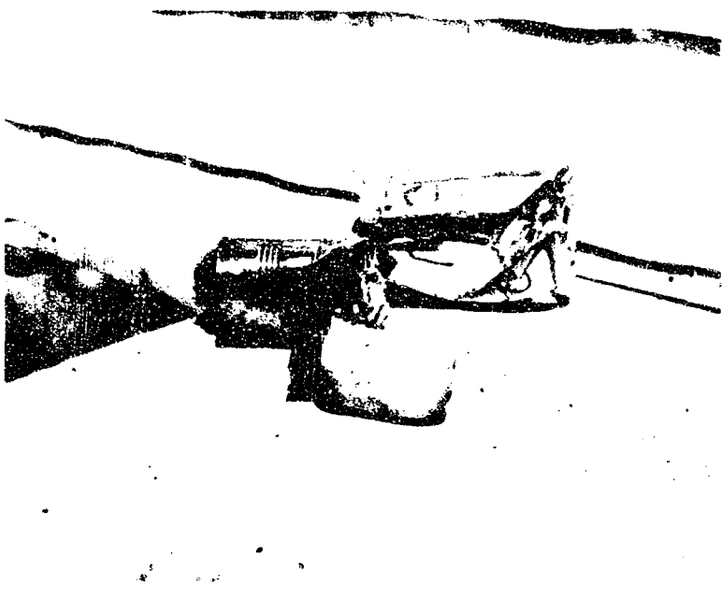

FIGURE 3. MC Container; Vessels Ruptured with External Leakage.

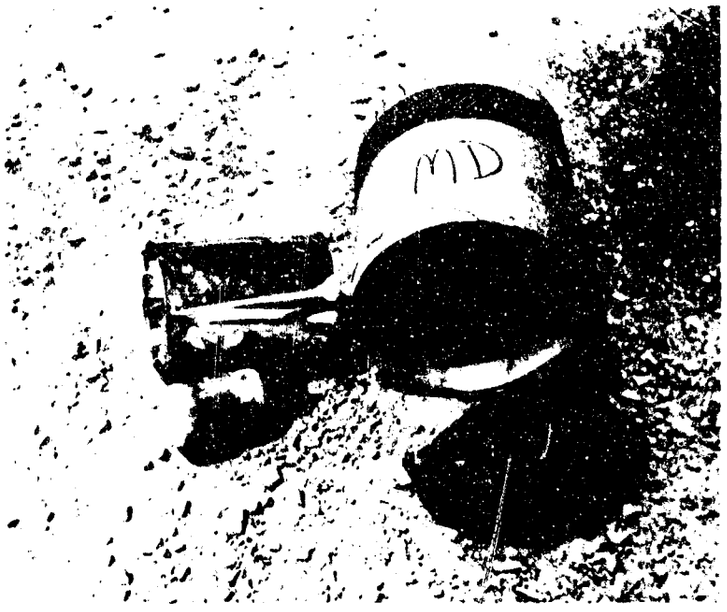

FIGURE 4. MD Container; the Plastic Bottle Ruptured without External Leakage. The vermiculite in No. 12 tin can absorbed the dye.

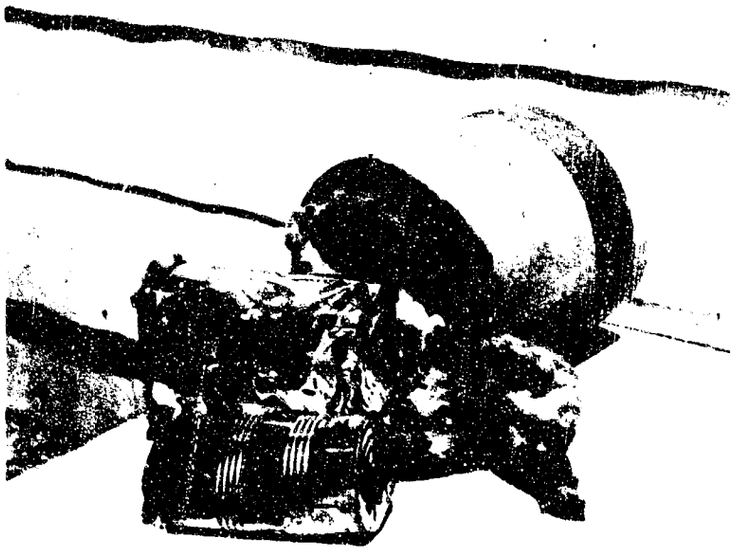

FIGURE 5. ME Container; All Vessels Ruptured with External Leakage.

