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THE DEVELOPMENT OF CLOSURE DEVICES FOR FLEXIBLE CONTAINERS

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ABSTRACT

The development of an improved closure system for the construction of flexible engine containers in conjunction with the development of new barrier materials (PTPT Report No. 76-21) has been completed. A thorough study of designs, materials, and manufacturing processing was conducted. An extruded polyurethane standup closure met the requirements for efficient opening and closing and providing a controlled environment for protection of military hardware when installed on the new improved flexible engine container (PTPT Report No. 76-21). Field tests are recommended before approval of production quantities.

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INTRODUCTION

The purpose of this project was to develop a closure system to provide an efficient opening and closing device, easy and simple to operate which when installed on a MIL-C-9959, "Container, Shipping and Storage (Flexible)", will provide a controlled environment for storage and protection of military items.

This report outlines the history of the development program, the deficiencies in the present state of the art, closure designs and evaluations by All American Engineering Corporation, Global Chemical Systems Incorporation development work, testing and evaluation, and describes the successful completion of a satisfactory closure system with an extruded polyurethane closure device.

DISCUSSION

The development program was divided into several work programs as follows: Study of the state of the art and deficiencies of the present closure systems; contractual development program with All American Corporation; and the development work by Global Chemical Systems Incorporation under the guidance of AFPEA.

State of the Art and Deficiencies in Present Closure Systems.

Flexible containers designed and fabricated in accordance with MIL-C-9959 have met with unusual and utilitarian success in the storage and environmental protection of many military items (Figure 1). For many items, it is the most efficient, cost-effective method of preservation with the additional benefit of effective handling and transporting techniques. However, the methods of closing and opening (closure devices) have been limited to three types or methods, viz., (1) heat sealing of the plastic-type materials to soften and fuse the interface of the material together to make an effective seal; (2) the common slider fastener device known as "zipper", constructed of plastic/rubber-like materials (Figure 2), and (3) metal interlocking teeth in a plastic or rubber strip or sheet (Figure 3).

The plastic fastener has two edges designed to fit together so as to be fastened when a slider draws the two edges together. The edges remain together until they are released by drawing the slider in the opposite direction over the edges. The metal fastener operates similarly except that the edges of the plastic-rubber-like

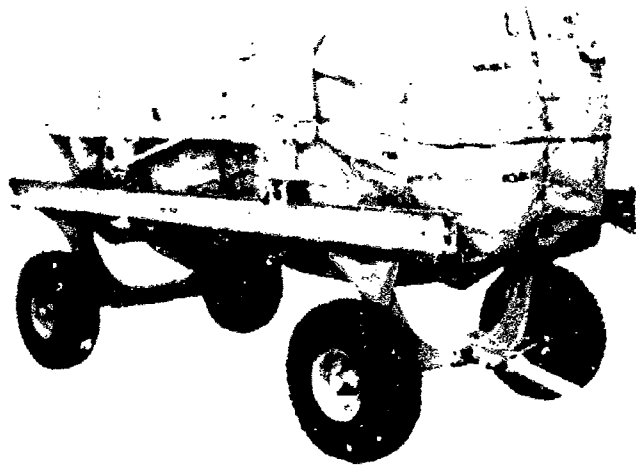


Figure 1. FLEXIBLE CONTAINER, MIL-C-9959,
TYPE III (60 DAY STORAGE LIFE)

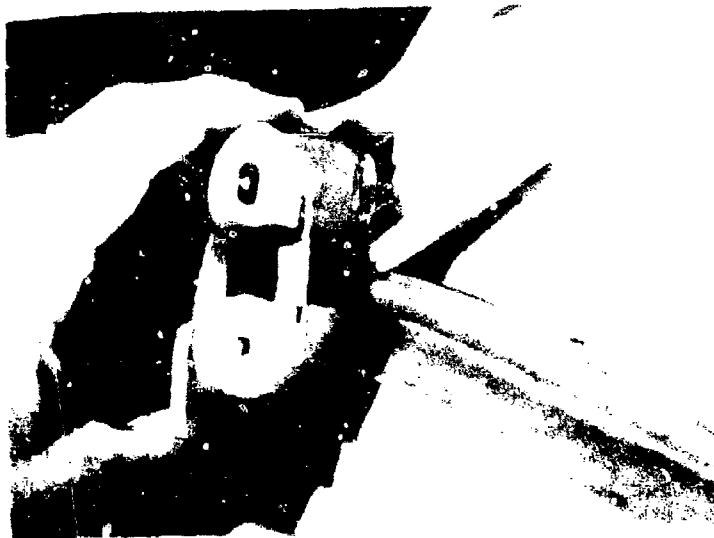


Figure 2. ALL PLASTIC CLOSURE EXTRUDED
FROM POLYVINYL CHLORIDE



FIGURE 3. METAL TOOTH TYPE CLOSURE

materials have metal teeth and hollows which fit into each other snugly. To insure a good water vapor seal, a plastic/rubber-like seal is provided as the fastener is closed. Adhesives and pressure sensitive tapes have been used in selected applications.