FIGURE 6. MF Container; the No. 3 Can Ruptured with no External Leakage. Vermiculite in the No. 12 tin can absorbed the dye.

polyethylene. In the 1,000-foot drop test the 500- and 1,000-ml glass bottles were chemical reagent bottles. The plastic bottles were thin-walled plastic (type unknown); one had contained sodium hydroxide, the other, hydrochloric acid. All of the No. 3 and No. 12 cans used were crimp-sealed metal cans. The lids were sealed on the metal cans with Dixie canning machines. The fiberboard cartons were readily available. Vermiculite was that used to insulate buildings.

During the 500-foot drop tests, the only primary receptacle to remain intact was a plastic bottle placed in a No. 12 can packed in a fiberboard carton. Vermiculite had been placed as a cushioning absorbent material between the receptacles (1 and 2; 2 and 3). The two other containers that had no external leakage after the 500-foot drop were the glass bottle and the plastic bottle, each of which was in a No. 3 can inside a No. 12 can with absorbent cotton as the cushioning material.

After the 1,000-foot drop test, no primary receptacle remained intact. Only two containers survived the 1,000-foot drop test without external leakage. One was the plastic bottle in a No. 12 can in a fiberboard carton, and the other was a No. 3 can in a No. 12 can in a fiberboard carton. Vermiculite was used as the absorbent cushioning material in both of these containers.

The results clearly indicate the unlikelihood of packages surviving drops from the test-drop heights unless exact material specifications are established. The data obtained in May 1961 at drop heights of 2,000 and 4,000 feet above ground level clearly indicate that containers for 250 and 500 ml can be packaged to withstand the impact of such drops. Containers similar to those tested in May 1961 later withstood the crash of a C-119 aircraft at 138 miles per hour (203 ft/sec) (Appendix B).

The results summarized in Appendixes B and C indicate that adherence to the present requirements in 42CFR72.25 is very unlikely to produce a 1-gallon container that will not leak after a severe impact. It is recommended that a performance specification be required for volumes exceeding 500 ml in individual shipping containers. The advised minimum is a 40-foot drop to concrete. However, Appendixes B and C show that a performance specification of no leakage after an impact at 145 to 165 feet per second is not an unreasonable requirement when the volume of infectious fluid in the individual shipping container exceeds 500 ml.

V. CONCLUSIONS

The triple packaging provisions of 42CFR72.25(b)(1)(2) provide absence of leakage under "conditions ordinarily incident to transportation handling" but will not necessarily provide a package that will withstand a major accidental impact, as during crash of an aircraft.

For volumes of infectious fluid exceeding 500 ml, it is recommended that 42CFR72.25 be revised to include a performance standard, such as "no leakage from the individual shipping container after an impact at 145 to 165 feet per second."

APPENDIX A

REVIEW OF PACKAGING REQUIREMENTS FOR DANGEROUS ARTICLES OTHER THAN ETIOLOGIC AGENTS

1. Atomic Energy Commission, Title 10, Part 71.64,

(a) To be applied separately to the package:

(1) Thirty-minute water spray and then a 4-foot drop.

(2) One-foot drop on each corner in succession.

(3) Drop a 13-pound, 1½-inch-diameter steel cylinder 4 feet onto the most vulnerable point.

(b) To be applied sequentially:

(1) Thirty-foot drop (flat surface) onto the most vulnerable point.

(2) Forty-inch drop onto end of a steel bar 6 inches in diameter.

(c) Miscellaneous minor tests.

2. Interstate Commerce Commission (now Department of Transportation),

(a) 49CFR173.335, Class A poison in Police Grenades, packaged, requires a 5-foot drop test.

(b) 49CFR78 various sections, Class A poisons, only 4- and 6-foot drops and a 55-inch swing.

3. Air Force Manual 71-4 (Army TM 38-250), 15 November 1965, paragraphs 10-23, for Military Aircraft. (Except for laboratory samples, Class A poisons are not transportable on commercial airlines.)

(a) Agents

(1) VX and V agents, Tabun, Lewisite, mustard gas - all up to 125 pounds of agent per cylinder.