The heat sealed closure is deficient in that it is limited: (1) by the requirement for a source of heat; (2) by the number of openings and closings which is, in turn, dependent upon the amount of material allowed for successive "heat seals"; and (3) by the thermoplastic materials themselves that can be softened by heat and fused together to make a seal.

The all plastic slide fasteners have proven to be difficult to open and close particularly on large items such as flexible containers, MIL-C-9959A, for aircraft jet engines. It has been found that the present design should have improved barrier qualities against water vapor.

The metal fastener deficiencies are: (1) the metal teeth are easily damaged in use so as to make the closure inoperable and difficult to repair in the field; (2) the presently used plastic/rubber-like materials to which the metal teeth are attached are not thermoplastic; thus, presenting difficulty in fabrication of containers when the heat sealing techniques are preferred for cost savings reasons; and (3) the presently available barrier-type metal type fastener is too costly a method of closure, particularly on many smaller sized containers.

Adhesive systems have been ruled out by the more complicated and costly fabrication required. Pressure-sensitive tapes have not found acceptability because of the difficulty in sealing surfaces that become oily, dirty, and/or are inherently difficult to seal.

Closure Designs and Evaluations.

A contract, Development of Closure Devices for Flexible Containers, was awarded to the All American Engineering (AAE), Wilmington, Delaware, 30 Jun 1972. The contractor, during Task I, developed fifteen design considerations (Figure 4). Two designs, numbers seven and ten, were selected for further study (Figure 5). The selections were based on preliminary Water Vapor Transmission Rate (WVTR) test results and manufacturing feasibility (reference All American Engineering Report No. AF 312). The Talon OEB Metal Tooth Slide Closure was also recommended for further development subject to the success of the extruded polyurethane designs, numbers seven

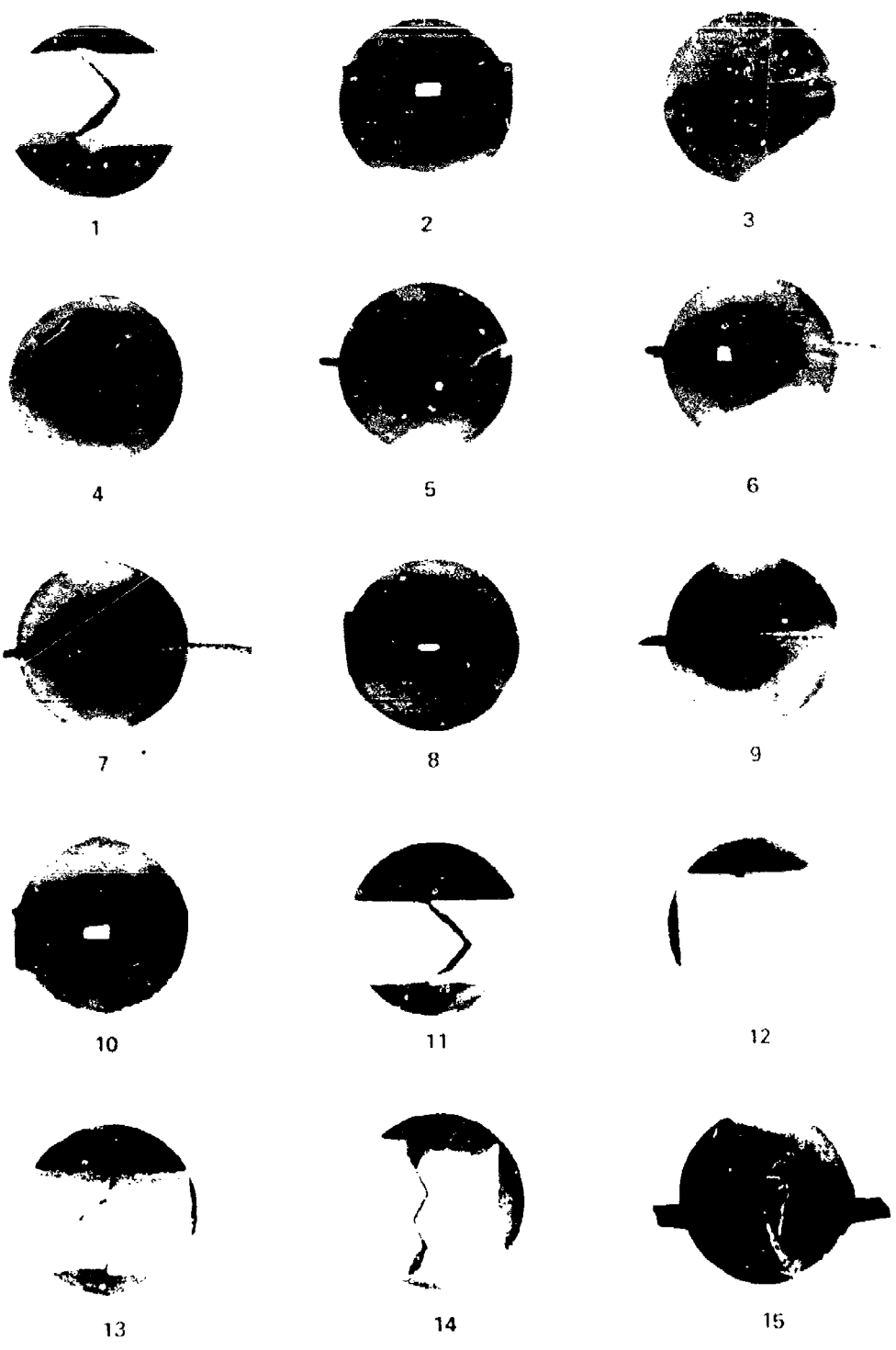


Figure 4. CLOSURE DESIGN CONSIDERATIONS

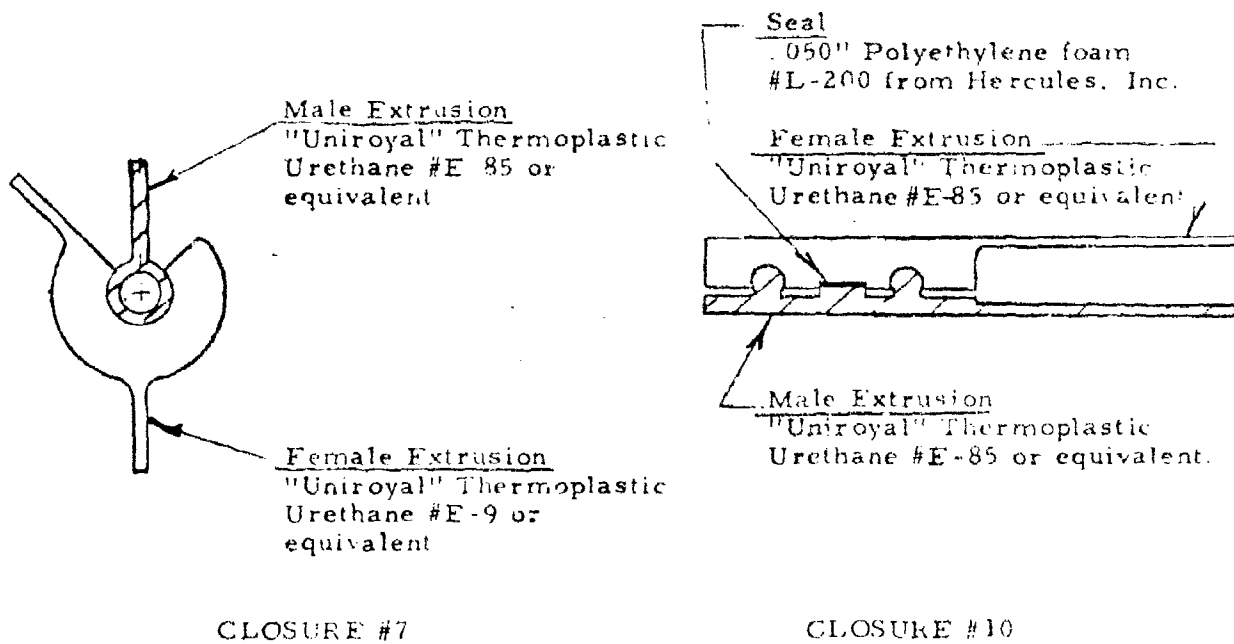


Figure 5. SELECTED CLOSURE DESIGNS

and ten.

During the Task II, great effort was made to extrude the two selected designs from polyurethane. Unforeseen technical difficulties were encountered in extruding the polyurethane. Dimensional control and flexibility of the closures were the two major deficiencies (Figure 6). The contractor failed to solve these problems, and the contract was terminated.

Concurrent with this contract, development and investigation was conducted into closure devices by the Minigrip Corporation, Orangeburg, New York (Figure 7). Minigrip closure designs and one of the selected closure designs of AAE Corporation were very similar (Figure 8). Minigrip Corporation had perfected the extrusion of several plastic materials, but not polyurethane. AAE did conduct WVTR tests on the several of the Minigrip plastic extrusions and reported the results in their Report AF-320. The WVTR of the closures did meet the requirements for flexible containers, MIL-C-9959. However, Minigrip and AAE were not interested in developing the techniques for extruding polyurethane minigrip type closures which would be acceptable for MIL-C-9959 containers. They believed that the technical difficulties were too great to be overcome.