(2) Phosgene up to 150 pounds of agent per cylinder.

(b) Containers

(1) Cylinder specification referred to in AFM 71-4 is in Agent T.C. George's Tariff 19 (49CFR) para. 178.41 - 14(d) no drop test required. To be tested to at least 5/3 times the service pressure.

(2) One-ton container tanks (to hold 170 gallons of agent) are not mentioned in AFM 71-4, but are included in Army Materiel Command Regulation 385-232, page 8, para. 24d. They can be shipped by air (page 31, para. 106). I.C.C. Specification 106A (49CFR173.333); Tariff 19, 173.357(b)(4) and 179.300-6 and -9 state that no drop test is required; tanks are tested at 500 to 1,000 psi depending upon the tank specification. This container leaked a forceful gross spray after a 40-foot drop.*

(3) Cylinder mentioned in AMCR 385-232, page 8, ICC Specification 3A 1800 (Tariff 19, page 184, paragraph 178.36), to hold less than 1,000 pounds' water capacity: No drop test is required; they are tested at 1,800 psi.

* Naval [illegible]apons Lab., Dahlgren, Va., Report NWL, No. W-27/64, October 1964.

APPENDIX B

DROP OR CRASH TESTS OF ETIOLOGIC AGENT SHIPPING CONTAINERS, 1953 TO 1967

Identification	Test Time, Place	Drop Height and Surface	Number of Containers Dropped	Impact Speed, ft/sec	Inner Container
Fort Detrick	July '53 Fort Detrick Maryland	5 to 20 ft to concrete	4 dropped 7 to 12 times each	Unknown	500 ml in Pyrex bottle
Fort Detrick	24 May '56 Wash Airport cargo transfer	One box dropped	Leaked Mahoney virus	Unknown	2½-gal Pyrex bottle of polio virus
42CFR 72 25 USPHS		"withstand conditions ordinarily incident to transportation handling"		Unknown	Watertight & airtight 1-gal max.
USPHS[1/] Report 75, Nov. '60	1960 Chamblee, Georgia	1,000-1,500 ft to hard baked soil	17 packages of liquid, dropped once each	Unknown	Milk dilution bottle or 15 x 150 mm glass tubes
Fort Detrick[2/]	16 May '61 Dugway PG Utah	2,000 & 4,000 ft to sandy soil	15 at 2,000 ft 15 at 4,000 ft[a/]	151 ±22%	250- or 500-ml Pyrex or plastic bottle
Fort Detrick	April '61 Fort Detrick	30 ft to concrete	30 (6 each of 5 varieties) each dropped 6 times. 12 frozen[a/]	Unknown	As above
Edgewood Arsenal	June '62 Edgewood, Maryland	1,500 ft to concrete	One dry fill. One wet fill.	313	3 pint glass jars, rubber between them
Fort Detrick	26 June '64 Fort Detrick	100 ft to black-top macadam	[1] 6 frozen, 2 liquid, 1,200 ml [a] One 500-ml liquid	Unknown	[1] Number 3 can [2] 500-ml Pyrex bottle
Fort Detrick	19 July '65 Fort Detrick	100 ft to black-top macadam	Four 1-gal frozen pellets (1,514 ml liquid)	Unknown	Number 12 (1-gal) crimp-sealed tin can

Type of Packing	Middle Container	Packing	Outer Container	Total Weight	Result
Absorbent cotton	404-700 crimp-sealed can	Sponge rubber	610-708 friction-sealed can (1 gal)	about 7 lb	No leakage of agent.
Rubber floor pad & wrapper	5-gal steel ice-cream can, unsealed slip cover	Compressed bleached cellulose fiber	10 inch square corrugated cardboard box, taped	33 lb	Pilot fingered & smelled fluid. Cargo handler's clothes moistened.
Must absorb all liquid contents	Must be durable, watertight, airtight	None required	Corrugated cardboard, fiber glass, wood or equivalent	Unknown	No infections known to PHS.
"Shock absorber" or paper	Friction- or crimp-sealed can	"Shock-resisting"	Some cases not required; others, cardboard box	Unknown	No leak thru outer package. One tube broke.
Absorbent cotton	No. 3 or No. 12 crimp-sealed can	Vermiculite	15 1-gal fric. sealed cans. 15 10-in O.D.x 12½-in fiber cylinder	5 to 7.2 lb	No leakage to outside. One bottle broke.
As above	As above	As above	As above	As above	No leakage. No bottles broke.
Sponge rubber wrapper	No. 3 crimp-sealed can	Sponge rubber	M18A1 metal propellant container 26½ x 6 3/4 in. O.D.	24 lb	No leakage outside. Condition of bottles unknown
Absorbent cotton	No. 12 (1-gal) crimp-sealed can	Absorbent cotton	702-906 fiber cylinder, telescopic	5 lb	[1] In one, liquid leaked to outside. [2] No leakage to outside.
[1] 2 absorbent cotton [2] 2 Vermiculite[b/]	None	None	702-906 fiber cylinder, telescopic	5.2 lb	[1] No leakage to outside. [2] One leaked to outside when pellets melted.

Identification	Test Time, Place	Drop Height and Surface	Number of Containers Dropped	Impact Speed, ft/sec	Inner Container
AFATL (ATCB) Contract F08-635-67C-0012 Eglin AFB[3/]	[1]20 Oct '66 Phoenix, Arizona	[1]C-119C aircraft crashed concrete wall	[1]One CNU-103/E	[1]203 (aircraft speed)[c/]	[1]Plastic bag in A/B45Y-1
	[2]16 Nov '66	[2]C-119C aircraft crashed concrete wall	[2]One CNU-103/E	[2]203 (aircraft speed)[c/]	[2]Plastic bag in A/B45Y-1
	[3]25 Jan '67	[3]C-119C aircraft veered over concrete wall	[3]Three No. 3 crimp-sealed cans [4]One 1-gal plastic bottle	[3]203 (aircraft speed)[c/]	[3]Number 3 crimp-sealed cans [4]One 1-gal plastic bottle
Pine Bluff Arsenal	[illegible] Jan '67 PBA, Ark.	114 ft to grassy ground	5 cotton waste 5 vermiculite packing	Unknown	Number 12 1-gal crimp-sealed can, crushed ice
Fort Detrick	30 June '67 Fort Detrick	100 ft to black-top macadam	2 MD Div. SKE 7-1088, 1 May 67	Unknown	Aluminum cylinder 19 x 6 inches O.D. 1900-ml vol.
Edgewood Arsenal	13 Oct '67 Edgewood Arsenal	1,000 ft to concrete	Four 1-gal metal cans	80	610-707 can, friction-sealed, 3-point solder

Type of Packing	Middle Container	Packing	Outer Container	Total Weight	Result
[1]Balsa	[1]36 x 169-in steel cylinder	[1]Balsa	[1]Plywood + aluminum shock absorber etc. 60 in. sq x 229 in. long	[1]12,000 lb	[1]No liquid leaked, still freon-tight.
[2]Balsa	[2]36 x 169-in steel cylinder	[2]Balsa	[2]Plywood + aluminum shock absorber etc. 60 in. sq x 229 in. long	[2]12,000 lb	[2]No liquid leaked, still freon-tight.
[3]Absorbent cotton	[3]Number 12 crimp-sealed can	[3]Absorbent cotton	[3]702-906 fiber cylinder, telescopic	[3]5 lb	[3]No leakage to outside.
[4]Cellulose cushion	[4]6-gal steel drum MS63049-1	[4]Cellulose cushion & plywood spacers top and bottom	[4]12-gal steel drum MS63052-2	[4]72 lb	[4]No leakage to outside.
5 cotton 5 vermiculite[b] #4	808-906 2-gal friction-sealed can, soldered lid	None	Corrugated fiber box 812 x 812 x 10 in. O.D.	8 lb	4 inner cans leaked. No outside leakage.
Wood, fiber spacers & vermiculite[b]	9-gal metal drum MS63049	Vermiculite grade #2	Cleated plywood box 15½ x 15½ x 30 in.	94 lb	Aluminum cylinder helium-tight after drop (dry fill).
Bleached cellulose fiber stripping	804-908 2-gal can friction-sealed, 4-point solder	Bleached cellulose fiber strip	Corrugated fiber box 12½ x 10 3/4 x 10 3/4 in.	13 lb 13 oz	All leaked liquid to outside.

a. These are the standard containers listed in Appendix VII, AMCR 385-101.
b. Agricultural grade - water absorbent.
c. 155.5 ft/sec ±6.5% was impact speed of the CNU-103/E (NA-67-785 Evaluation 21 August 1967, by North American Aviation, Inc., USAF Contract FO 8635-67-0002).