Global Chemical Systems Incorporated Development Work.

The Global Chemical Systems Corporation approached the AFPEA on their polyurethane covers for aircraft jet engines and helicopter covers. They indicated that they were interested in upgrading their barrier materials and closure devices to meet the Air Force requirements of flexible containers, MIL-C-9959. AFPEA presented the potentials of polyurethane/saran composite films, and the extruded polyurethane minigrip closure designs.

The Global Chemical Systems made arrangements with the Minigrip Corporation for the use of their equipment and facilities for development of polyurethane Minigrip designed closures. After several months of effort a three track "layflat" (Figure 9) and a two track "stand-up" (Figure 10) closure designs were perfected. Figure 11 shows a Global Flexible Container, TF 34-GE-100, with a three track "layflat" closure device. Figure 12 and 13 shows the two track "stand-up" closure installed in a T-100 engine container. The two track "stand-up" closure was selected for use in flexible containers because of the ease of opening and closing pressure without the necessity of a special tool. Finger pressure is sufficient to close the closure device.

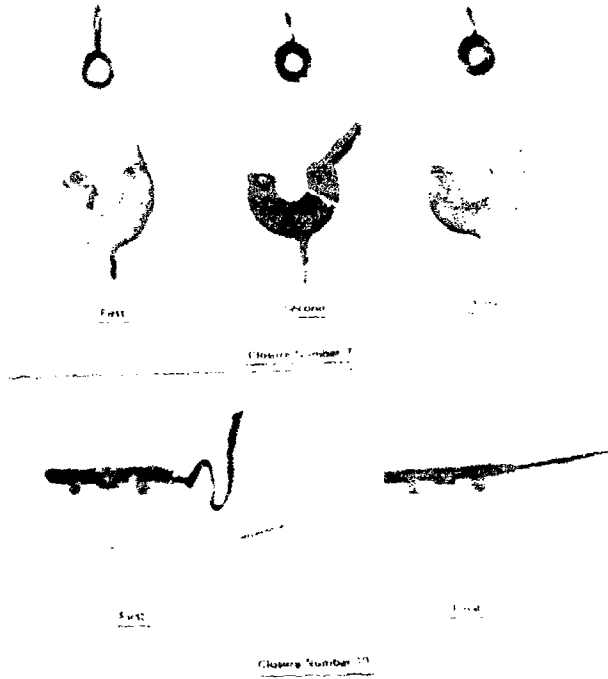


Figure 6. EVOLUTION OF CLOSURE EXTRUSIONS SHOWING DIMENSIONAL CONTROL PROBLEMS--AAE REPORT 320

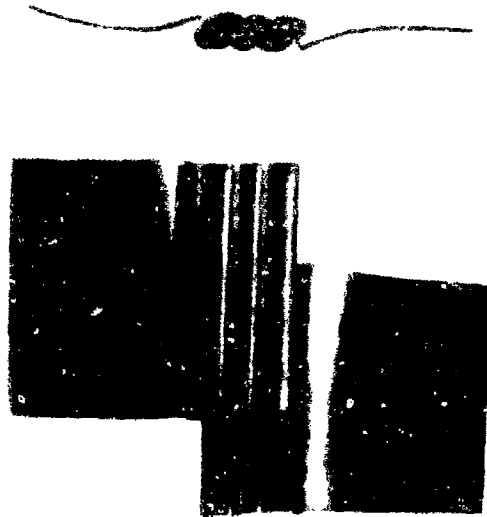
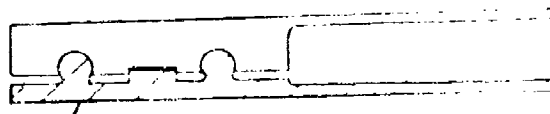