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APPENDIX C

DROP TESTS OF ETIOLOGIC AGENT SHIPPING CONTAINERS FROM 1,000 FEET TO CONCRETE[a]

Number of Containers	Impact Speed,[b] ft/sec	Inner Container	Packing	Middle Container
4: No. A1, A2, A3, A4	A3-100 A4-117	500-ml Pyrex bottle, 500 ml water	Absorbent cotton	1-gal 603-812 crimp-sealed can #12
4: No. B5, B6, B7, B8	B5-100 B7- 81	500-ml Pyrex bottle, 500 ml water	Vermiculite #3	1-gal 603-812 crimp-sealed can #12
4: No. C1, C2, C3, C4	C1-95 C3-75 C4-96	500-ml Pyrex bottle, 500 ml water	Cellulose fiber stripping	1-gal 603-812 crimp-sealed can #12
2: No. D1, D2	D2-92	500-ml Pyrex bottle, 500 ml water	Cellulose fiber stripping	2-gal 804-908 can, friction-sealed; 4-point solder
4: No. E1, E2, E3, E4	E3-80 E4-79	1-gal 610-707 can, friction-sealed; 3-point solder	Cellulose fiber stripping	2-gal 804-908 can, friction-sealed; 4-point solder
6: No. F1, F2, F3, F4, F5, F6	unknown	Glass test tube 20 x 150 mm, 10 ml liquid	Absorbent cotton	1 1/8 inch dia., x 7 inch can, screw cap
3: No. G1, G2, G3	unknown	Glass vaccine bottle rubber stopper, 32 x 62 mm; 15 ml	Absorbent cotton	1 5/8 inch dia. x 3 11/16 inch can, tin screw cap
3: No. H1, H2, H3	unknown	Glass, 25 x 55 mm, rubber stopper 10 ml liquid	Absorbent cotton	1 5/8 inch dia. x 3 11/16 inch can, tin screw cap
6: No. I1, I2, I3, I4, I5, I6	unknown	4 Glass test tubes 20 x 150 mm, 10 ml liquid each	Absorbent cotton	2 7/8 inch dia. x 6 13/16 inch can, tin screw cap & bottom
2: M1, M2	M1-87 M2-78	#3, 404 407 tin, crimp-sealed 1400-ml liquid	Cellulose fiber	1-gal #12 can 603-812, crimp-sealed
1: PEMA 15-gal drum	184	15-gal drum, metal, MS63052-2	Vermiculite #4	30-gal metal drum, MS24209-2
1: PEMA 5-gal drum	196	5-gal plastic drum in metal drum, Mil-D-40030	Vermiculite #4	16-gal metal drum, MS63053-1
1: IBM	103	1900-ml aluminum cylinder 19- x 6-inch diameter SKE-7-1088	Wood, fiber, vermiculite	9-gal metal drum MS63049

Packing	Outer Container	Total Weight	Results
Vermiculite #3	10 inch dia. x 12½ inch fiber cylinder	8 1/8 lb.	All bottles broke. All #12 cans intact. A2 #12 can ejected. No external leaks.
Vermiculite #3	10 inch dia. x 12½ inch fiber cylinder	8 1/8 lb.	B5, B6 bottles broke. B7, B8 intact. B6, B7, B8 tins intact. B5, B8 tins ejected. B5 had major leak.
Cellulose fiber stripping	10 inch dia. x 12½ inch fiber cylinder	7 11/16 lb.	All bottles broke. All tins intact. No external leaks.
Cellulose fiber stripping	10 inch dia. x 12½ inch fiber cylinder	7 7/8 lb.	Both bottles broke. Both tins intact. No external leaks.
Cellulose fiber stripping	Corrugated fiber box 12½ x 10 3/4 x 10 3/4 inches	13 lb. 13 oz.	All 1 gal & 2 gal tins leaked. All had serious leakage into cellulose.
Absorbent cotton	Fiber, 1½-inch dia. x 7 5/8 inch, metal cap, metal bottom	5 oz.	Only F4 test tube did not break. All tins intact. No external leaks.
Absorbent cotton	Fiber, 2-inch dia. x 4 inch, metal screw cap, metal bottom	5 oz.	No glass bottles broke. No external leaks.
Absorbent Cotton	Fiber, 2-inch dia. x 4 inch, metal screw cap, metal bottom	5 oz.	No glass bottles broke. No external leaks.
Absorbent cotton	Fiber, 3½-inch dia. x 7 7/16 inch, tin screw cap & bottom	1 lb.	1 or more test tubes broke in each package, but only I3 leaked past tin container. Only I3 had slight leak into inner cotton.
Cellulose fiber	Corrugated fiber box 10 x 8 3/4 x 8 3/4 inches	7½ lb.	M2 slight leak after standing 2 days. M1 slight leak into cellulose. (M2 dropped twice).
Plywood & Styrofoam spacers	55-gal drum MS63054, 23½-inch dia. x 50 inches	321 lb. without ice	All fluid lost after impact on side.
Plywood & Styrofoam spacers	30-gallon metal drum, MS24209-2	128 lb. without ice	Slight leak through secondary container. No external leak.
Cellulose fiber stripping	Cleated plywood box 15½ x 15½ x 30 inches	99 lb.	Aluminum cylinder intact. No external leak.