Figure 7. MINIGRIP CLOSURE EXTRUDED OF CHLORINATED
POLYETHYLENE AAE CORP. REPORT 320



TYPICAL MINIGRIP CLOSURE DESIGN



AAE #10 CLOSURE DESIGN

Figure 8

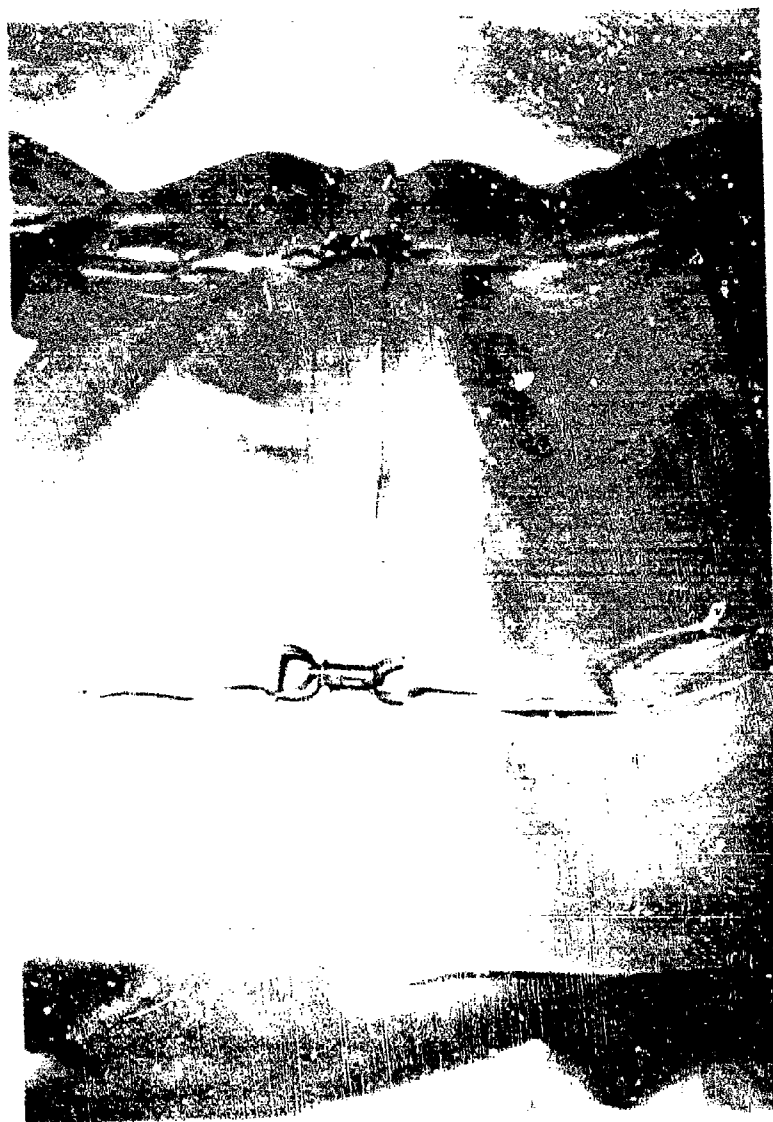


Figure 9. GLOBAL THREE TRACK
LAYFLAT CLOSURE



Figure 10 GLOBAL TWO TRACK STANDUP CLOSURE

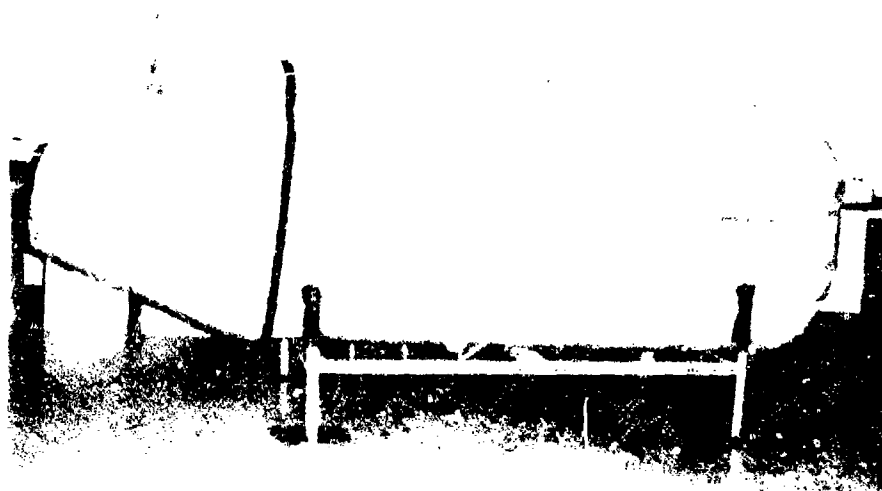


Figure 11. GLOBAL FLEXIBLE CONTAINER, TF 34-GE-100,
WITH THREE TRACK LAYFLAT CLOSURE



Figure 12. CLOSE-UP VIEW OF THE CLOSURE
DEVICE WITH SNAP FASTENER

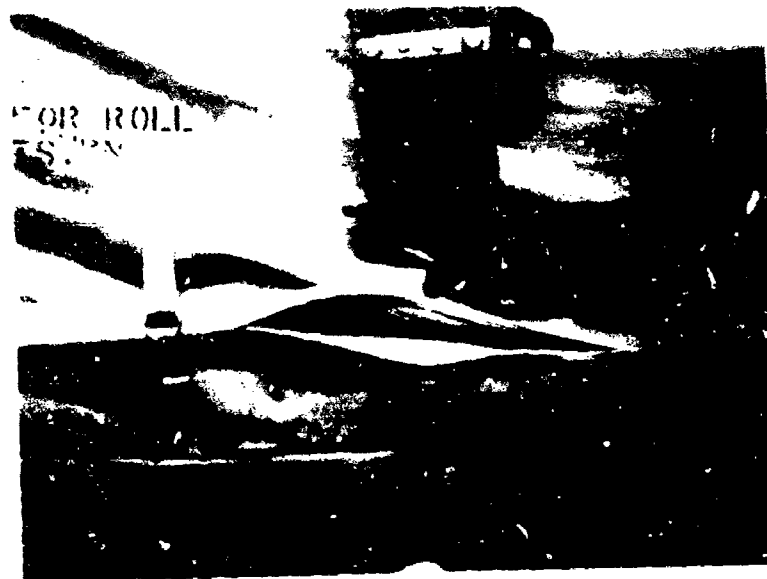


Figure 13. CLOSE-UP VIEW WITH CLOSURE
DEVICE PARTIALLY OPEN

TESTING AND EVALUATION

Table I shows the results of WVTR tests on one cubic foot test containers. The evaluation of the WVTR effectiveness of the closure devices was conducted according to a modified Method 3030 of Federal Test Method Standard 101B, which is described in the Appendix of PTP Report 76-21, "The Development of Barrier Materials For Flexible Aircraft Engine Containers". The Global one cubic foot container with the 24" length closure had a WVTR approximately equivalent to the DuPont #264-3-1 cubic foot container without a closure device (difference of 0.01 grams/100 sq. in./24 hrs.). Since a 2' x 2' x 5' container made from DuPont #264-3-1 barrier material with a Talon metal tooth closure gave over one year protection (did not reach 40% RH) outside at Eglin AFB, FL (AAE Report AF-275-A) without redessiccation, it can be safely assumed that a flexible container constructed of Global #4051 barrier, and the extruded polyurethane closure should exhibit approximately the same protection under similar conditions.

Figure 14 shows the WVTR testing device of a one cubic foot test container with 24" length closure device mounted on a test fixture placed in an environmental chamber.

The data in Table II further confirms that a flexible container manufactured from Global barrier material #4051 and the extruded polyurethane closure device will meet the specific protection period of one year without redessiccation as required by MIL-C-9959, Type I container. This table shows the results of a simulated test using 10% of the desiccant required for a one year protection period. The container reached 31% at the end of 37 days (approximately 10% of 364 days). This is equivalent to more than a one year protection period (10 x 37 days = 370 days).

By projecting the time to reach 40% RH from the 31% RH, the test container would require a total of 60 days. This indicates that a container with 100% of the desiccant required by MIL-C-9959, Type I container will give over 1-1/2 year specific protection period. Further testing is being conducted to confirm these projections.

It should be noted that a container with no closure device (heat sealed) will give an estimated 2-1/2 year protection period. This indicates that the newly developed closure device, although superior to previous closure devices, does allow moisture vapor into the container.

TABLE I
 WATER VAPOR TRANSMISSION RATES
 OF ONE CURIC FOOT FLEXIBLE CONTAINERS (NOT DESICCATED)

BARRIER MATERIAL	TEST CONDITIONS		
	100°F 95% RH	80°F 80% RH	73°F 50% RH
	(gm/100 sq. in./24 hrs.)	(gm/100 sq. in./24 hrs.)	(gm/100 sq. in./24 hrs.)
DuPont #264-3-1* Without Closure	0.05	0.039	0.003
Global #4051 Without Closure	0.03	0.009	0.003
With Closure 24" Length - Stand-up Design	0.06	---	---

*DuPont #264-3-1 - 2' x 2' x 5' container with Talon Closure gave over one year protection outdoors at Eglin AFB, FL (AAE Report AF-275-A).