a. Edgewood Arsenal, 13 October 1967.

b. Findings are based on the film's being taken at 1800 frames per second. The camera speed was checked by mechanical timing and light blips on the film. It was found to operate consistently at that speed.

APPENDIX D

PROPOSED SMALL-VOLUME CHEMICAL AGENT SHIPPING CONTAINERS

Drop tests were conducted for shipping containers of less than 1-gallon volume for chemical agents from altitudes of 500 and 1,000 feet above ground level onto dry, baked, desert soil, macadam, or concrete at Dugway Proving Ground. Commercially available Pyrex lyophilization ampoules (50 ml) containing 25 ml of an Oil Red dye dissolved in carbon tetrachloride were used as proposed shipping containers (Fig. 1). After the dye was placed in the ampoule the ampoule neck was heat-sealed without being reannealed. One to four ampoules were placed in a crimp-sealed No. 3 tin can (size 404-700), which was placed in a No. 12 crimp-sealed tin can (size 603-812). One of three types of absorbent cushioning material (absorbent cotton, vermiculite (construction grade) size IV, and small fragments of Styrofoam) was used to fill the void between the ampoules and the No. 3 can, and between the No. 3 and No. 12 cans. All of the ampoules remained intact after landing on dry, baked, desert soil, macadam, or concrete (Fig. 1). The following tabulation shows the test protocol.

Ampoules/ Container	Number of Containers[a]	Absorbent	Distance Dropped, ft
1	4	cotton	500 & 1,000
1	4	vermiculite	500 & 1,000
1	4	Styrofoam fragments	500 & 1,000
2	4	vermiculite	500
3	4	vermiculite	500
4	3	vermiculite	500

a. All contained a No. 3 can with ampoules inside.

FIGURE 1. Proposed Chemical Agent Shipping Containers (50-ml Glass Ampoules, Heat Sealed). All ampoules remained intact after being dropped 500 or 1,000 feet onto dirt, macadam, or concrete.

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13. ABSTRACT

Etiologic agent shipping containers with fluid volumes between 450 and 1,300 ml were prepared from readily available materials and dropped from 500 and 1,000 feet onto hard desert soil, concrete, and macadam. The purpose was to determine whether (i) the containers would be likely to withstand a severe impact during shipment, and (ii) such a container could be assembled from a general packaging instruction in the absence of explicit specification of container materials. All containers were prepared in accordance with the Interstate Quarantine Provisions of the U.S. Public Health Service in the Code of Federal Regulations, 42CFR72.25.

Materials evaluated were plastic, glass, and metal inner containers; cotton and vermiculite absorbent cushioning materials; and metal and cardboard outer containers.

The drop tests established that adherence to the packaging requirements of 42CFR72.25 will not assure a package that will not leak when dropped on a smooth surface at the velocities reached in these tests. However, packages prepared in accordance with 42CFR72.25 will not leak under "conditions ordinarily incident to transportation handling" as stated in 42CFR72.25.

For volumes of infectious fluid exceeding 900 ml, it is recommended that 42CFR72.25 be revised to include a performance standard, preferably "no leakage from the individual shipping container after an impact at 145 to 165 feet per second."

14. Key Words

*Shipping containers
*Biological agents
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