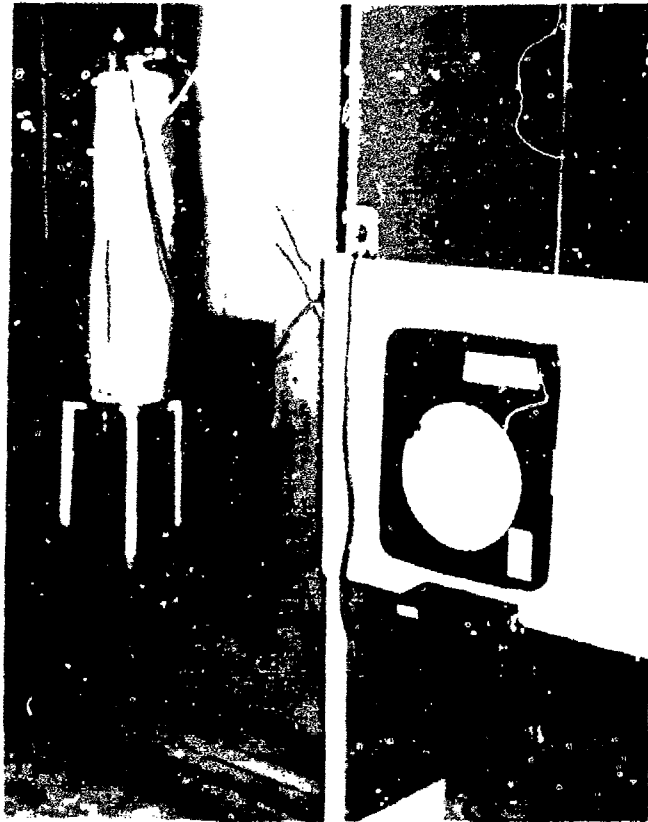


Figure 14. ONE CUBIC FOOT TEST CONTAINER MOUNTED
ON TEST FIXTURE IN ENVIRONMENTAL CHAMBER

TABLE II

SPECIFIC PROTECTION PERIOD EVALUATION
 MIL-C-9959, TYPE I CONTAINER
 ENVIRONMENT - 80% RH AT 80°F

CONTAINER	UNITS OF DESC. FOR ONE YEAR FOR ONE CUBIC FOOT CONTAINER MIL-C-9959, TYPE I	UNITS OF DESC. FOR 10% OF ONE YEAR (37 DAYS)	DAYS TO REACH 40% RH (FROM 5% RH)	ESTIMATED PROJECTED DAY TO REACH 40% RH (FROM 5% RH)	ESTIMATED SPECIFIC PROTECTION PERIOD USING 100% DESC, MIL-C-9959 TYPE I CONTAINER
Global Barrier Material #4051 Closure-Extruded Stand-Jp - Polyurethane	26.4	2.64	37 (The Container Reached 31% RH in 37 Days)	60	1-1/2 Yrs
Global Barrier Material #4051 No Closure (Heat Sealed)	26.4	2.64	37 (The Container Reached 15% RH in 37 Days)	100	2-1/2 Yrs

The ease of opening and closing was checked out on sections of extruded closure devices, and an aircraft engine cover TF-30-GE-100 provided by Global Chemical Systems Corporation. The closure devices were easily opened and closed at room temperature. The container was placed in a cold chamber at 32°F. After 24 hours, the container closure device was opened and closed with moderate effort. At 0°F, the closure device became more rigid, and difficult to open and close. At -32°F, the closure was not operable; however, the closure did not fracture upon bending. These results were considered acceptable (PTPT Report No. 76-21).

The Global Chemical Systems will certify that the closure meets all other physical property requirements of MIL-C-9959 including the resistance to aging, light, synthetic lubricating fluids and petroleum products.

Twenty prototype flexible containers designed according to Global Drawing Code Identification No. 5403, "Envelope, Engine Protective Outline and Mounting", for F-100 engine (Figure 15) have been procured and are to be used for field test and evaluation.

The First Article fit and function test was conducted at Pratt & Whitney Aircraft Corporation, Hartford, Connecticut. The assembly of the flexible container to the F-100 engine was performed easily, and the closure device was closed by finger pressure without auxiliary tools. The performance of the container through the First Article fit and function test was satisfactory, and the test indicated that in field use the container should perform excellently.

Figure 16 shows the F-100 engine (without cover) that was used during First Article fit and function test. Figure 17 shows the top half of the container installed. Figure 18 shows the container/engine assembly mounted on 4-wheel trailer ready for transportation/storage. Figures 12 and 13 are close-ups of the closure device. The straps, with snap fasteners, for reinforcement between the two halves of the container should be noted.

CONCLUSIONS

The purpose of this project, to develop a closure system for MIL-C-9959, "Container, Shipping and Storage (Flexible)", that would be easy and simple to operate and would maintain a controlled environment for storage and protection of military items has been accomplished. The Global Chemical Systems Corporation extruded

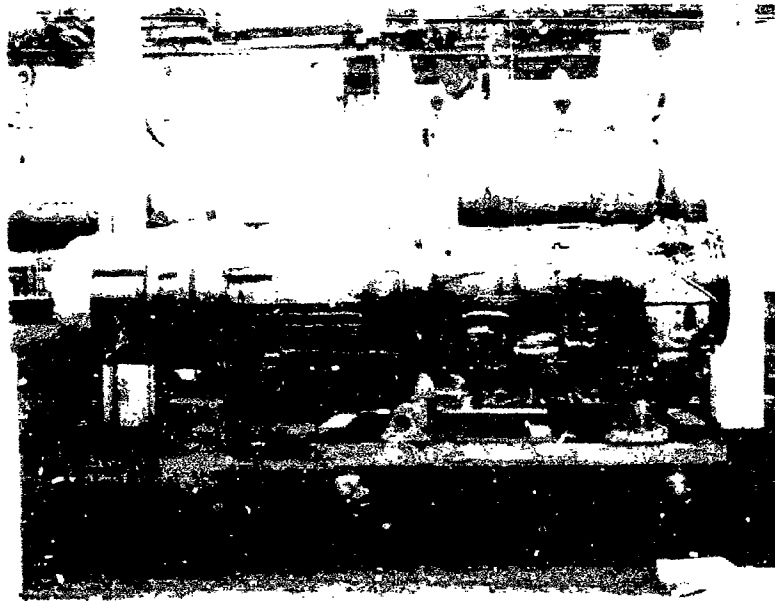


Figure 16. F-100 ENGINE MOUNTED ON HANDLING DOLLY

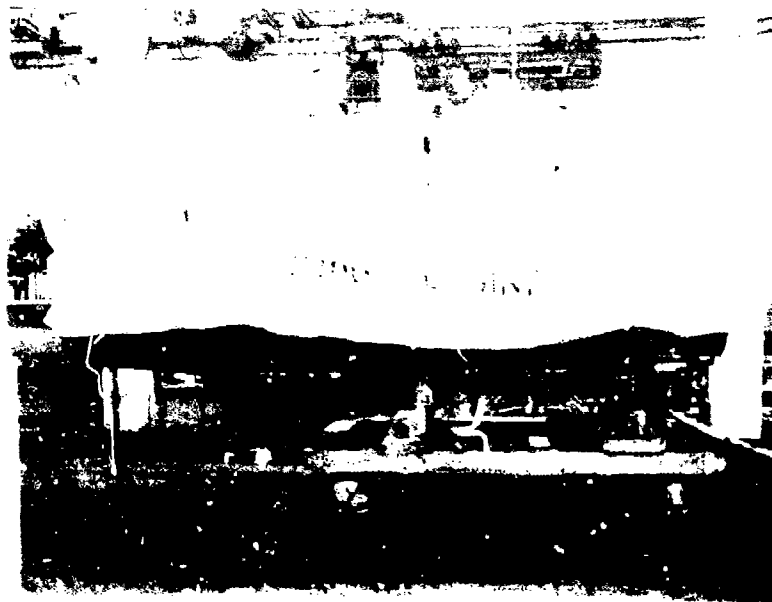


Figure 17. TOP HALF OF CONTAINER INSTALLED

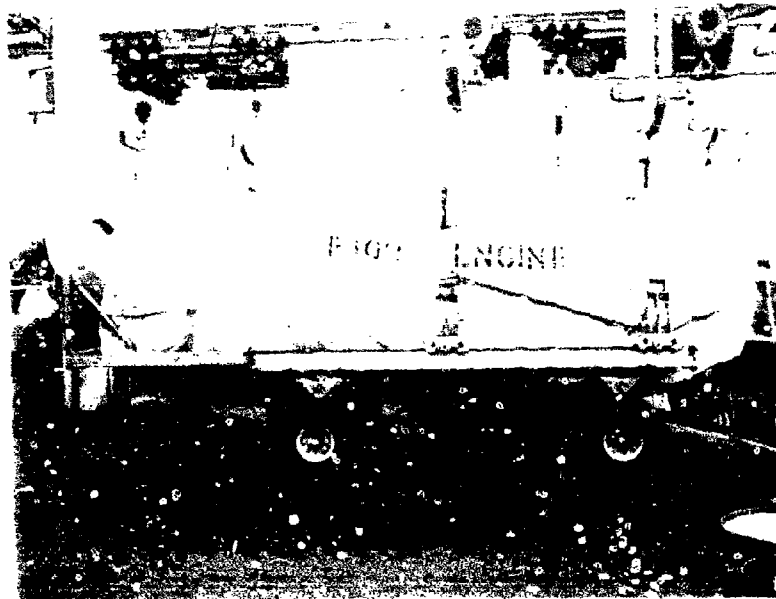


Figure 18. F-100 CONTAINER/ENGINE MOUNTED
ON 4-WHEEL TRAILER

polyurethane "stand-up" closure device meets the requirements for easily installing and removing flexible containers from aircraft jet engines. Field testing will complete the evaluation program.

RECOMMENDATIONS

It is recommended that field tests and evaluation be conducted on the Global closure device installed on the 20 prototype F-100 flexible engine containers procured from Global Chemical Supply Corporation using barrier material, Global #4051, in conjunction with the field tests as recommended in PTPT Report No. 76-21, "The Development of Barrier Materials For Flexible Aircraft Engine Containers".

It is recommended that the requirements for closure devices in MIL-C-9959 be revised to specify the improved characteristics of the newly developed closure device.

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